In the Privy Council.

No. 74 of 1928.

ON APPEAL FROM THE SUPREME COURT OF CANADA.

BETWEEN

CANADIAN GENERAL ELECTRIC COMPANY, LIMITED .. .. .. (*Plaintiff*) *Appellant.*

AND

FADA RADIO, LIMITED .. .. .. (*Defendant*) *Respondent.*

RECORD OF PROCEEDINGS.

VOL. I.

PLEADINGS. EVIDENCE AND JUDGMENTS.

INDEX OF REFERENCE.

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RECORD OF PROCEEDINGS.

VOL. I.

PLEADINGS, EVIDENCE, AND JUDGMENTS.

In the Exchequer Court of Canada.

No. 1. Statement of Claim, 23rd Oct., 1925.

No. 1.

Statement of Claim.

IN THE EXCHEQUER COURT OF CANADA.

BETWEEN:

CANADIAN GENERAL ELECTRIC COMPANY, LIMITED,

Plaintiff,

and

FADA RADIO LIMITED,

Defendant.

Filed the 23rd day of October, 1925.

1. The Plaintiff is a body politic and corporate, having its head office and principal place of business at the City of Toronto, in the Province of Ontario, and Dominion of Canada.

2. The Defendant is a body politic and corporate, carrying on business at 821-827 Queen Street, East, in the said city of Toronto.

3. By Letters Patent numbered 208,583 dated the 15th day of February, 1921, under the seal of the Patent Office of the Dominion of Canada there was duly granted to the Plaintiff, as assignee of Ernst F. W. Alexanderson, for a period of eighteen years from the date of the said Letters Patent, the exclusive right, privilege and liberty of making, constructing and using and vending to others to be used in the Dominion of Canada, an invention consisting of Improvements in Selective Tuning Systems, as described in the specification, a duplicate of which is attached to the said Letters Patent and made an essential part thereof. The Plaintiff will, at the trial of this action crave leave, for greater certainty and particularity, to refer to said Letters Patent.

4. The Plaintiff is the owner of the aforesaid Letters Patent.

5. The Plaintiff has complied with all the necessary provisions and requirements of the Patent Act and other Statutes, and has paid all necessary fees, and the said Letters Patent are now in full force and effect and the sole title to the same is fully vested in the Plaintiff.

6. The Defendant has, for some time past, without the license, permission or assent of the Plaintiff, made, constructed and used and vended to others to be used, in the Dominion of Canada, the invention described in and covered by the said Letters Patent, and has infringed the said Letters Patent, and is still making, constructing, using, vending and infringing as aforesaid, and threatens to continue to do so unless restrained by order of this Honourable Court.

7. By reason of the wrongful acts aforesaid of the Defendant, the Plaintiff has suffered great damage.

8. Through its wrongful acts aforesaid Defendant has made large profits.

9. The said Letters Patent was duly placed under the provisions of Section 44 of the Patent Act, Chap. 69 of Revised Statutes of Canada, 1906.

THE PLAINTIFF THEREFORE CLAIMS:

(a) A declaration that the said Letters Patent is valid.
(b) A declaration that the Defendant has infringed the said Letters Patent.
(c) An injunction restraining the wrongful acts aforesaid.
(d) An order for the destruction of, or the delivery up by the Defendant of all products or articles in the possession or control of the Defendant which infringe the said Letters Patent.
(e) Payment of damages or an account of profits, as the Plaintiff may elect.
(f) All necessary accounts and inquiries.
(g) Such further or other relief as the nature of the case may require.
(h) The costs of this action.

(Sgd) RUSSEL S. SMART,

Of Counsel for the Plaintiff.

In the Exchequer Court of Canada.

No. 2.

Particulars of Breaches.

No. 2. Particulars of Breaches, 23rd Oct., 1925.

1. The Defendant, at its factory in the City of Toronto, Canada, has manufactured and sold, and has used radio sets which are an infringement of the Plaintiff's Letters Patent No. 208,583, referred to in the Statement of Claim.

2. The Plaintiff alleges that claims 1, 2, 3, 7, 9, 10, 11 and 12 of said Patent No. 208,583 have been infringed as aforesaid.

DELIVERED with the Statement of Claim this 23rd day of October, A.D. 1925, by Macfarlane & Thompson, 212 King St., West, Toronto, Ont., Solicitors for the Plaintiff.

No. 3.

Amended Particulars of Breaches.

No. 3. Amended Particulars of Breaches, 29th Sept., 1926.

1. The Plaintiff will at the trial of this action allege that Claims 1, 2, 3 and 7 have been infringed.

DATED at Ottawa, this 29th day of September, 1926.

RUSSEL S. SMART,
Of Counsel for the Plaintiff.

No. 4.

Statement of Defence and Counterclaim.

No. 4. Statement of Defence and Counterclaim, 24th Nov., 1925.

Filed the 24th day of November, A.D. 1925.

1. The Defendant admits that it is a body politic and corporate, carrying on business in the City of Toronto, in the Province of Ontario and Dominion of Canada.

2. The Defendant does not admit the allegations contained in paragraphs 1, 3 and 4 of the Statement of Claim, and puts the Plaintiff to the strict proof thereof.

3. The Defendant denies that the Plaintiff has complied with all the necessary provisions and requirements of the Patent Act and other Statutes and/or has paid all necessary fees and denies that said Letters Patent are now in full force and effect and denies that title to the same is fully vested in the Plaintiff.

In the Exchequer Court of Canada.

No. 4. Statement of Defence and Counter-claim, 24th Nov., 1925 —*continued.*

4. The Defendant denies that it has manufactured and sold apparatus which infringed the Letters Patent referred to in the Statement of Claim.

5. The Defendant denies that it is manufacturing for sale apparatus which infringes the Letters Patent referred to in the Statement of Claim.

6. The Defendant denies the allegations contained in paragraphs 7 and 8 of the Statement of Claim and denies all other allegations made in the Plaintiff's Statement of Claim and in the Plaintiff's Particulars of Breaches.

7. The Defendant asserts that said Letters Patent No. 208,583 is and always has been invalid, null and void for the reasons given in the Particulars of Objection delivered herewith.

8. The Defendant submits that this action should be dismissed with costs.

AND BY WAY OF COUNTERCLAIM.

9. The Defendant impeaches said Letters Patent No. 208,583, and submits that said Letters Patent should be adjudged to be invalid, null and void and be avoided by this Court for the reasons given in the Particulars of Objection delivered herewith.

GEO. F. HENDERSON,
Of Counsel for the Defendant.

No. 5. Particulars of Objection, 24th Nov., 1925. Amended 8th Jan., 1927.

No. 5.

Particulars of Objection.

Filed the 24th day of November, A.D. 1925.

Amended the 8th day of January, A.D. 1927, by consent.

The following are the Particulars of Objection on which the Defendant relies in addition to any on which it may be entitled to rely without delivering any further particulars than those given in the Statement of Defence:

1. The alleged invention was not proper subject matter for Letters Patent of invention.

2. The subject matter of said Letters Patent was not an invention.

3. The alleged invention, comprising the said Letters Patent, was not new at the time of its alleged invention, and/or at the time of the application for a Patent, having regard to the general common knowledge of the art and to the prior patents set forth in Schedule 1 hereto, and/or the applications therefor, and/or numerous other printed publications, the titles, names, publishers, dates and places of publication of which printed publications are unknown to the Defendant at this time, but which, when known, said Defendant prays leave to insert in its Particulars of Objection by proper amendment.

4. The alleged invention forming the subject matter of the Letters Patent set forth in the Statement of Claim was known and/or used by another or others before the date of the alleged invention thereof by said Ernst F. W. Alexanderson.

(a) The alleged invention was described in the Patents set forth in Schedule 1 hereto and/or in the applications for patents or petitions therefor.

(b) The alleged invention described in said Letters Patent was, prior to the alleged invention thereof by the said Ernst F. W. Alexanderson, invented by and/or known by and/or used by the following persons :

G. Lorenz Aks. Ges................Berlin
Wilhelm Schloemilch..............Berlin, Germany
Irving Langmuir ....Schenectady, N.Y., U.S.A.
Lee DeForest ....New York, N.Y., U.S.A.
William C. White ....Schenectady, N.Y., U.S.A.
William Gardner ....Schenectady, N.Y., U.S.A.
John Stone Stone ....Boston, Mass., U.S.A.
E. H. Colpitts ....New York, N.Y., U.S.A.
W. L. Richards ....New York, N.Y., U.S.A.
H. D. Arnold ....New York, N.Y., U.S.A.
John Mills ....New York, N.Y., U.S.A.
Robert Von Lieben ....Berlin, Germany
Eugen Reisz ....Berlin, Germany
Siegmund Strauss ....(Deceased)
Edwin H. Armstrong ....New York, N.Y., U.S.A.
Alexander Meissner ....Berlin, Germany
Graf Georg Von Arco ....Berlin, Germany
Henry J. Round ....London, England
George Maurice Wright ....London, England
Charles Samuel Franklin ....London, England
George W. Pierce ....Cambridge, Mass., U.S.A.

and various other persons whose names and addresses are not at present known to the Defendant but which it prays leave to insert in its Particulars of Objection by proper amendment when known.

(c) The alleged invention was described in the printed publication referred to in Schedule II hereto.

5. The alleged invention described in said Letters Patent is not useful.

6. The alleged invention described in said Letters Patent is inoperative.

7. The claims of said Letters Patent are not based upon and are not justified by the specification.

8. If the said Ernst F. W. Alexanderson made the invention, (which is not admitted but denied), the claims are too broad and claim more than such invention.

9. The specification forming part of said Letters Patent does not clearly and fully describe and does not state clearly and distinctly the mode or modes of operating the said alleged invention as contemplated by the alleged inventor and does not state clearly and distinctly the contrivances and things which are claimed as new and for the use of which an exclusive

property and privilege is claimed, and it would not be possible for any one skilled in the art to which the alleged invention appertains to make, use, apply or work out the same from the information reported in the specification.

10. The material allegations in the petition and declaration of the applicant for the Patent referred to in the Statement of Claim are untrue.

11. Under paragraph 10 of the Particulars of Objection already delivered, the Defendant further states that the oath of the inventor is untrue in that he swears that the invention " has not been patented to me or others with my knowledge or consent in any country."

12. The said Letters Patent is invalid, null and void on the ground that what is described and claimed therein by the applicant Ernst F. W. Alexanderson, was previously described and claimed by Irving Langmuir in Canadian Letters Patent Number 196,390, of which Canadian Letters Patent Number 244,847 is a re-issue; and that the said Irving Langmuir and the said Ernst F. W. Alexanderson were in the common employment of the General Electric Company, to which they had each made a general assignment of their inventions.

13. The Specifications, including the Claims, forming part of the said Letters Patent, each contain more than is necessary for obtaining the ends for which they purport to be made, and such addition was not an involuntary error.

GEO. F. HENDERSON,
Of Counsel for the Defendant.

SCHEDULE I

Referred to in the annexed Particulars of Statement in Defence. Canadian Patent No. 208,583 of February 15, 1921.

CANADIAN LETTERS PATENT

Number	Date	Inventor or Patentee
156,452	June 23, 1914	Wilhelm Schloemilch and August Lieb
159,794	December 29, 1914	Lee De Forest
159,855	December 29, 1914	George W. Pierce
187,793	December 3, 1918	Charles Samuel Franklin
187,794	December 3, 1918	Henry Joseph Round
196,145	January 13, 1920	Irving Langmuir
196,390	January 20, 1920	Irving Langmuir
198,803	March 30, 1920	Irving Langmuir
208,836	February 22, 1921	Irving Langmuir
212,366	July 5, 1921	Irving Langmuir
216,321	March 7, 1922	Edwin H. Armstrong
216,322	March 7, 1922	Edwin H. Armstrong
218,235	May 2, 1922	Lee DeForest
228,764	February 13, 1923	Graf Georg von Arco and Dr. Alexander Meissner
244,847	November 25, 1924	Irving Langmuir

UNITED STATES LETTERS PATENT

706,738	August 12, 1902	R. A. Fessenden
714,756	December 2, 1902	J. S. Stone
734,048	July 21, 1903	C. D. Ehret
742,779	October 27, 1903	R. A. Fessenden
756,436	April 5, 1904	John Trowbridge
767,976	August 16, 1904	J. S. Stone
864,272	August 27, 1907	J. S. Stone
841,386	January 15, 1907	L. DeForest
841,387	January 15, 1907	L. DeForest
879,532	February 18, 1908	L. DeForest
884,110	April 7, 1908	J. S. Stone et al
899,243	September 22, 1908	S. Cabot
916,840	March 30, 1909	S. Cabot
995,126	June 13, 1911	L. DeForest
1,087,892	February 17, 1914	W. Schloemilch et al
1,112,655	October 6, 1914	C. W. Pierce
1,156,625	October 12, 1915	G. W. Pickard
1,163,180	December 7, 1915	W. Schloemilch and Lieb
1,297,188	March 11, 1919	Irving Langmuir
1,282,439	October 22, 1918	Irving Langmuir
763,772	June 28, 1904	G. Marconi

BRITISH LETTERS PATENT

10,210	1910	W. P. Thompson
8,821	1913	W. P. Thompson

FRENCH LETTERS PATENT

425,047	1911	R. Von Lieben et al
13,726, addition to 425,047		R. Von Lieben et al
456,788	September 4, 1913	Gesellschaft fur Drahtlose Telegraphic

GERMAN LETTERS PATENT

197,807	R. Von Lieben et al
258,478	G. Lorenz Akt. Ges.
271,059	Gesellschaft fur Drahtlose Telegraphic
293,300	Gesellschaft fur Drahtlose Telegraphic

AUSTRIAN LETTERS PATENT

71,340	Issued March 10, 1916 Filed December 11, 1912	Siegmund Strauss

SCHEDULE II

Referred to in the annexed Particulars of the Statement of Defence.

PUBLICATIONS

Article by John Stone Stone "Interference in Wireless Telegraphy" Electric Review, Vol. 46, No. 12—Mar. 25, 1925, pp. 502-507.

In the Exchequer Court of Canada.

No. 6. Further Particulars of Objection, 21st Jan., 1926.

No. 6.

Further Particulars of Objection.

The following are Further Particulars of Objection, furnished pursuant to the Order of the Honourable Mr. Justice Audette, dated the 9th day of December, A.D. 1925:—

1. Under Paragraph 6 of the Particulars of Objection already delivered, the Defendant further states that the invention described in the said Letters Patent is inoperative, in that no means are provided or described in the drawing or specification for preventing the system from oscillating or tending to oscillate when the alleged invention described in the said Letters Patent is applied to a vacuum tube system wherein each of the plurality of resonant circuits is adjusted to be resonant to a given frequency.

2. Under Paragraph 7 of the said Particulars of Objection already delivered, the Defendant further states that the claims of the said Letters Patent, if they define an operative arrangement, are not based upon and are not justified by the specification, in that the specification does not describe or provide means for preventing the system oscillating or tending to oscillate, and that therefore, assuming the claims to define any operative vacuum tube system, they are not based upon and are not justified by the specification.

3. Under Paragraph 10 of the said Particulars of Objection already delivered, the Defendant says that the Petition and Oath of Application of said Letters Patent were untrue, in that the Petition states "that he hath invented certain new and useful improvements in selective tuning systems, not known or used by others before his invention or discovery thereof, and not being in public use or on sale with his consent or allowance as such inventor, for more than one year previous to his application for Patents, therefor, in Canada."

DATED at Ottawa, this 21st day of January, A.D. 1926.

(Sgd) GEO. F. HENDERSON,
Of Counsel for the Defendant.

Plaintiff's Evidence.

No. 7. Frank N. Waterman. Examination

No. 7.

Evidence of Frank N. Waterman.

FRANK N. WATERMAN, Sworn. Examined by MR. SMART:

MR. SMART: Are you satisfied that Mr. Waterman should be seated, my Lord?

HIS LORDSHIP: Yes.

MR. HENDERSON: Would your Lordship think it convenient that I should hand you this memorandum of dates?

HIS LORDSHIP: Which you mentioned just now in your closing?

Mr. Henderson: Yes. I can easily replace it from my brief. It is just a convenient way of having it. There are a few words on here, which I mentioned in argument. They do not hurt.

Mr. Smart: Q. What is your residence and occupation, Mr. Waterman?—A. My residence is, Summit, New Jersey; and I am a consulting engineer.

Q. I propose to examine you with respect to the issues in this action, as an expert; and I should ask you to state in a general way your qualifications to give that kind of evidence?—A. I was educated in Cornell University, graduating in the course of Electrical Engineering. For 11 years thereafter I was in the employ of the Westinghouse Electric and Manufacturing Company. Since that time I have been acting as a consulting engineer and have devoted special attention since about 1910 to the subject of radio; or, as it was then called, wireless transmission and reception. I have in that connection frequently testified in litigations and have made a special study of that subject in its various phases.

Q. Have you read and do you understand the Alexanderson patent which is in suit in this action?—A. I have, and I do.

Q. Now I wish you would state in a general way such of the facts relating to radio transmission and reception as may be helpful in understanding the disclosures of that patent?—A. In order that I may be sure that I understand the scope of your inquiry, I will say that I will answer your question first, briefly, as to what radio signals are, and how they are produced and transmitted; the effect of receiving antennae; how they carry messages; how the receiving station is affected by a plurality of such transmitting stations; and then proceed to the principles by which selection is governed.

Q. Yes, I think that would about cover the scope of what I have in mind. It will of course be a repetition in part of what I have said in opening, but I think Mr. Waterman can express it more accurately than I have.

His Lordship: Yes, I should like to hear the witness. As briefly of course, as possible?—A. In radio signalling we have to do with the transmission of very high frequency electrical waves, as we call them. They travel with the speed of light, and are quite analogous to light waves in their nature. We could therefore conveniently think of a radio transmitting station as in the nature of a lighthouse, sending out radiation in all directions. The vertical wire or antennae by which the radiation is caused, corresponding to the vertical shaft of the lighthouse.

The waves are produced by causing charges of electricity to travel up and down the height of that antennae.

If a positive charge, for example, starts towards the top, an electric wave starts travelling out from the antennae. It arrives at the top, returns to the bottom, and in so doing a negative charge takes its place. That is, a negative charge immediately follows; and that negative charge returns to earth. While this process was going on, the wave that started has been travelling with the speed of light away from the vertical antennae. At the end of the cycle which I have just described, it has reached a distance away from the antennae which will be equal to the velocity of light multiplied by the elapsed time. That distance, with waves such as we are using in broadcasting to-day, would be from say 200 metres to 600 metres. That sequence of events in the antennae is constantly repeated. Therefore a continuous succession of waves is emitted and they continue travelling away with the speed of light, 186,000 miles per second; and therefore at the end of one second the number of such waves that have been emitted is equal to the wave length divided into the speed of light; and in ordinary broadcasting ranges that varies from 500,000 per second to 1,500,000 per second.

Very briefly, the effects which the current travelling up and down the antennae produces are these: when a charge is at the top of the antennae, it establishes what we call an electric field; that is to say lines of strain, as we call them, connecting the top of the antennae with the earth; and a certain amount of energy is represented by those lines of strain, and when a charge rushes to earth, it constitutes what we call an electric current, and sets up what we call an electric magnetic field. The electric field extends from the top of the antennae to the earth, the electromagnetic field however extends in circles parallel to the earth around the antennae. And that electric wave—and this is about all we know about it—consists of those two fields travelling together, and they travel out through space with the speed of light.

Wherever there is a piece of metal in their path, which intercepts these travelling waves or fields, current is produced. Or more strictly, I should say, an electromotive force is produced. An electrical pressure. Something which causes a current in a suitable path.

The current which actually flows will depend upon many circumstances, but it will be caused by this electromotive force or pressure or potential (all of these terms are used) which is set up by the passage of this very high speed travelling wave or succession of waves.

A receiving antennae is such a piece of metal. It is a wire, for example, erected with the specific intent that it shall intercept these travelling waves and shall have electromotive force developed in it.

His Lordship: So you have the electromotive force developed between the sending and receiving antenna, is that it?—A. The sending antennae sends out waves. The receiving antennae has developed in it as a result of intercepting those waves, a pressure existing, one instant for example, between the top and the bottom of the antennae. The top may be positive, and the bottom negative. And that electromotive force varies just as the waves vary. It therefore goes through the same enormously high frequency changes that are caused at the transmitting station. If the current at the transmitting station is reversing to produce one million complete cycles per second, then the electromotive force produced in a receiving antennae will similarly go through one million complete cycles per second.

Such a continuous emission of uniform waves would have no utility. It is created therefore for the purpose of serving as a means of carrying some useful effect. It is therefore subjected to what we call modulation.

Modulation consists in varying the intensity of those waves; the intensity of the current which travels up and down in the transmitting antennae, in other words.

HIS LORDSHIP: Is that equivalent to what Mr. Smart stated this morning about the telegraphic current; in which you chop the current into dots and dashes?—A. That is one mode of modulation, yes.

Q. And that is what happens in the radio waves?—A. Yes.

Q. That is the wave is modulated up or down and causes these strange figures which we saw here this morning?—A. Yes. It may be modulated partially or it may be modulated completely. By that I mean that the intensity of the fields constituting the waves, may vary between a maximum and say zero, or may vary between a maximum and something greater than zero. But it is necessary, in order that the wave may be useful, that it should vary.

MR. SMART: Q. I take it that you are going to deal with the difference between telegraphy and telephony in dealing with modulation?—A. I will if you desire it. In other words, in order that this high frequency continuous oscillation which is produced shall be useful, it is necessary to vary it in some way. Now we may vary it to form dots and dashes. We may vary it to form speech. We may vary it to form music. In any case, we superimpose upon it an audio frequency effect.

Now this very high frequency radio effect which I have been speaking of, which varies between 500,000 complete cycles per second and 1,500,000 complete cycles per second in the broadcast range, vastly exceeds the power of any instrument to follow, to make sound. If any instrument were able to follow it, it would vastly exceed the power of our ears to respond.

HIS LORDSHIP: Do you say that is superimposed upon the air waves? Or is not the wave begun, and the form changed by the instrument?—A. That is the effect which we call the super-position. We vary the intensity of the strength of the current rushing up and down in the transmitting antennae in accordance with some audio frequency modulation, which may be dots and dashes, which may be speech, or which may be music. That is equivalent to the super-position of this audio frequency of the same antennae, and we speak of it in that way. It is known by the term " modulation " which better expresses the idea of varying up and down the currents that are applied to the transmitting antennae.

Audition ranges of frequency are very much less. The ordinary ear perceives from perhaps as low as thirty or fifty cycles per second, up to a number of thousands. The line of demarcation that is officially recognized between audio frequency and radio frequency is 10,000 cycles per second; but of course ordinary speech or ordinary music rarely reaches that range. The difference between the telegraphic signal and the speech signal or the music signal is merely the difference in the form of modulation.

I did not see the figures that Mr. Smart drew this morning, but I assume that he drew out lines such as represent speech wave forms.

The telegraph wave form, instead of being irregularly curved, is a succession of square outlines by which the carrying wave is modulated.

Usually, or at least commonly,—I do not know that I can say as to the usual practice,—the majority practice,—the intensity of the wave merely is modified. It is not cut entirely off, because it is very difficult to do that. To represent a dot the waves go out full strength for an instant, and then they fall in strength, corresponding to the space between the next dot, and do not entirely die out; then they rise to the full amplitude again, corresponding to a dash perhaps, and then fall to represent another space and we have the telegraph letter "A." If instead of rising abruptly and falling abruptly we vary the rate at which they rise and fall, we would have the spoken letter "A." That is all the difference.

The medium through which these waves travel is simply, as we say, the air. There being only one such medium all other transmitting stations have to occupy it simultaneously. It is like the surface of a pool of water. If a dozen men are fishing and the bobs are going up and down and sending out ripples, the effect on the surface of the water is a composite choppiness which represents the sum of all of the ripples caused by all the bobbing corks. So if we have a number of stations transmitting, sending out radio broadcast matter for example, they are all occupying the same space, the same air; they are all travelling with the same speed, they all reach a given receiving antenna; they all produce electromotive force, and current in that receiving antenna. Now they differ from one another in their wave length; therefore in their frequency.

One station may, for example, be sending at 500 metres; that is 600,000 cycles per second. Another may be sending at 450 metres, another at 400 metres, another at 300 metres, and so on. In other words, the one characteristic by which they may be, generally speaking, differentiated is the frequency at which they occur, or as we ordinarily say, the wave length. They are travelling at the same speed. They have the same intensity or a different intensity, but the thing that characterizes them is their wave length. Now as these waves travel out from any given station they are attenuated just as light is attenuated. If you stand close to a lighthouse the light looks bright, but if you are a long way off the light appears very dim. So that if we were close to a transmitting station a given receiving apparatus will make the signal seem very loud. If we carried that same receiving antennae and apparatus farther away, the apparent intensity of the signal would progressively decrease. So that the signals arriving at any given receiving antennae will have an intensity which depends upon two things; the original intensity with which the signals were emitted and the distance that the receiving station is away from the sending station. There are very many other effects more or less understood and more or less mysterious to us which affect the transmission, so that we say we have good radio nights and bad radio nights. They are more or less like the weather, but for any one state of what I may call radio weather the conditions which I have just described hold. If any one receiving station wants to hear the programme or the message, whatever it may be, sent by the one particular emitting or transmission station, it must be able to pick it out of the jumble of currents in the receiving antennae as that particular one. It may happen that that particular one comes from a somewhat distant station and is relatively feeble, while an undesired signal may come from a relatively near station or a relatively much more powerful station, whose effects therefore are very much louder when received with an effectiveness which produces much greater currents in the same antennae. The problem which is so acute to-day is therefore a problem of selection. Selection involves a good many problems. If two transmitting stations are transmitting waves whose frequencies are very close together they cannot be separated. We as yet do not know of any means by which for example two stations of the same frequency could be separated. If they differ very slightly still we cannot separate them. But one of the very important problems, of paramount importance in fact, in view of the present large number of transmitting stations and of paramount importance on the seaboard for example, to successful radio communication to ships at sea and foreign countries, is the ability to select a feeble signal through a very powerful signal of quite widely different wave lengths or frequencies. If, for example, the receiving antennae is in the vicinity of a large city having a powerful broadcasting station, that receiving station at once is presented with a problem of receiving other more distant and therefore more feeble stations through the very powerful effect of that closely adjacent sending station. That is the particular problem which is here dealt with.

Now in order to understand the possibility of selection which appears in the use of different transmitting wave lengths it is necessary to understand the principles upon which such selection is possible. The fundamental principle used in all selective systems, so far as it is necessary to consider them here, is the principle of resonance. We are all very familiar with resonant system, although we do not ordinarily speak of it by that name. I refer to the mechanical resonant system. The system which is very highly developed which we carry, namely in our watches, is an excellent illustration of the mechanical oscillatory resonance system. The balance wheel and hair spring of a watch oscillate with such an amazing constancy of oscillatory actions that a good watch will run for days or weeks with only a trifling variation in the time, notwithstanding the fact that it oscillates a number of times per second. The fundamental pre-requisites to such an oscillatory system are that there shall be two elements involved, one of which has the property of momentum, and the other of which has the property of resilience. Of course the pendulum is another oscillatory system and we do not in that case have resilience, but the resilience is compensated for by the effect of gravitation which takes its place. In other words, there must be momentum to cause some object to swing past a position of equilibrium and there must be a restoring force tending to pull it back to its position of equilibrium.

In the balance wheel hair-spring system of a watch the delicately mounted balance wheel is an element having momentum: that is, having inertia, because if it is started in motion it tends to continue in motion and it will continue unless some force stops it. That balance wheel in our watch is associated with the hair spring, and if our watch stops we know that by giving it a slight twist we set the balance wheel in motion. The balance wheel, due to its momentum, travels so far that it winds up the hair spring, and it is stopped in that excursion by the tax that it puts on the hair spring; the hair spring then tends to rotate the balance wheel in the opposite direction, and having got the wheel moving, its momentum carries it beyond its position of equilibrium. The hair spring is wound then in the reverse direction and it reacts to draw the balance wheel back, and so the combined system of a momentum and restoring force acts to cause

In the Exchequer Court of Canada.

Plaintiff's Evidence.

No. 7. Frank N. Waterman. Examination —*continued.*

a continued oscillatory motion of the balance wheel which occurs at constant periods. Of course, if no new energy were added to that balance wheel it would after a while stop ; that is, if you did not have the main spring wound up the watch would not continue running but the function of other mechanism in the watch is to enable the main spring to at intervals impart to the balance wheel of the watch just as much of an impulse as has been taken out of it by the friction of the pivot. The reason of course that the balance wheel would stop eventually if it were not for the continued addition of impulses to it is that there is some friction even in the most delicate pivot, and that it is moving through the air and that there is air friction. All of those qualities have their analogues in an electric circuit, and it is for the same reason that an electric circuit exhibits oscillatory or resonant phenomena, and for analogous reasons, if the electric circuit is set into a state of oscillation, by which we mean has oscillating currents set up in it, those currents will die out, by reason of the losses which correspond to the friction in the balance wheel system I have just spoken of. The element in such an electric circuit which has momentum, which therefore corresponds to the balance wheel, is the coil ; that is the inductance and it has that property because, as an electric current flows in it, it creates a magnetic field around it, and that magnetic field reacts upon the coil, and gives to it the property of momentum.

I dare say we all remember the days of gas lighting, and when it was common to have a gas jet out of reach lighted, by causing a spark to take place. That illustrates the momentum of the inductance. The means of producing that spark was simply that if we pulled the string the current flowed, and if we pulled the string further the path was broken, but the current kept on flowing due to the property of inductance or electrical momentum and the fact that it kept on flowing was evidenced by the spark which lit the gas. This property of the inductance, acting as though the current had momentum, is an element in the electric circuit corresponding to the balance wheel of the watch. I have already spoken of the electrostatic field which is created by an antennae. Now, an electrostatic field exists whenever there is a difference of electrical pressure, where there is an electromotive force between two points in an electrical circuit. If we impress such an electromotive force across the plates of a condenser, we force a certain quantity, large or small, generally a small quantity of electricity into that condenser. We have, in other words, given the plates different electrical potentials. We thereby have an electrostatic field in those plates. We have stored energy in that electrical field which is pressing to come out. It is acting like a wound up spring. The condenser therefore corresponds to the hair spring of the balance wheel system of the watch. If such a condenser is associated with such a coil as I have spoken of, and a current is created in the coil, that current will charge the condenser up to such a potential that the current ceases to flow, thereupon the restoring effect of the condenser comes into play, and the condenser begins to discharge through the coil, whereupon, due to the momentum of the coil, the current overshoots, and the condenser is charged in the reverse sense, and when the current comes to rest it is forced back again.

So that we have an oscillatory flow of current in the circuit which is analogous to the balance wheel and the hair spring in the balance wheel system of a watch. That oscillation will occur at a definite rate, just as the motion of the balance wheel system of the watch occurs at a definite rate. That rate will be determined by the amount of inductance and the size of the condenser, or the amount of the capacity; therefore, since we have the ability to control those two things, a system of an oscillatory type can be brought about which is of the desired oscillatory period.

For the sake of making clear, I want to refer to another oscillatory system for just a moment, and that is the piano string or any mechanical instrument string. If we sound a particular note in front of a piano where the strings are exposed, and sustain that note for a moment, and suddenly stop it, if the note produced corresponded to the same pitch that one of the piano strings was tuned to, we will hear that string continue the sound after the original sound has been discontinued. That is because the string has a definite period, and if we have sounded that period, sounded a note of that pitch, for instance, the string would take up the vibration from the sound waves as they strike it.

So an oscillatory system of an electrical type is set in oscillation, if it is subjected to electrical impulses, as electrical waves for example, of the same frequency as that to which the circuit itself naturally responds. If the sound that we produce in front of the piano is not exactly in tune with the string it is often possible to notice that the string of the piano acquires a slight vibration, but less than would have been the case had the sounded note been exactly the pitch of the string.

So it is with an electrical circuit. As the frequency or pitch of the electrical wave departs from that natural to the circuit, the effect produced in the circuit will be less and less. It therefore follows that if there is a heterogeneous jumble of received frequencies due to many broadcasting stations in an antennae, and we cause that antennae to influence a tuned circuit—that is, a well chosen combination of inductance and capacity, having precisely the natural rate of oscillation corresponding to one of the many signals in the antenna—that circuit will tend to be set in oscillation more by the signal of its own frequency than it will by the signal of any other frequency coming in. The effect is similar also to that of a piano in that as the frequency of the signal departs from the natural frequency of the circuit, the effect of the signal upon the circuit will rapidly diminish. It may be useful, your Lordship, to see a pictorial representation of that effect.

(The witness produces pictorial representation which is shown to the Court.)

In that type of illustration we show the intensity of the effect or the extent of the response of the electric circuit by a dot placed at a distance above the base line, measured on the scale at the left of the drawing. The different frequencies or the different pitches, so to speak, of the wave are represented by the scale along the bottom of the base line, and those are arranged in per cents., and in making that drawing I have assumed that 100 per cent. would correspond to the frequency with which a particular circuit, any circuit, is tuned, and in drawing the curve I have presumed

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that that particular circuit has a certain amount of pivotal or frictional loss which we call resistance, and that it has a certain amount of inductance. What I actually assumed was that it had a certain ratio of those two things, a matter that I will come to later.

MR. HENDERSON: Will that document be put in?

MR. SMART: I will have a photostat made of it and file it to-morrow. I put in now the Alexanderson patent.

EXHIBIT NO. 1:—Filed by Mr. Smart Jan. 10th, 1927. Alexanderson patent No. 208,583.

THE WITNESS: Now if we assume that it is possible for us to act upon that circuit with electrical waves whose frequency varies from zero up to some very high frequency, we will get a certain response in that circuit from every frequency applied to it, and for each frequency we make a dot above the base line, and those dots connected up are the curved lines drawn there, and the curve illustrates the fact that the electric waves which are not closely in tune with the natural frequency of the circuit have a very small and more or less constant effect, but as we approach that frequency mark 100 per cent., to which the circuit naturally responds, the effect produced by a wave of exactly the same intensity rapidly gets greater until it reaches 100 per cent. when a very large effect is produced in the circuit as compared to the smaller effect that is produced when the frequency is quite low, as for example, 10 per cent.

Now if the circuit has a good deal of resistance it corresponds to the balance wheel of a watch where the pivotal friction is high; then the intensity of the effect that will be produced when the wave is exactly of the same frequency as that of the circuit will be very much less.

The lower line on the drawing practically illustrates relatively the small effect that would be produced by the same identical wave in a circuit having ten times as much resistance as the other.

I think the selective systems that we will be interested in depend directly or indirectly upon this property of resonance. When such a circuit receives electrical waves or electrical impulses, however produced, what occurs is first a relatively small effect. Now that small effect, being due, for example, to a single impulse, when another impulse is added, that impulse will tend to build up, provided that it occurs in exactly the right period, so that its effect will be felt. It is like the swinging of a pendulum and can be illustrated in that way. A very small impulse will not have much effect, but a succession of very small impulses will bring about a wide swing. However, if those same small impulses do not occur in synchronism, if I may use a large word, or in time with the swinging of the pendulum, then there will be either no building up or less building up. That capacity of a resonant circuit which is illustrated in the drawing just produced is the accumulative or amplifying capacity of a resonant circuit, in virtue of which it is able to distinguish between waves which come in its own frequency, in its own natural period, and waves which although simultaneously received may be of different frequency.

MR. HENDERSON: Will your Lordship indicate what you think of doing in the way of sittings?

HIS LORDSHIP: How many witnesses will you have, Mr. Smart?

MR. SMART: I do not think there will be a great many. It is difficult to say until I hear my learned friend's case.

HIS LORDSHIP: Have you many, Mr. Henderson?

MR. HENDERSON: A good deal depends upon what Mr. Waterman says.

MR. SMART: The fact witnesses will not take long.

MR. HENDERSON: Will your Lordship allow me to make a suggestion in the spirit of frankness? I know I will find that a comparatively short day's sitting will be of advantage. I do not know what my friend may think. I do not mean a very short day's sitting.

HIS LORDSHIP: Do you mean from 11 to 1 and from half past two to half past four?

MR. HENDERSON: I think I would almost prefer 11 o'clock, as that will give an opportunity to get some other things done. For instance, I found enough work on my desk this morning, outside of this matter to take several days.

HIS LORDSHIP: I suppose we might meet at two o'clock in the afternoon, after an hour's recess and sit until four o'clock?

MR. SMART: My mind was rather on a four and a half hour day, than on a four hour day.

HIS LORDSHIP: That is that we meet at ten-thirty?

MR. SMART: Yes. As a matter of fact the long lunch hour is often useful in arranging material for the afternoon, and if there is not a break of sufficient length it may only mean that the material is not as well arranged. It is not wasted time.

MR. HENDERSON: I agree that reasonable opportunities for conference are going to shorten the matter.

MR. SMART: Yes, it works both ways.

HIS LORDSHIP: All right. We will adjourn now until ten-thirty tomorrow morning, and see how it works.

(Court adjourned Monday, January 10th, 1927, at 4.30 P.M., to resume on Tuesday, January 11th, 1927, at 10.30 A.M.)

MR. SMART: I propose to file this typical resonance curve which the witness was referring to yesterday.

EXHIBIT NO. 2:—Filed by Mr. Smart Jan. 11th, 1927. Typical resonance curve submitted by witness, F. N. Waterman.

HIS LORDSHIP: Do counsel wish to correct the evidence as we go along?

MR. SMART: I have a number of corrections noted. Sometimes it is a very convenient way to give the corrections to the reporter and have them extended on the record.

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MR. HENDERSON: I must confess that I did not go over this evidence last night because it was of an introductory nature. I would suggest, however, that it would be very easy to get together on this matter and then correct your lordship's copy. I doubt if there will be anything we do not agree upon.

HIS LORDSHIP: It is easier to make the corrections daily.

MR. SMART: Suppose to-morrow we endeavour to correct the two days' copy.

MR. HENDERSON: I will acknowledge it was my fault that I was not ready this morning, but I looked upon proceedings yesterday as rather introductory matter.

HIS LORDSHIP: As I understand it this patent has to do altogether with the matter of selectivity.

MR. SMART: Yes.

HIS LORDSHIP: And that means a mechanism which excludes extraneous matter—everything except the thing you desire to have.

MR. SMART: Yes.

HIS LORDSHIP: In plain language that is the meaning of it?

MR. SMART: Yes. In the Alexanderson patent, Exhibit No. 1.

F. N. WATERMAN, Examination resumed by MR. SMART:—

Q. In the Alexanderson patent, Exhibit No. 1, in the third paragraph, I find this statement:

> "The method now commonly employed for this purpose consists in using an electric circuit in which a train of waves of a given frequency acts cumulatively so that each successive impulse adds its energy to the previous impulse, while disturbing impulses of a different frequency have little effect. However, to screen out strong disturbing impulses effectively when weak signals are to be received requires an accuracy of adjustment which imposes a definite limit upon the possible selectivity of the system."

I wish you would explain the kind of tuning that is referred to in that extract from the patent.

HIS LORDSHIP: Are you going to put together before me an Exhibit, or something for my own information, showing a unit circuit?

MR. SMART: Yes. There will be.

MR. HENDERSON: There will be several different circuits.

HIS LORDSHIP: I mean showing the condenser and circuit and valve.

MR. HENDERSON: We will have what we call a simplified drawing.

HIS LORDSHIP: I do not mean a drawing. I mean the actual exhibit.

MR. SMART: We have the exhibit here.

MR. HENDERSON: We have one now.

MR. SMART: You might answer the question which I put to you?—
A. The passage which you referred to in the patent has to do with the action

of such a circuit as I was engaged in describing in the latter part of my last answer. I pointed out that such a circuit contains an inductance, corresponding to an element having a mass in a mechanical system, and a condenser, corresponding to an element having elasticity in a mechanical system. And I pointed out that just as a piano string or a pendulum can be caused to act cumulatively to build up a vibration by adding the energy of successive impulses received by it, so an electric circuit adding up the impulses received from successive waves is caused to develop a larger and larger oscillatory current corresponding in frequency to the received waves.

HIS LORDSHIP: An oscillatory current, Mr. Waterman, is simply a forward and backward movement?—A. Yes, your lordship, a current which moves first in one direction around a circuit and then in the opposite direction.

Q. That is an oscillatory current?—A. Yes.

MR. SMART: *What is the distinction between the alternating and the* oscillating current?—A. There is no fundamental distinction. We commonly use the term oscillating to apply to high frequencies, and alternating to apply to lower frequencies; but that distinction is not hard and fast, and "alternating" is often used when "oscillating" is meant.

Q. So that oscillating is a terminology belonging more to radio?—A. Yes.

HIS LORDSHIP: That is probably the distinction?—A. Yes, your lordship. The extent to which such a circuit is able to act cumulatively to add up the energy of successive impulses depends upon two things, the exactness with which its own natural period of oscillation corresponds to the frequency of the received impulses, and the energy dissipative qualities of the circuit, that is its resistance, the readiness with which it loses energy, as in the balance wheel, if the pivots have resistance or there is appreciably, air resistance, the balance wheel if not continuously supplied with impulses, tends to come to rest; and conversely will build up to a lesser degree. So an electric circuit will build up to an extent governed by the rate of dissipation of energy; because when the dissipation of energy in one swing or oscillation of the current equals the energy which is received by each impulse, then there can be no gain. And this passage refers, in the first portion of it, to such cumulative action, and it contrasts the cumulative action of an impulse which has the same frequency as the natural rate of oscillation of the circuit with one which is referred to as a disturbing impulse of a different frequency, which has relatively little building up effect. I have made a sketch illustrating the difference.

MR. SMART: This is the sketch, your lordship.

MR. HENDERSON: Wait a moment, Mr. Smart, please. I object to the use of this, my lord, until the witness tells us how this is arrived at.

MR. SMART: If the sketch which the witness has made will illustrate anything, it should go in.

MR. HENDERSON: I object to the use of it.

HIS LORDSHIP: What is the objection to it, Mr. Henderson?

MR. HENDERSON: Until we know whether this is based upon the calculation, or how it is arrived at, it will be impossible to follow it.

HIS LORDSHIP: I presume he is going to explain that.

MR. HENDERSON: It is not proper simply to hand in a sketch before giving some idea of what the sketch is.

HIS LORDSHIP: The witness has been discussing this, has he not?

MR. SMART: Yes, my lord.

MR. HENDERSON: He has not discussed this yet, my lord.

HIS LORDSHIP: I do not see any objection. It may help or it may not. It may help to illustrate what he says.

MR. HENDERSON: My friends who are with me have had previous experience with this witness of something very similar, oscillograms, which have been ruled out in another court.

MR. SMART: They have been ruled in, as I understand it.

MR. HENDERSON: I say they were ruled out. And the reason is that unless we are there to check the making of them, or unless they are based upon mathematical calculations with which we are furnished, we have no opportunity of checking them.

HIS LORDSHIP: You will have an opportunity upon cross-examination or upon the production of your own witnesses to attack this. I have no idea as to their force or the weight of them, as yet.

MR. HENDERSON: As yet I do not know what they are, but I desire to point out to your lordship now that they may be very misleading.

HIS LORDSHIP: I do not think I will be misled by it. I will receive it, subject to objection.

MR. SMART: Q. Will you go on with your evidence?

The sketch produced by the witness is offered as exhibit No. 3.

EXHIBIT NO. 3:—Filed by Mr. Smart. Jan. 11th, 1927. Sketch of oscillations in an oscillatory circuit.

A. The sketch which has been called exhibit 3 is intended to illustrate the two statements contained in the first sentence quoted. The two upper figures marked A and B illustrate the building up cumulatively of oscillations in a circuit when the received oscillations or waves have the same frequency as that natural to the circuit. The two lower curves, marked a and b, illustrate the statement that disturbing impulses of a different frequency have little effect, comprising the latter part of the first sentence quoted in the question.

In each case the sinusoidal or wavy line, marked A represents an incoming wave of continuous or sustained oscillation. The line B in each case illustrates such cumulative action as takes place in a circuit of somewhat higher resistance when the oscillations are experienced by it. The words "act cumulatively so that each successive impulse adds its energy to the previous impulse" is illustrated by the gradual increase in height of the upper sinusoidal or wavy line marked B after the beginning of the oscillations A. Your lordship will see that each successive wave is higher than the preceding, and that this continues up to a certain point; and at that point the losses, the energy dissipation of the circuit becomes equal to the energy received in each wave, and therefore it does not build up higher. Now, if the circuit were one having a higher tuning factor, that is having a higher energy conserving power, in relation to its dissipating power, then the curve would build up still higher.

In the typical resonance curve which I produced yesterday, exhibit No. 2, which is merely another way of showing this phenomenon, I called attention to the fact that the circuit having quite small losses gave a high-peaked resonance curve. The peak was quite sharp and rose to a great height; whereas a circuit having greater energy dissipating characteristics or higher resistance rose to a much less height.

So the number of waves that will be required to build up in the line *b* just referred to will depend upon the losses that occur in the circuit.

In the two lower lines the action of the same circuit is illustrated by the wavy line B; but the waves A that are received are no longer of the same period as those to which the circuit naturally responds; therefore we have a quite different sort of building up, and the curve B illustrates the irregular sort of cumulation which takes place and the relatively small current that is ultimately reached in a circuit when acted upon by waves of a different frequency.

This illustrates the last portion of the first sentence, passage, quoted, namely beginning in line 18 of the U.S. Patent, which says:—

"While disturbing impulses of a different frequency have little effect."

Roughly this lower line B represents the effect of impulses some 15 to 20 per cent. different from that to which the circuit naturally oscillated. If the frequency had differed more widely from that normal to the oscillations of the tuned circuit, then the height to which the lower line oscillations B build up would have been progressively less as the frequency departed from that natural to the circuit.

The second sentence quoted in the question which says:—

"However, to screen out strong impulses effectively when weak signals are to be received, requires an accuracy of adjustment which imposes a definite limit upon the possible selectivity of the system,"—

refers to the difficulty that is encountered when the signals being received by the antenna inherently differ greatly in intensity.

If I may refer for a moment to Exhibit 2: your lordship will notice that at about 60 per cent. on the horizontal scale, and at about 160 per cent.—these percentages referring to the percentage of the resonant frequency which an incoming signal has with respect to the natural frequency of the circuit assumed to be under consideration,—the current generated, I say, at about 60 and about 160 per cent. is 1 per cent. of that generated at 100 per cent. It means that if a circuit, let us say, is tuned to a million cycles, so that its natural rate of current oscillation is 1,000,000 times per second, is affected by a signal say 600 thousand oscillations per second, the effect in this particular circuit diagram in Exhibit 2 by the sharp peak curve, will be to produce only one per cent. of the current that would be produced by the signal to which the circuit is tuned. If, however, the signal which has only 60 per cent. of the tuned frequency, comes say from the Ottawa station, when a listener in Ottawa desires to receive a signal coming from New York or Chicago—some relatively distant point—it may easily be that the actual intensity of the signal as it approaches the antenna is 100 times or more greater than the intensity of the desired signal as it approaches the antenna. Should it be 100 times as great, then evidently the signal having only 60 per cent. of the resonant frequency would produce just as loud a noise in such a circuit—that is just as large a current and hence just as large a response in the receiving system of which that circuit is a part,—as though it had come in at the tuned frequency. And that is the problem that Alexanderson is referring to in the second paragraph quoted.

He says that while by constantly improving such circuit in respect of constantly minimizing its losses and constantly increasing therefore the height or intensity to which the current could build up by a resonant signal, and relatively minimizing the extent of building up by an out-of-tune or disturbing signal, nevertheless that process cannot be carried too far. There are various reasons why that cannot be carried to such an extent as will solve the problem. It is difficult to build into an actual radio set a circuit of very much better performance than that diagrammed in Exhibit 2, by the higher curve. If such a circuit by itself could be constructed it would hardly preserve that excellence when built into a receiving set, because the losses of a circuit subject to high frequency oscillatory currents are not, unfortunately, determined purely by the construction of the coil and condenser themselves, and, due to the very high frequency oscillation of the magnetic and electrostatic fields, losses are produced by all the surrounding matter. Metal causes losses due to induction, and insulating materials cause losses due to the electrostatic effects. Further, if such a circuit were feasible and were made so sharp that the distant signal could be received through such interference, it is still true that it would be impractical because it would be almost impossible to find the desired signal. The circuit would receive the desired signal only when absolutely precisely adjusted, which is extremely difficult.

Further, if the signal were obtained, it probably would not stay—to use a rather crude expression. That is, it is extremely difficult to maintain perfectly constant the frequency with which the signal itself is radiated. The high frequency wave which carries the voice, or the code, or the music, whatever it may be, does vary in frequency, and if exactly tuned at one moment, and the frequency varied, then it would be out of tune another moment in so sharp a circuit.

There is a further difficulty. Naturalness of reception, whether it be in speech or in code or in music, depends upon the impressing upon and modulating of the carrier wave by a wave of much lower or audio frequency having its own shape. I think it has been pointed out to your lordship that the sound waves of a simple sound—such as the letter " A " in " father," which I believe is musically the simplest of the speech sounds,—contains in the feminine voice some eight different frequencies, and in the masculine voice approximately twice that—and these frequencies must be carried by the carrier wave, and must be preserved in the receiving wave. This means that a wave which is too sharp at the point, at the top, will cut off some of those frequencies.

There are therefore many reasons, which the patentee refers to generally.

MR. SMART: Q. What would be the effect of cutting off some of those frequencies in that way?

MR. HENDERSON: Just before you answer that, will my friend pardon me for a moment? I do not desire to object, because I think your lordship will want to get as much information as you can; but Mr. Waterman has said that Mr. Alexanderson says so and so in the patent, and he just now says this is what the patentee refers to. That of course can only be his opinion.

HIS LORDSHIP: Oh yes, that is all.

MR. HENDERSON: I do not want to be objecting to that kind of evidence, as attempting to interpret the document. I do not understand that your lordship is taking it as interpreting the document at the moment?

HIS LORDSHIP: I have got to interpret it. He is giving his view of it.

MR. SMART: Q. Will you deal with the point mentioned, as to the effect of cutting off some of those frequencies belonging to the voice transmission?—A. Yes, I should have done that. The effect of cutting off some of the frequencies which are component parts in the message, whatever it may be, impressed upon the transmitter, is to make them sound unnatural. For example, let us assume we are doing as simple a thing as receiving a code message from a spark station. Those stations have their individual characteristics. With too sharp a circuit they lose their individual characteristics and one no longer recognizes the sound of the station he is receiving, even in continuous waves, when modulated for code signals. The modulation has certain characteristics. I have had no difficulty, for example, in reading the code signals of one station through another by recognizing the character of the modulation which was imposed. That is done, or that can be done, quite readily and telegraphers do it provided that there is not too great a discrepancy between the volume of the sound of the desired signal and that of the undesired signal. If the undesired signal is overpoweringly strong, of course it cannot be done. Then suppose music is coming in. It would be quite difficult or impossible to tell the difference between a flute and a violin if the width of the top of the resonance curve of such a circuit as I am considering, was too narrow; or to recognize the familiar characteristics of one individual's voice as compared to another; or to get the full mellowness of any piece of music, or the full impression of the effect of a speaker. In other words, distortion results.

HIS LORDSHIP: Mr. Smart, that paragraph does not seem difficult to me. I think the inventor merely states that you have a difficulty, or at that time had a difficulty in suppressing waves with a different wavelength to that of the receiving set.

MR. SMART: Yes.

HIS LORDSHIP: He says how it is done and he says he proposes a way of suppressing or improving that. The paragraph is very simple is it not?

MR. SMART: Then perhaps you might go on, Mr. Waterman, and state how Alexanderson proposed to obtain the selectivity which he describes in his patent Exhibit 1.—A. May I simply state that I understand that in the description of how Alexanderson proceeds, he is referring more particularly to the second one of the two difficulties mentioned in the paragraph above. The first refers to differences of frequency; and the second refers to differences of frequency plus great differences of volume; and I understand that the invention is addressed particularly to the last named difficulty.

Q. Now will you go on and state how Alexanderson proposes to overcome that difficulty.

HIS LORDSHIP: Does Mr. Waterman say the particular difficulty he had in mind was the production of weak wavelength as against stronger wavelengths?—A. Yes, my lord.

Q. That is in the last few lines of the third paragraph?—A. Yes, beginning at line 25 of the United States Patent, page 21, he then states that in accordance with the present invention, "selective tuning is securing by the use of a plurality of resonant circuits arranged in cascade in such a manner that the selectivity of the system increases in geometric ratio with the number of circuits employed."

Q. What is a resonant circuit?—A. A resonant circuit is one having one element which possesses the quality of mass, and that is what we call an inductance; and also possesses an element having the quality of elasticity, which we call a "capacity." So that a circuit having inductance and capacity is a circuit having a strongly developed tendency to oscillate at a particular rate.

Q. When you speak of a tuned circuit, that is one calculated to receive a certain wavelength?—A. Yes, my lord, and a tuned circuit is a resonant circuit.

MR. SMART: Q. Now, you are going on with your former answer?—A. Yes. He states: "The Selective circuits are respectively inter-linked by a relay controlling a separate source of energy to initiate oscillations corresponding to potential oscillations impressed upon the relay." And in the next few lines he points out in a very general way how that combination operates. The central thought, if I can put it that way, of that passage, to my understanding of it, is that of receiving oscillations in one circuit in the old way and causing the potentials built up in that tuned circuit to act merely as controlling means, not by giving up energy, but acting as controlling means only, to cause a repetition of the signal with energy drawn from an entirely new source. In other words, to initiate oscillations, a completely new signal, corresponding to the potential oscillations that were produced in the first circuit. And he proposes to do that with "a plurality of resonant circuits," repeating therefore a new signal as often as desired to effect the required number of successive selections. The emphasis, as I understand it, is upon the initiating of a wholly new signal, from a separate source of energy.

HIS LORDSHIP: Is it a new signal? Is it not an old signal modified or purified?—A. No, that is the distinction. It is literally a new signal, which is derived from a new source of energy. And that is the thought which he stresses at the outset, and the emphasis on which is maintained throughout the patent.

The signal which the second tuned circuit receives—referring, if I may, to say figure 2, which is as simple as any—which is received in the circuit 15, is a new signal, drawn from a new source of energy, but it is, as nearly as the perfection of the relay permits, identically such a signal as was received in the first circuit, just above the numeral 6—it has no actual numeral applied to it in figure 2. Ignoring interference for the moment, we assume a signal impressed upon the antenna 1 by the passage with the speed of light, of a signal past that antenna.

Q. What is 2? An induction coil?—A. 2 is an inductance coil acting in that case as the primary of an oscillation transformer. The received signal causes a current up and down in the antenna and therefore through the coil 2. The patentee points out that the association of the coil 2 with the coil at the right of it, just above the numeral 6 is very loose; so that the effects of the antenna 1 upon coil 6, I will call it, may be ignored. We then have repeated in the circuit 6 the signal received by the antenna 1. Now that is the same signal as was received; it is the same identical energy.

Q. There is no connection between the coils in 2? I see they are referred to as primary and secondary?—A. They are primary and secondary coils of an oscillation transformer and there is no physical connection between them. The connection is that of the magnetic field. The energy which appears in that secondary circuit, however, is the actual energy drawn from the passing wave. It therefore is the same signal as was originally received.

Now by the way of the wire 5 to the grid "g" in the tube bearing the Roman numeral "I," the potentials, that is the effective force set up in the secondary coil, are embraced between the grid "g" and the filament "c" of the tube. Those electromotive forces cause a variation in current of the battery 11 which is connected between the anode or plate element "a" and the filament.

Q. What is that you say it does in the battery element?—A. It causes a variation of the current flowing from the battery 11 through the interior of the tube by way of the anode or plate "a" and the filament "c." I have not yet described the operation of that tube.

Mr. Smart: You will do that later?—A. For the moment we will assume it. Those variations of current of battery 11 correspond to the varying potentials produced by the signal on the grid "g"; but they are entirely new signals. None of the energy received from the air is imparted to the circuit 15 or the circuit 12. That signal is a new signal, the energy for which comes wholly from the battery 11. Now that new signal will be a signal different from the received signal in that it has been purified to the extent that the circuit—comprising the secondary of the transformer which I have called circuit 6—is able to purify it.

This new signal existing in the battery circuit 11, is imparted through the magnetic field of the oscillation transformer—just under the numeral 10; and the resonant circuit 15 again acts cumulatively from this new signal, and builds up a current to a relatively great height for the desired signal and to a relatively low height for an undesired signal and so again selects that signal—or that selective effect, perhaps I had better say, although it carries the signal of course,—develops a high electromotive force in the oscillatory circuit 15; and that electromotive force is embraced between the grid " g " and the filament 2 of the tube bearing the Roman number II.

HIS LORDSHIP: Well now is there any distinction mechanically between the two circuits? That is where you end the primary coil 12 and where you begin with the secondary coil right above 12 and on to 18? There are two separate units. It is one continuous thing, I know, but is there any distinction mechanically or structurally between the two units? You pass secondary coil 12 and go through the condenser. You have your circuit, you have got your batteries, you have your filaments, your grids and plates, the very same thing again. Is there any distinction between the first and the last?—A. Not necessarily. There may or there may not be. That is a matter of choice of construction. The same sort of action goes on.

Q. That is in 1, 2 and 3?—A. Yes. The point is that the relay is interposed and new signal oscillations are initiated.

Q. By process of filtering?—A. No, those two are distinct. That is the point I was trying to make clear.

Q. The purification is going on?—A. Yes, each time the new signal is produced.

Q. I am using the words selection and purification as analogous terms. —A. Yes, quite so; each time there is a selection there is a repetition.

Q. In using the word signal do you distinguish? Is it being changed into what you call a signal?—A. No, I use those terms synonymously.

MR. SMART: That is when you get to the detector stage?—A. Yes, but not before.

Q. In each of those stages of purification or filtration is energy added under the Alexanderson arrangement?—A. Yes. None of the old energy is taken on but new energy is drawn from the local battery of the tube.

Q. That is the *b* battery?—A. Yes.

Q. Perhaps the point is not clear, but I might suggest that in each circuit the repetition is through a new source of energy, so that a new signal which corresponds with the old is initiated at each stage. Now did you wish to say something further?

HIS LORDSHIP: Do the batteries differ in strength?—A. The battery is selected with reference to a variety of things. They may differ in strength. The battery is selected for its amplitude to suit the qualities of the particular tube that is being used. It is selected in accordance with the amount of amplification that may be desired, and it is also selected with reference to making the repeated signal to accurately correspond to the selected signal applied to the grid of that tube.

Q. But normally they are the same?—A. Yes.

MR. SMART: That *b* battery, or battery which initiates the new oscillation, is of substantially higher voltage than the battery which heats the filament?—A. Yes. In such a tube as produced, the partly dismembered tube 201-a, it is quite customary to use from 67 to 90 volts on the plate circuit; that is corresponding to the batteries 11 and 17 of the Alexanderson patent, while the battery which lights the filament is ordinarily six-volt battery and the voltage actually applied to the filament is five volts.

In the Exchequer Court of Canada.

Plaintiff's Evidence.

No. 7. Frank N. Waterman. Examination —*continued.*

HIS LORDSHIP: As to the word cascade, what does that refer to?—A. The word cascade refers to such a seriatim connection of devices that the output of one connects to the input of the next and the output of that one to the input of the succeeding one. It is arranged seriatim. There is a little distinction made between cascade and series, but cascade means connection successively or seriatim.

MR. SMART: Acting like a cascade waterfall?—A. In a certain way—passing on something to the next.

Q. I was going to ask you to give us some explanation of the kind of incandescent lamp or vacuum tube described in the Alexanderson patent, if you have finished your previous explanation of the Alexanderson circuit.—A. I have just one further matter to add.

Q. Perhaps you will finish what you had to say on that, and then I will ask you as to the tube?—A. Another way of emphasizing the distinction which I was just dwelling upon between initiating a new signal and passing on the old or original signal is that the amount of signal so repeated is more or less under control. It may be repeated at the same strength as when received. It may be repeated in amplified form, and that, as has been pointed out, will be governed by the adjustment of the various batteries. There is a further point involved, namely, that if we were to attempt to pass a signal initially received, and successively purify or filter that signal, we would find ourselves confronted with two very unfortunate alternatives; either we must make the repeated signal progressively very much weaker or we will not purify it, but will introduce a fresh set of distortions which it never had originally, and I observe that that distinction has been already referred to in the opening address to your lordship by the expression "one-way coupling."

Q. You mean that connection in the Alexanderson method?—A. Yes, the connection in the Alexanderson device differs from the direct association of two tuned circuits in that it is essentially a device in which the first circuit selection is passed on to the second, the second is passed on to the third, but the second does not pass forward anything to the first nor the third to the second, which would disturb that selection. That is what I mean by one-way coupling. It is the sense in which I understand the term has been used by Counsel in his opening address.

Q. Now perhaps you will deal with the kind of electron discharge tube and relay referred to in the Alexanderson patent, Exhibit 1, and give us some explanation of how it operates?—A. The specification at page 1, line 47, refers to the relay preferably used. It is very brief and I will read it:

"The relay preferably used for this purpose is an electron discharge tube having an incandescent cathode, an anode and a grid."

HIS LORDSHIP: Is it claimed that Alexanderson invented this?

MR. SMART: Not the tube.

MR. HENDERSON: I think he makes it clear as he goes along that he leaves that to Langmuir. This is simply a tube, and in addition to that you will see that he says it is preferable. You will find the claim reads that it is preferable.

In the Exchequer Court of Canada.

Plaintiff's Evidence.

No. 7. Frank N. Waterman. Examination *—continued.*

HIS LORDSHIP: It was my impression he was not making a claim.

MR. SMART: My learned friend is just at the point—perhaps he might deal with that—as to what kind of relay his patent would disclose.—A. First, if I may call your lordship's attention to the fact that the figures of the patent show two different kinds of relay. Take sheet 1 of the drawing for example and your lordship will notice that in figures 1 and 2 each one of the tubes shown comprises such a structure as is definitely recited in the passage which I have just quoted. There is an incandescent cathode *c*; that is a cathode *c* which has a filament like that of an incandescent lamp, and which would be rendered incandescent when the battery *b* is properly connected to it. That tube has an anode marked *a* which is shown as a plate and which may be a plate. Its precise form is not of great consequence, and third it has a grid which is marked *g*, the same sort of structure is shown in figure 2. If your lordship will look at figure 3 you will see quite a different structure is shown. There you see the same evacuated bulb R and there is a filament or cathode element *c*. There is not merely an anode but there are two anodes, *a* and A^1.

HIS LORDSHIP: Q. There are grids around the filament?—A. No, they are quite separate, connected differently. There are two grids, *g* small and *g* small prime, and there is a third shielding element similarly surrounding the filament which perhaps your Lordship refers to. That is a distinct element not comprised in this description beginning at line 47 of page 1, and which is merely described in the first portion of the second column of page 3 of the United States patent and referred to as:

> "An additional grid 42 is used in this case, connected to the positive terminal of a source of electromotive force, such as a battery 43, the negative terminal of which is connected to the cathode *c*."

This grid element, it will be noted, is not connected to the receiving circuit at all. Furthermore there are two of what I may call normal grids, *g* and *g'*. There are two anodes, and the circuit connections are quite different. As I understand it the specifications express a preference for the form shown for Fig. 1 and Fig. 2. Of course, I have no knowledge of why this preference is expressed. I have tested the structure shown in Fig. 3. It performs extremely well, and I have no knowledge of the reason for the inventor's preference there. I think I had probably better call your Lordship's attention to the fact that the so-called grid audion or grid bulb is one of what I may call a family of bulbs. There were, for example, bulbs or audions, electric discharge devices in which, instead of having a grid element there were two plate elements, and one was used more or less to perform the functions of the grid, but it is not necessary really to have them in mind because the patentee describes two forms, and I assume he is choosing between them in his expression of preference. On page 1, line 75, referring to a tube produced by Irving Langmuir, he says:

> "This particular type of device operates with a substantially pure electron discharge, and comprises usually an incandescent cathode, and an unheated gas-free anode in a very highly evacuated space——"

I pause there for a moment to direct your Lordship's attention to the fact that he uses the expression "comprises usually."

HIS LORDSHIP: Is Doctor Langmuir connected with the General Electric Company?—A. Doctor Langmuir is connected with the General Electric Company. Mr. Alexanderson is in the Engineering Department and Doctor Langmuir in the Research Department.

MR. SMART: Mr. Alexanderson has some standing I think in the scientific world to-day?—A. Mr. Alexanderson, if one were to grade the men, stands very high in the engineering world in regard to this art. He has probably contributed more individual useful inventions to this art than any other man in it. At the time of this application he was a high frequency specialist, and known the world over for the remarkable development of the high frequency alternator. Practically all of present-day trans-oceanic telegraphy is done by inventions of Mr. Alexanderson.

Q. Will you go on with that?

HIS LORDSHIP: What is the name of the professor associated with Marconi? I think he is connected with the Columbia University?

MR. SMART: Doctor Pupin. Is that the name?

HIS LORDSHIP: Yes.

MR. HENDERSON: He is probably at the top, or near the top, of his profession on this continent.

*HIS LORDSHIP: The foreword in his book refers to Doctor Alexander*son.

THE WITNESS: I would like to say one word. I do not think Doctor Pupin is a radio engineer at all. He is a mathematician. His work is of great value and his work is of great value in long distance wire telephony. The advance in trans-continental telephony is largely due to Doctor Pupin in this sense, that the mathematical theory developed the possibility of doing such a thing was due to Doctor Pupin. Then the engineers developed the instrumentality.

The passage which I was quoting continues, line 80:

"The vacuum being so high that gas ionization by collision is substantially absent."

The reference there is to the very high order of evacuation of the air which Doctor Langmuir produced, and whose advantages he discovered, which are nowadays used in most of these tubes, and are used for example in 201-a tube. The electrons which are emitted by the heated filament under the influence of the *b* battery acquire very high velocity, perhaps even as high as a respectable fraction of the velocity of light, and if they strike air molecules or atoms on the journey from the filament to the plate, they are apt to disrupt them, producing therefore positive as well as negative charges by splitting up the atom. Each atom being split into a negative and a positive charge known as an ion and since the positive charges move more slowly than the negative ones, they have a predominant effect, which makes the operation of the tube less regular and less reliable, and in the passage which I have quoted Doctor Alexanderson expresses his preference as I understand it for the tube having the higher degree of exhaustion, so that gas ionization by collision—namely, by the collision of electrons with gas atoms—is substantially absent. These tubes therefore comprise the three elements recited in the highly evacuated Alexanderson bulb, and the qualities and the precise kind of performance that the tube will give depend upon the sort of filament; for example, that is the freedom with which it emits electrons and the number emitted at a given temperature. It depends upon the dimensions of the plate or anode element. It depends upon the construction of the grid element, how large the wires are, how close together they are, how many there are and how near they are to the plates. That in general is the device. I understand the patentee refers to his perfected form of relay.

HIS LORDSHIP: Q. You say the negative electrons move more rapidly than the positive electrons?—A. Yes.

Q. Is that an accepted fact?—A. Yes.

Q. And can you give a reason for that?—A. It is quite impossible to give a reason. It is an accepted fact.

MR. SMART: I think the negative move the faster.

THE WITNESS: I do not know which way your lordship put it but the negative move the faster.

HIS LORDSHIP: I thought you stated it the other way.

THE WITNESS: The negatives move the faster. The negatives are very light. An electron—that is a negative charge—has the weight of about one-eighteenth hundredth part of the weight of an atom of hydrogen which is the lightest atom.

The air atom—it might be an atom of any one of the constituents of the air, of course, but taking it to be an atom of oxygen whose atomic weight, if I remember rightly, is 16, therefore when an electron is knocked off such an atom leaving the atom with a positive charge, evidently its weight would be sixteen times eighteen hundred times as great as that of the negative charge, the electron. Therefore it is evident that the same force would in the small distance between the filament and the plate not get up anything like so high a velocity in the enormously more massive ion.

HIS LORDSHIP: So that it is weight then that determines?—A. Yes, sir.

Q. Not the electrical content?—A. No. The positive charge produced by such simple disassociation as I have spoken of would be equal but opposite to the negative charge spit off from it; but since the tendency to move in the same given electrostatic field would be only proportional to those charges, and therefore would be alike in the two, it is evident that the acceleration produced in the heavier element would be very much less than in the lighter one.

MR. SMART: Perhaps you will explain shortly the action of a three electrode tube as a one way repeater, but in the way it is used in the Alexanderson patent, Exhibit No. 1?—A. These tubes may function in many ways. The Alexanderson specification refers to the functioning of the tube as a repeater to, as he says, initiate a new signal. The fundamental action of the tube is the emission of negative electricity by the filament, and the flow of that negative electricity to the plate A, the force causing it to flow and the energy involved being furnished by the battery 11. Now, the grid element *g* interposed between those two is given an initial polarization by a battery 9 which is connected in the wire 5 leading to the grid. By properly proportioning the batteries *b* 9 and 11, the operation of the tube is controlled. When an electromotive force from, say, the tuned circuit associated with the antenna is impressed upon the grid, the electrostatic field or the electrical effect produced by the battery 11 between the plate or anode *a* and the cathode *c* is modified, and the relation is such —I think we will have to take it as a physical fact without undertaking to explain the theory—that the modification of the electrostatic field between *a* and *c* by an electrical potential applied to *g* will with a proper adjustment be such that the variations in the strength of that current caused by the battery 11 will correspond to the variations in potential impressed upon the grid *g*.

We might, for the purpose of the rough analogy, look upon the battery 11 as a pump, and the bulb I as a valve, and the wires connecting the anode *a* and the cathode *c* as pipes, and the grid element as a shut-off gate normally set so that a certain flow of water, due to the pump 11, is continually taking place.

Now if we look upon the signal as something capable of moving the gate or valve, element *g*, up and down, the current of water flowing in response to the efforts of the pump through the valve element would vary. Yet the energy involved in that stream of water would be wholly derived from the pump 11. That is very crude.

His Lordship: That does not differ from 9 and *b*, in any way, does it?—A. Only that it may have a greater voltage.

Q. Has it in practice a greater voltage?—A. Yes, in practice battery 11 has a much higher voltage than either of the other two.

Mr. Smart: Q. You might mention the order?—A. It depends upon the tube somewhat. Taking 201-a for example, if the battery 11 has a voltage of 90 volts, then a tube used in the capacity of the tubes I and II, in figures 1 and 2 of the Alexanderson patent, battery 9 would have a voltage not to exceed about 4½ volts, whereas the voltage of the battery *b* is determined by the size of the filament and is merely a matter of how much current is required to heat that filament up to a favourable degree of electron emission; and the actual voltage used on such a tube is nominally five volts, but may be anywhere from four to a little over five in practice.

Referring to the mode of operation of the tube, I think the analogy which I have just used is sufficient to give a fair picture of what happens; but of course the electrons which are being dealt with there are substantially imponderable. In water you have a good deal of mass, and therefore water could not respond in any way to such very high frequencies, and therefore we must not be misled by such an analogy. An analogy is a very dangerous thing if pushed beyond its proper application; and therefore I do not desire for a moment to be understood as saying that the pump and water flow analogy, which I just gave, has any application to radio frequencies. But it does give a picture of the sort of action that is involved. And when the batteries are properly proportioned, a very true repetition of the signal may be obtained in the output circuit, that is the B-battery circuit. I may say that in our common terminology, in using these tubes, we refer to that circuit which is connected between the grid and the filament as the input circuit, while that circuit which is connected between the plate and the filament we commonly refer to as the output circuit; the input being that which controls but does not contribute to the output.

MR. SMART: Before putting the next question to Mr. Waterman, I wish to file the consent dealing with question of infringement and other things.

EXHIBIT NO. 4.—Filed by Mr. Smart, Jan. 11th, 1927. Consent re question of infringement and other things.

MR. HENDERSON: Do you want to read from it?

MR. SMART: Yes.

HIS LORDSHIP: Why do you want to put it in here?

MR. SMART: I am now relying on a paragraph in it dealing with the question of what the defendant did. I will read the paragraph in question. It is a consent applied generally to each of the cases.

"After the date of issue of each of the patents in suit and before the institution of any actions the defendant manufactured and sold in Canada radio receiving sets employing the circuit arrangement shown on page 13 of and described in a certain booklet entitled 'How to Build Hazeltine's Neutrodyne Circuit Receivers,' such booklet having been delivered to the solicitors for the plaintiff by the solicitors for the defendant on or about the 30th of November, 1925, and identified for the purposes hereof by the admission of said solicitors."

And I have the copy of the booklet which I offer as exhibit No. 5.

EXHIBIT NO. 5:—Filed by Mr. Smart, Jan. 11th, 1927. Booklet entitled How to Build Hazeltine's Neutrodyne Circuit Receivers.

Then the next paragraph of the consent deals with the radio receiving set which was submitted to Mr. Waterman in New York for examination, and which is in court to-day; and I will ask my learned friend to be good enough to produce it.

MR. HENDERSON: It is on the window-sill. I was going to suggest, as it is rather clumsy for Mr. Waterman to have the papers on his knee, that it would be well to have a table put there for him. Then exhibit No. 6 will be the radio receiving set.

EXHIBIT NO. 6:—Filed by Mr. Smart, Jan, 11, 1927. Radio receiving set.

MR. SMART: I want to show your Lordship some of the inside of this set before the witness talks about it. (Indicates parts in the set to his Lordship.) I will leave the model before your Lordship, as Mr. Waterman has a diagram.

Q. Mr. Waterman, have you examined the defendant's set, exhibit 6, as well as the diagrams and descriptions contained in exhibit 5?—A. I have.

Q. Will you explain to his lordship the construction and operation of the defendant's set ?—A. The set which has been marked exhibit 6 is substantially that which is diagrammed in exhibit 5 on page 12 thereof, and of which I have an enlargement more easily read.

MR. HENDERSON : I think you mean page 13, Mr. Waterman.—A. Page 12 in this book which was furnished to me.

MR. SMART : This is an enlargement of page 13 of the booklet, exhibit 5.

WITNESS : Then change 12 to 13.

MR. SMART : The enlargement of page 13 of exhibit No. 5 will be exhibit No. 7.

EXHIBIT NO. 7:—Filed by Mr. Smart, Jan. 11, 1927. Enlargement of page 13 of booklet, exhibit No. 5.

MR. HENDERSON : Apparently there are some differences in these, Mr. Smart. Your photostat is taken from the one which Dr. Morse had.

MR. SMART : That is the one with respect of which he is giving his evidence, so that it is all clear. The witness is making a little change in the drawing, which will be put in the copies.

Q. Can you produce a simplified diagram of the defendant's circuit, omitting the audio amplifiers and using the same electrical symbols as used in the Alexanderson patent, exhibit No. 1 ?—A. Yes, I have such a diagram marked " Diagram of Defendant's Circuit omitting audio amplifiers."

EXHIBIT NO. 8:—Filed by Mr. Smart, Jan. 11, 1927. Diagram of Defendant's Circuit, omitting audio amplifiers.

Q. Will you proceed with your description of that portion of the defendant's structure related to what is described in the Alexanderson patent ? —A. I should state that exhibit No. 8 omits the actual convention for the batteries and the complication of wires which is found in the diagram exhibit No. 7. Otherwise it shows substantially what is on that diagram. Viewed or read from left to right, the elements correspond to those located from left to right in the set, exhibit No. 6. At the extreme left in the set will be seen some green wire coils wound on black tube supports and inclined at an angle. Those coils comprise the primary and secondary coils.

HIS LORDSHIP : This structure comprises both ?—A. Yes, one within the other.

HIS LORDSHIP : In that respect it is a little different from the drawings we have seen.

MR. SMART : The drawings would diagrammatically indicate the one coil within the other.

WITNESS : It is very confusing if we try to draw one over or inside the other. It is usually shown in this conventional form which is used. It is an induction transformer the transformer at the extreme left in exhibit 8 therefore corresponds to that green wire coil on black spools, shown at the left of exhibit 6. I have indicated in exhibit 8 by dotted lines the antenna that would be connected to the antenna terminal; and a similar dotted line indicates the ground connection, connected to the ground terminal of the set.

The primary coil in the set has two terminals, which I have indicated by circles, and those two terminals are, if my memory serves me correctly, marked " Ant " and " Gnd "; and in exhibit 7 they are in the extreme lower left-hand corner. The secondary of the transformer is connected to a condenser, indicated in exhibit 8 by inter-leaved lines, corresponding to condenser 8 in figure 1 of the Alexanderson patent.

That condenser is connected to the left hand dial on the front panel of the set, Exhibit 6; and the capacity variation indicated by the arrow across the condenser 8 in the Alexanderson patent is obtained by turning the handle—your Lordship will observe that turning the dial at the extreme left causes moveable plates to enter more or less between the fixed plates —that circuit constituted by the secondary of the transformer and the condenser is a resonant or tuned circuit which takes the signal received by the antenna; everything which comes into the antenna is transferred over into this tuned circuit with greater or less purification, and the circuit selects those that it will cumulatively build up. It cumulatively builds up those waves which come in tune with it; that is, whose number of waves per second corresponds to the number of oscillations per second which the circuit adjustment, would cause it to naturally have. The grid element of the first tube, the socket of which your lordship will see at the left on the back side of the panel.

Mr. Smart: The tube is in that?—A. The grid of that tube is connected to one side of this tuned circuit as in the Alexanderson patent. Perhaps it would be well, Mr. Smart, if I put the letters of the patent on here as I go along?

Q. Yes, I think as you go along. I have a crayon here if it will suit you better.—A. The filament being lighted by what we customarily call the " A " battery—terminals for which are provided and shown on Exhibit 7 at the bottom of the sheet marked " 6V." And underneath it " A " battery and with the symbols plus and minus, is in the Alexanderson patent indicated by the letter " b," and I have put the letter " b " underneath the letter " A " on Exhibit 8.

Between the anode " *a* " and the cathode " c " there is connected a battery ordinarily known as the " B " battery, which in the Alexanderson patent is designated by the numeral " 11 " and I have accordingly put the number 11 adjacent to the letter " B." These terminals are seen in the lower line and are marked " B " battery. The effect of so embracing the signal received in the tuned secondary circuit of the input transformer is to cause the current furnished by the B battery 11 through between the anode and the cathode, to vary in accordance with the electromotive forces developed in the tuned or resonant input circuit 8. Thereby the signal is repeated through the coil 12 which is the primary coil of the second transformer.

Mr. Smart: That being in the model?—A. Being in the model the inner member of the second set of green coils, the second from the left, which are wound on black spools.

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Plaintiff's Evidence.

No. 7. Frank N. Waterman. Examination —*continued.*

Associated with the primary 12, is the secondary, this transformer being in all respects similar to the first one, so far as I remember, and being similarly tuned with the condenser 15, as in the figures of the Alexanderson patent. This condenser 15 is that controlled by the second dial from the left as one faces the set, Exhibit 6. The thus repeated signal initiated by the first tube is selected by the second tuned circuit, comprising the secondary of the transformer and the condenser 15. That is it is filtered and the second selection is thus made, in which elimination to a greater extent than had been effected in the first circuit, in geometrical progression, is effected. And the electromotive force so generated is impressed upon the grid of the second bulb to which the numerals II are applied. This bulb is like the other in having cathode " c," anode " a " and grid " g " and operates in the same way to repeat and initiate a new signal by means of a battery " B " corresponding to the battery 17 in the Alexanderson patent.

In this plate circuit of the second tube a new signal is initiated and passed on to the secondary of the third transformer, which is number 3 from the left as your lordship faces the set, and that secondary is in identical manner—

His Lordship: Passed on by induction?—A. By induction as in each case, and in identical manner that secondary is tuned to resonance with the desired signal by the manipulation of the condenser 19, and from this newly initiated signal a circuit 19 again makes a selection and thus again geometrically altering the ratio between the desired and the undesired components of the antenna reception.

Thus, as the patent states, while the circuits are increased arithmetically, in 1, 2, 3 order, the selectivity increases geometrically, taking the illustration which is set forth at great length or at considerable length,—I have not called your lordship's attention to it, but it is found beginning at line 36 on page 2 and extends well, it may be substantially completed at line 117 of page 2. That describes what is meant by "geometrical progression." If, for example, the first circuit permits the development of currents due to the desired and the undesired signal, only in the ratio of 10 to 1, then the second circuit will permit their development in substantially the ratio of 100 to 1, and the third circuit will permit their development in substantially the ratio of 1000 to 1. Of course these are figures chosen merely for illustration. If the first circuit determined a ratio of 100 to 1, and the second determined a ratio of 100 to 1, then the result of the first two steps would be 10,000 to 1. Or if the first circuit determined the ratio, let us say of 20 to 1, and the second a ratio of 50 to 1, then the combined effect would be in a ratio of 1000 to 1. That is in general what geometrical progression means here. It means that we come out with a product rather than a sum in the matter of the selectivity ratios.

Mr. Smart: Then what would you say is the method of selection used in the defendant's receiver?—A. It is successive selection by repetition, the selectivity progressing geometrically; while the number of circuits and the selection of each circuit progresses arithmetically.

Q. Now perhaps you will make some comparison of the means which are disclosed in the Alexanderson patent for effecting that selectivity with

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Plaintiff's Evidence.

No. 7. Frank N. Waterman. Examination *—continued.*

the means which you find used in the defendant's structure?—A. The means are identical. We have, as it so happens, a succession of three transformers with their secondaries tuned by condensers, the first one loosely associated with an antenna; the first and second being connected only through a one way coupling, which one-way coupling is an audion or three element electron discharge such as the patent refers to; the second and third are similarly tuned or resonant circuits such as the patent discloses, and they are connected by a one-way coupling relay, which is the same sort of three element tube; and the output of that tube is again selected in a third resonant circuit as shown in figures 1 and 2, for example, of the Alexanderson patent. And its final output of this third circuit is taken to a third tube, which tube is arranged to act as a detector in substantially the manner shown in figure 2 of the Alexanderson patent; and the final output which is only indicated in this diagram, but which is fully shown in Exhibit 7, is passed through audio frequency transformers, where all of the frequencies so detected are supposed to be uniformly amplified to produce a faithful reproduction of the original message impressed upon the radio frequency wave at the transmitting station.

Q. Now I observe in the diagram something that you have not yet referred to, and that is these condensers on the upper part which are connected to the succeeding transformers?—A. Yes, I was about to call attention, and I will if I may, to certain differences that exist as for example the battery "g" is not found in this diagram. These tubes are so constructed that they may be used by impressing the grid with the voltage of the negative terminal of the A battery; and although they may perform somewhat better if given a slightly more negative voltage than that, they perform very well, and are intended to perform well when so connected.

The Exhibit set contains condensers which on Exhibit 7 are marked "neutrodons," in parenthesis, and also "Neutralizing capacities." Those are shown as small condensers just above the grid of each tube. These tubes 201A tubes, are quite powerful amplifiers. That is to say they may be used to give quite powerful amplification, and if that amplification is taken full advantage of in the circuit arrangement of these tubes, they are likely to amplify to such an extent as to set up automatic oscillation, as we call it, of the tube itself. In order to prevent that oscillation, these condensers are connected from what we call a "See-saw" arrangement, in the output side of the tube, back to the grid element 5, so as to prevent such oscillation. It is a means, in other words, which permits a tube of powerful amplifying properties to be employed in obtaining this geometrical progression, so that not only is the selectivity obtained but the amplification is the greatest that the tubes are capable of giving in such a circuit.

Mr. Henderson: That is the subject matter of the other patent?—A. Yes.

Mr. Smart: No, not of the other Hazeltine patent.

Mr. Henderson: Mr. Waterman agrees with me.

The Witness: The subject matter of these other patents that are involved in these various cases, namely the Hartley & Rice.

Mr. Henderson: The subject matters of the other three patents?

Mr. Smart: No, I entirely disagree.

His Lordship: What are the remaining three tubes in the model? —A. The three tubes counting from the left? May I take a look? The remaining tubes which are at the extreme right as one faces this set, are the audio frequency amplifier tubes.

Q. They have nothing to do with the selectivity?—A. Nothing whatever to do with the selectivity.

Mr. Smart: I can have them described if your lordship wishes, but I think it is simpler to leave it as being the audio end of the receiver, with which we are not presently concerned.

His Lordship: Just what is the function of the amplifying tube if that is what you call it? These three last tubes.

Mr. Smart: The audio frequency tubes.—A. May I perhaps define the tubes seriatim beginning at the left. The first tube beginning at the left is a repeater tube; the second is a repeater tube; the third is a detector tube, which so to speak de-modulates. I explained to your lordship that at the transmitting station the thing first generated is simply a high frequency continuous wave, or sustained oscillation. Upon that is impressed by way of modulation, a message. When the signal so sent has been received and properly filtered in the receiving set by the action of the first three circuits, into which the so selected signal is repeated, then it becomes necessary in order that we may get the original message, to take out the radio frequency. The radio waves merely carry it. We do not want those. They are of no use.

Q. You eliminate what you call the carrier wave?—A. Yes, we eliminate the carrier wave.

Q. You leave that out altogether?—A. Yes. That is done by the detector. Therefore the function of the detector is to transform back from that high frequency to the low frequency that the original voice, telegraph key or what not, had at the transmitting station. Now the fourth tube in the Exhibit 6 takes that audio frequency out-put. It is now like any telephone message; and amplifies it just as do the similar tubes in our present day long distance telephony tube. If your Lordship telephones to San Francisco or Vancouver, or some western point, the present day method is to repeat the signal at one or more points. Radio does not enter. There is no radio frequency. This combination of the last two tubes in this receiver Exhibit 6, is merely such an ordinary telephonic repeater. They are put in there in order that the signals may be amplified to a suitable volume, for example to be useful in operating a loud speaker. So in making Exhibit 8, I omitted those tubes which do not correspond to anything shown in the Alexanderson patent.

His Lordship: We will adjourn now until half past two. Hereafter we will resume in the mornings at 11 o'clock, and in the afternoons at a quarter past two and adjourn at a quarter past four.

Mr. Smart: Q. Has the Alexanderson system of electric tuning as described in Exhibit 1 been used in commercial radio receiving sets?—

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No. 7. Frank N. Waterman. Examination —*continued.*

A. Yes, very extensively. I would say I am familiar with a large number on the market at the present time, and I would say that it was substantially the universal method of reception to-day.

MR. HENDERSON: I have, my lord, a photostat enlargement of Fig. 1 of the Alexanderson patent. It is sometimes more convenient to follow than the patent itself.

EXHIBIT No. 9:—Filed by Mr. Smart, Jan. 11, 1927. Photostat enlargement of Fig. 1 of Alexanderson patent.

It is an enlargement of the drawing. Then I have a photostatic enlargement of Fig. 2 of the patent which will be easier to follow than the larger diagram:

EXHIBIT No. 10:—Filed by Mr. Smart, Jan. 11, 1927. Photostat enlargement of Fig. 2 of Alexanderson patent.

Cross-examination.

CROSS-EXAMINED BY MR. HENDERSON:

Q. You gave your place of residence as Summit, New Jersey?—A. Yes.

Q. Am I right in understanding that that is practically a purely residential place?—A. Yes, the usual character of suburban town.

Q. Mostly inhabited by people who have business in New York?—A. I do not know what the proportion is.

Q. But there are no electrical works of any kind there?—A. No, except the local electric light plant.

Q. No radio broadcasting?—A. Not immediately in Summit. There is some very close to it.

Q. You are not connected with anything electrical there?—A. I am not connected with any electrical activity in Summit.

Q. I gather that for some years your time has been fully occupied in giving expert or opinion evidence in different litigation?—A. Yes and no; only a very small part of my time has been employed in the giving of evidence.

Q. In the preparation?—A. But my time has been quite largely engaged in matters of one kind and another growing out of patents.

* *sic ?*

Q. And of course these cases *quest require considerable preparation?—A. Some of them.

Q. Conferences with uninformed lawyers very often?—A. Yes.

Q. And conferences with other expert witnesses?—A. Sometimes.

Q. It is not very desirable as a rule that you should agree?—A. I accept your statement.

Q. I notice, for instance, you gave evidence in the month of September, 1915, in the case of the Marconi Company vs. Kilburn and Clark. You recollect that case?—A. I remember the case but I could not tell you the date.

Q. I see that in that case you stated that during the past eighteen years you have very often testified as a witness in litigation involving infringement of letters patent for invention, and have been called upon to compare the device and electrical apparatus with patents, and to pass upon the commercial value of the same?—A. Yes.

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No. 7.
Frank N. Waterman.
Cross-examination —*continued.*

Q. I want to identify a few cases so that we will not have to go into detail when we come to them. You also mentioned the case of the Marconi Wireless vs. National Signalling Company?—A. I recollect there was such a case.

Q. What was then the Marconi Wireless Company is now included in what we know as the Radio Corporation of America, is it not?—A I am not informed as to that.

Q. That was a suit on the Marconi patent No. 763,772?—A. Which one are you speaking of?

Q. Marconi No. 763,772. I think you are familiar with it.—A. I think so. If I have the right patent in mind it was one of several patents that were involved in the litigation Marconi vs. National.

Q. You mentioned also—I take it only because it is in the same quotation—a case brought by the Marconi Company against DeForest in the United States district court for the southern district of New York?—A. I remember there was such a case.

Q. And you were in it?—A. I am not certain whether I testified in it.

Q. You say you were retained and made affidavits in it.—A. I think that is the fact. I had no part except making the affidavits.

Q. I think your evidence was an affidavit in that case?—A. I don't remember.

Q. Not very long ago there was an action brought by the Radio Corporation and others against Grebe?—A. Yes, that was one of the defendants.

Q. There were several defendants. You were in that case for the Marconi Company; that is the Radio Corporation?—A. I was in one such case.

Q. When was that?—A. It was tried week before last or thereabouts.

Q. And it is a fact is it not, probably a tribute to your ability in this regard, that for quite a number of years past your time has been very fully occupied with that class of work?—A. Would you mind defining what you mean by "that class"?

Q. I have to use an expression I think you will understand which I myself do not like—experting cases. You understand what I mean by that?—A. Yes, I have been engaged in a number of such cases.

Q. And I think I may pay you the compliment of saying that you are uniformly the leading expert on your side. I intend that to be complimentary.—A. I do not know what you mean by that.

Q. You are in the van here. I do not see that the witness blushes and I think he understands what I mean.—A. No, I do not.

Q. May I say generalissimo of the forces? There are generally some generalissimos in the more important cases, are there not?—A. I do not think I know what you mean. There are, of course, more or less professional men connected with cases, lawyers and technical men.

Q. And in these cases there is generally some one expert who takes the lead?—A. Only in the sense that there is some one expert who usually gives the evidence.

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Plaintiff's Evidence.

No. 7. Frank N. Waterman. Cross-examination —*continued.*

Q. Who is looked upon to assume the burden of the fray?—A. So far as the giving of evidence is concerned.

Q. Let me illustrate. Take the year 1926. Would you be good enough to tell me the different cases in which you gave evidence? I do not mean exclusively patent cases. By the way did you give evidence in any other case?—A. No.

Q. Purely patent cases?—A. Yes.

HIS LORDSHIP: Are you restricting it to radio?

MR. HENDERSON: No, I would like a year's experience.—A. I could not tell you Mr. Henderson, without looking the matter up.

Q. I do not want them in absolute chronological order. You were in several cases in 1926, were you not?—A. I really could not give you the list.

Q. I do not want an absolute list.—A. I think I can tell you the radio cases——

Q. I do not want to confine you to strict accuracy. Tell me the radio cases to start with.—A. If I remember, I acted in three radio cases in 1926, the calendar year.

Q. What were they?—A. One was Radio vs. the Twentieth Century and another was Radio vs. Splitdorf.

Q. You mean the Radio Corporation of America?—A. Yes.

Q. I think you mentioned the Grebe case?—A. Yes.

Q. That is also the Radio Corporation?—A. Yes.

Q. What others?—A. I cannot remember now the titles of the other cases.

Q. There were others?—A. Not radio cases.

Q. What other patent cases were you in?—A. I am afraid I cannot remember. I would be glad to tell you if I could.

Q. I would have thought you had a very accurate memory.—A. I try to remember those things that are important for me to remember and I rely on my memorandum for those things which it is not important that I should bear in mind.

Q. You have given His Lordship a very splendid exposition on the outlines of radio depending very largely on memory, have you not?—A. Well, I have been in these matters for years.

Q. Can you not tell me some of the other cases you have been in? —A. No, but I can ascertain them for you and let you know before the end of the trial.

Q. During the last year, subject to the usual days of relaxation which any man needs, has your time all been fully occupied with the class of work you are doing to-day?—A. I should think about half of it.

Q. Are you limiting it now to radio when you say half of it?—A. No. I assume by the class of work I am doing to-day you mean either the preparation for or the engagement in trial.

Q. Perhaps we might as well understand one another. I know that you have a very analytical mind and very readily differentiate. I am dealing broadly with the giving of evidence in patent cases including the preparation for them in the broad sense; that is the time that you could fairly say was devoted to your client's interests?—A. Yes, I think that

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I could fairly say that all of my business time is devoted to my client's interests, but not by any means all of it has to do with either preparation for or engagement in trial.

Q. You have said broadly that you were a consulting engineer ?— —A. Yes.

Q. And I am talking now on that branch of the activity of Consulting Engineer, which has to do with litigation, preparing for and taking part in trials ; what proportion of your time for the last twelve months would you say was taken up in that way ?—A. I should think about one-half, but I cannot be certain of that.

Q. Could you give me some idea of the number of cases other than radio cases that you took part in during the past year ?—A. I think there were two, but I am not sure.

Q. Concerning what ?—A. I do not distinguish them in point of time. I will be very glad to find out for you but I simply do not know now.

Q. What kind of patents in a layman's language, were these ?—A. I do not know.

Q. I happen to know of one that came to my notice.

His Lordship : I do not object to your leading if that will help.

Mr. Henderson : There was a roof shingling case ?—A. Yes.

Q. You remember that case ?—A. Yes.

Q. I do not know whether there was an antennae on the roof or not. You were concerned with shingles not with the radio ?—A. I was concerned with the machine.

Q. And it was not on the roof ?—A. No.

Q. Can you locate what the other case was ?—A. No.

Q. You are, are you not, under a general retainer from the Radio Corporation of America ?—A. I am not.

Q. Were you ?—A. I never have been.

Q. Are you in a position to take on other work, electrical work, particularly radio work, without some arrangement with the Radio Corporation of America ?—A. Yes. Of course, where I have been in confidential relation with any client I do not take a case which that client thinks would involve possible violation of those confidences.

Q. Like a lawyer in that regard ?—A. I should say like any gentleman.

Q. That is it is a matter of evidence with you ?—A. Purely.

Q. But you have been as a matter of fact in all the radio cases for some time ?—A. I am not in a small part of them.

Q. Only in the more important ones ?—A. Oh, I do not think you could say that at all. I certainly am not in that position.

Q. I am talking of radio cases.—A. Oh no, I am not in more than a small part of the cases of the Radio Corporation of America.

Q. But I am talking now of the cases involving the validity of their patents, and their effects on other patents. Do they not consult with you and rely on you generally ?—A. Oh, no. I have no such relations with them.

Q. Do you not consider you have a general retainer from them in that regard.—A. Absolutely no.

Q. No written agreement ?—A. No agreement either written or verbal.

Q. Coming to the Alexanderson case I see that you there spoke as you spoke to-day, of having had a very extended acquaintance with the Alexanderson patent—what we call the Alexanderson patent. A. I do not recollect making any such statement. I perhaps do not understand just what you mean.

Q. You have told us that in the American Splitdorf suit you acted for the Plaintiff?—A. Yes, I did.

Q. And that was an action on the Alexanderson patent against the Splitdorf Company?—A. Yes.

HIS LORDSHIP: It is the same suit.

MR. HENDERSON: It is the same suit, but there was this distinction; Mr Waterman, since you know about the suit, that in that case the Splitdorf Company did not pretend to be operating under the Hazeltine patent? —A. So far as I know they did not.

HIS LORDSHIP: All I meant was that the Alexanderson patent was involved.

MR. HENDERSON: The Alexanderson patent was involved, but the record as it developed was in an entirely different position. The Defendant in that case was not in a position to allege any other rights and was between the devil and the deep sea as it were. That will appear perhaps later. In that case you did speak of your familiarity with the Alexanderson patent, the Alexanderson arrangement?—A. Yes, I testified that I had read the patent and understood it, most certainly.

Q. And more than that was it not, that you had worked it out. Would you like me to give the precise quotation?—A. I certainly was very familiar with the patent.

Q. Explain now when you first commenced work on the Alexanderson patent. I do not want the date. I gather that you had done a good deal of work on it, experimentally and otherwise, extending over a considerable period of time.—A. I could not give you the date. There was a suit brought which I knew as the Pathe. It was brought by the Radio Corporation under the Alexanderson patent, against a corporation whose name I do not know, but I know as to the Pathe case, and I took the Alexanderson patent and made a good many tests on the Pathe receiver. The case never came to trial as the Defendant settled.* In the Splitdorf record at page 454 I find the following:

* *sic ?*

> "Q. You are reasonably familiar with the operation of apparatus of the type shown in the Alexanderson patent, are you not?—A. Yes, I am very familiar with it."

Then the next question reads:

> "Can you say whether or not the normal design of an apparatus of this type is such that the resistance of the plate circuit is higher or lower than the resistance of the grid circuit?—A. I can only say this, your Honour, I have personally designed and built those Alexanderson oscillation transformers in widely different constructions. I have never yet paid the slightest attention to whether the resistance of the coil which is to be connected into the plate circuit

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No. 7. Frank N. Waterman. Cross-examination —*continued.*

was greater or less than the resistance of the coil to be connected to the grid circuit."

That is at page 455 of the testimony. You say you have personally designed and built those Alexanderson oscillation transformers in widely different constructions?

Q. Later on in cross-examination you indicate that you have a very extensive knowledge of Alexanderson?—A. I think you confuse two things that are separate in my mind. I have quite a wide familiarity with the operation of apparatus of this general type which I conceive to be such as is disclosed in the Alexanderson patent in its operation commercial and experimental.

Q. Was that what you meant when you said:

"I have personally designed and built those Alexanderson oscillation transformers in widely different constructions."

A. Yes.

Q. Did you not intend to convey to the Court that you had a personal familiarity with the design and construction of the Alexanderson device? —A. That does not mean anything other than such transformers as would be suitable to carry out the Alexanderson invention as I understand it, and in that sense, yes, I know the apparatus that is on the market, and I have myself constructed a good many transformers in that line.

Q. We may tie that up with the last answer you gave Mr. Smart but I take your opinion that the Alexanderson device is used in a very general way for commercial purposes to-day.—A. Almost universally.

Q. And you may almost eliminate the word "almost?"—A. I stand on my statement.

Q. That is to say that practically all commercial receivers to-day have geometrical selectivity with relays?—A. A very large proportion of the different makes on the market, yes. As to the actual numbers in use I could not undertake to say because there are vast numbers of types and sets in use.

Q. I suppose a great many people are still very old fashioned?—A. Well, you see the art has grown with great rapidity. The need for more and more selective receivers has correspondingly developed, and there has been an abandonment of other forms and adaption of the Alexanderson form.

Q. Of course, you can still go into some of the larger shops and buy some pretty antiquated sets at cheap prices, but you are referring to the receivers now being manufactured generally?—A. Yes.

Q. When you say that as a rule they have geometrical selectivity with relays?—A. Yes.

Q. Now getting down to just what that means, you carry your acquaintance with the Alexanderson as it developed during the progress of the art?—A. I do not think I got the meaning you intend to convey.

Q. I am trying to explain the evidence you gave in the Splitdorf case and to get my understanding of your position.—A. If you will read it to me I will be glad to explain it.

Q. I take your evidence in the Alexanderson case to mean that you have been in close touch with the Alexanderson device both theoretically

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and practically for a very considerable period of time. You tell me now I was wrong. You tell me now, as I understand it, that what you meant to say there was that Alexanderson is almost universal and that when you see a radio receiving set you see Alexanderson? Is that right.—A. I have not said anything of the sort and I would like to know whether when you say Alexanderson you mean Doctor Alexanderson personally?

Q. No. I have read from the statement of no less important a gentleman than Frank N. Waterman speaking of so-and-so as the short way of referring to invention or the alleged invention that is in question, and when I say Alexanderson I mean the Alexanderson alleged invention, I would call it in this litigation.—A. What I meant in the statement that you quoted from the Splitdorf record was that I have been for some time familiar with receivers embodying this idea of successive selection by repetitions—and that is the fundamental thought as I understand it of the Alexanderson patent—it is true that in the receivers at the present time a larger percentage of different makes will be found to be built in that way.

Q. Of course, you would not dream of saying anything that would mislead at that time?—A. Certainly not.

Q. His Honour, Judge Bodine, was the presiding judge in the Splitdorf case?—A. Yes.

Q. I suppose you have read his judgment?—A. You mean what we call his opinion?

Q. Yes. We call it a judgment, or reason for judgment.—A. Yes.

Q. Did you not convey to him the impression that you were thoroughly familiar with Alexanderson?—A. Well I hope I did.

Q. And you endeavoured to both practically and theoretically?—A. Why, I think so. I do not know what limit you give to those terms.

Q. You say, "I have personally designed and built those Alexanderson oscillation transformers in widely different construction." Did you not desire to give him the impression that you had done just what those words say?—A. Certainly.

Q. And extending over some period of time?—A. Well, I do not think that I had a period of time particularly in mind. Certainly it would not have been true over a greater period than four or five years. Well, I will take that back because I perhaps did do that as long as ten years ago.

Q. I was going to ask you what period you would carry this answer back. For ten years back you would say you had that familiarity with Alexanderson which resulted from your having personally designed and built these Alexanderson oscillation transformers in widely different construction. That is right?—A. Yes.

Q. Right for ten years back?—A. Yes, right for every construction I can put upon it.

Q. You told us you gave evidence in the Twentieth Century case?—A. Yes.

Q. And when was the Splitdorf case tried?—A. I think it must have been in June.

Q. The Splitdorf case was tried in June?—A. Thereabouts.

Q. And when was the Twentieth Century case tried?—A. Perhaps in March, may be April.

Q. So less than two months intervened between those two trials?—A. I could not say.

Q. I am going to quote to you from page 428 of the Twentieth Century Record, where you are asked by Mr. Davis on cross-examination, question 461:

> "Will you look Mr. Waterman, at the Alexanderson patent to which you referred yesterday and particularly Fig. 4. Is it your understanding in that arrangement Alexanderson gets this beneficial effect of high reactance in the plate circuit which you discussed yesterday?—A. I am not very familiar with the actual performance of that circuit. I mean that particular one of the various Alexanderson arrangements. If you want authoritative information regarding it you had better ask somebody else."

Was that correct?—A. Yes.

Q. You do not know about that feature of Alexanderson?—A. I meant what I said, that I had not had personal extensive experience with that particular arrangement.

Q. Take Question 476:

> "Do you want to withdraw your admission that in the arrangement of Fig. 4 of Alexanderson, used with the old tubes and the inefficient circuits of Armstrong, the elements 55-60 could be adjusted to give the full plate circuit reactance without oscillating?—A. Yes, unless you understand I am only guessing and I am not standing by my answers, and I do not think they are worth anything to the Court. If you want to proceed on that assumption, all right."

A. I do not know the context of that, but I have no doubt I said it. My recollection of the circumstances is that notwithstanding the fact that I very frankly told Counsel that I had no extensive experience with that particular set of circuit connections, he insisted on cross-examining as to what it would do with certain particular tubes.

Q. Is that your recollection of what happened?—A. Yes.

Q. Well, you know the introduction of this question 476, "Do you want to withdraw your admission." Do you recollect what Mr. Davis had in mind there?—A. No.

Q. Does it seem to you at all strange that an expert of your understanding and experience should have had this extraordinarily intimate acquaintance with one part of Alexanderson and could only guess about another part?—A. I do not get that.

Q. Does it seem to you strange that an expert of your understanding in the art should have had the extraordinary familiarity practically and theoretically with one part of Alexanderson that you speak of in the Splitdorf case, and could only guess about another part of it in the Twentieth Century case?—A. I do not think your question quite fairly states the matter, but I do not think it extraordinary in any case.

Q. You had made a study of one and not of the other?—A. I had widely used the circuits such as are now shown on Figs. 1 and 2 and had an extensive practical familiarity with them.

Q. In the sense that you have told me already?—A. Yes. I had not used to any considerable extent, if at all,—I cannot remember if I had used it at all or not—the particular arrangement of Fig. 4. My recollection is that I had used it but not with the tubes and under the circumstances that Mr. Davis was there inquiring about. Of course, when you extract one part of a record and take it out of its context you do not get the correct impression of what happened.

Q. When you say you had widely used this method, what was the character of your use? You have not been in the business of constructing sets, have you?—A. No.

Q. When you speak of using do you not mean at least nothing more than a laboratory set-up?—A. That is what I mean, and such use as I had made of commercial sets.

Q. I gather you are too busy to dabble much with commercial sets, are you not?—A. I devote a great deal of my time to experimenting in radio, and I have for many years.

Q. When you speak of laboratory set-up, that would be largely in connection with the preparation of cases or preparing your evidence on different matters?—A. In that connection and otherwise. There was a great deal not at all in connection with the preparation for cases.

Q. You spoke of using the arrangement of Alexanderson now in suit as late as ten years back. What kind of set was that?—A. Well, it was an arrangement for trans-Atlantic reception, and it was one made up of course——

Q. Would you be good enough, so that we will recognize it, just to give us a simple sketch of the set you have in mind?—A. Substantially as in Fig. 2. I would not draw any different sketch. I should only draw specifications Fig. 2. Do you want me to reproduce it?

Q. You say it was a trans-Atlantic reception; that would be telegraphic, would it not?—A. It would be a continuous wave telegraph reception.

Q. Let me see the set.—A. I do not remember at this time specific details.

Q. And by the way did you use common batteries for the different tubes?—A. I have used both. I cannot tell you which I used at that time.

Q. Can you visualize what happened now to yourself, or is this just a broad general statement?—A. I remember that the circuits other than those involved in the set itself were all varying and in some instances rather a complex character and had to do with directional reception.

Q. Where did you use it?—A. Belmar and Roselle, New Jersey.

Q. Let us keep to Belmar. What were you doing with it?—A. I was working in connection with the improvement trans-Atlantic reception in times of heavy static.

Q. But were you working as a student or on a particular mission?—A. Both.

Q. For somebody ?—A. Yes. I did part of that work for the Marconi Company and part of it as a matter of personal investigation. Later some of it was done for the United States Government.

Q. Did you know of the Alexanderson circuit now in suit as an Alexanderson circuit then, ten years ago ?—A. I cannot tell certainly whether I did or not. I knew that Alexanderson had been working in such lines but I do not think I had ever seen the Alexanderson patent at that time.

Q. Was there an Alexanderson patent to see ?—A. I do not remember what the date of the patent was.

Q. As a matter of fact you used an apparatus, a circuit, similar to what you now know as Alexanderson's ?—A. Yes. I got the information, whether from Alexanderson or some other member of the General Electric Company I can not tell, but I remember it came from them.

Q. I suppose you were then familiar with the Marconi circuits, you were working for Marconi at the time, you say ?—A. In some of it.

Q. Were you working for the Marconi Company then, and were you familiar with the Marconi circuit ten years ago ?—A. The Marconi circuit per se does not mean anything particularly to me.

Q. I am talking generally. Now, Mr. Waterman, do you mean to say that Mr. Waterman does not know what I mean by the Marconi circuits ten years ago ?—A. The Marconi Company ten years ago used many circuits, and I would not undertake to say that I was familiar with them all.

Q. Perhaps I may be overlooking a distinction. There is a man who is actually using them, the wireless operator; there is the man who is designing on paper, and there is the man who is constructing. You know the differences, do you not ?—A. Your words do not convey any very clear picture to my mind.

Q. Don't they ?—A. No.

Q. Would they if you were on my side ? I say there is the man who is using circuits, there is the man who is designing circuits on paper,—there is such a man is there not, the scientist pure and simple ?—A. I do not happen to know any. Maybe there are.

Q. And there is the man who actually constructs circuits already designed for him ?—A. The workman, yes.

Q. I do not mean the mere workman, but the man who carries on from the paper drawing. Would you consider yourself any of these, or are you the student of the art who can advise with others, advise with the practical men ?—A. Well, I hope I may be called a student of the art, I have both designed circuits and built circuits and used circuits,—in fact I am doing it constantly.

Q. Experimentally ?—A. Yes.

Q. Well, will you now do something for me, please ? You know Alexanderson. Will you illustrate by a sketch showing a circuit diagram the arrangement referred to in the Alexanderson patent on page 1, lines 18 to 29 inclusive—that is the quotation we already have, and I am again talking from the United States patent which you have in your hand. I wish we had plain paper. The lines on that paper do not hurt any, do they ?—A. Oh no. I have done as you request, and hand you the sketch.

Q. Thank you. You here have drawn a simplified circuit, and you say at the right-hand side " to some detecting means " meaning leading to some detecting means ?—A. Yes, indicating the two wires left unconnected.

Mr. Henderson : Then I put this in and wish to have it marked, please.

EXHIBIT NO. " A ":—Filed by Mr. Henderson, Jan. 11, 1927. Sketch showing simplified circuit.

Q. In Alexanderson the detecting means, I understand, Mr. Waterman, may be a crystal or a tube,—Alexanderson speaks of both and leaves it open, does he not ?—A. I do not remember.

Q. Will you just take a look ? I do not know that he uses the word " crystal " but he leaves it wide open.

Mr. Smart : I do not know that he uses the word.

Mr. Henderson : I do not know that he uses the word " crystal," but he leaves it wide open.—A. I do not notice any such statement.

Q. I do not think the word " crystal " is used, but he does not limit himself as to the nature of the detector ?—A. Will you please tell me what passage you are referring to ?

Q. I am referring to my general recollection of the Alexanderson patent. May I put it in this way, Mr. Waterman : in drawing this sketch, exhibit " A," do you limit yourself to any particular type of detector ?—A. No. You asked me to draw the prior art referred to in that passage, and all sorts of detectors were used.

His Lordship : There is no detector in Alexanderson's, is there ?

Mr. Henderson : It does not reach that stage. I am talking now about the practical illustration. The witness gives us a simple diagram and then puts it " to some detecting means."

Q. Do you consider yourself that Alexanderson limited it to any particular form of detector ?—A. I have not considered the question at all, but I should say that any detector that he could use without impairing the action which he describes would be within his description, although so far as I see or remember he describes only the use of the tube detector.

Q. But would the use of a crystal detector impair its action ?—A. Some certainly I think would not.

Q. And of course they do vary ?—A. Yes.

Q. You know, of course, that in the case of crystal detectors some have better qualities than others do you not ?—A. Yes.

Q. Would any useful detector impair the action of Alexanderson,—I do not mean one that would not work ?—A. Well, a load, of course, put on a circuit would alter its efficacy ; otherwise, no.

Q. Would a load put on the circuit make Alexanderson inoperative ?—A. No, provided that the load was proportioned with a view to carrying out the Alexanderson instruction.

Q. What instruction ?—A. That the successive circuits should be selective circuits.

Q. I thought he was aiming at selectivity ?—A. He was ; so that anything which was in violation of that action would not be in accordance with his disclosure.

Q. I am assuming fair treatment of Alexanderson.—A. You asked me whether substantially anything designed to carry it would be within the patent, and I think it would.

Q. I am assuming Alexanderson carried out as Alexanderson describes it.—A. As Alexanderson describes it, I think it would be quite effective.

Q. That it would be quite effective to use a crystal detector ?—A. Your last question did not ask me about a crystal detector.

Q. Do you remember what my last question arose out of, an answer of yours ?—A. I think perhaps we had better start over again.

Q. Let me put it in this way : if a crystal detector were substituted for the vacuum tube detector in the figures of the Alexanderson patent, would you still have the Alexanderson invention ?—A. I think so, assuming that it was so applied as to carry out the Alexanderson instruction and obtain the Alexanderson results.

Q. Are you not reasoning in a circle there ?—A. No.

Q. Is not that a question which could be answered simply ?—A. It could be answered simply only in the event that I could be sure that it would be interpreted as I mean it, and therefore I qualified it, so as to make sure.

Q. Would it still be geometric selectivity ?—A. If applied so that geometric selectivity was not destroyed, yes.

HIS LORDSHIP : What is the point, Mr. Henderson ? Is it that with a crystal detector Alexanderson is not operative ?

MR. HENDERSON : Rather the other way about. There are such things as crystal detectors that are very poor in quality. As long as it is a reasonably good detector it could be used with the Alexanderson arrangement and not interfere with the Alexanderson ideas.

HIS LORDSHIP : If it is a poor crystal detector.

MR. HENDERSON : Then it is not a crystal detector at all except in name.

Q. Does it make any difference to Alexanderson what kind of detector you use ? He stops short of the detector does he not ?—A. No, I do not think it makes any difference at all, provided it is a suitable detector and applied suitably so as not to defeat the object.

Q. I call that a simple answer.—A. I thought I had said that several times before.

Q. No, it was always said by way of qualification, and this time it is said in the affirmative, and that is different. Now then, in your sketch, exhibit " A," you do not show the antennae tuned, do you ?—A. No. I have no objections to doing so, if you want me.

Q. In this sketch how is the coupling as to looseness or closeness. I do not mean to say looking at this particular piece of paper, but how do you intend that to be ?—A. I intend that to illustrate the passage which you asked me to illustrate. The passage says :

" The method now commonly employed for this purpose consists in using an electric circuit in which a train of waves of a given frequency acts cumulatively "—line 18.

Q. But that does not answer what I asked you as to whether the coupling is close or loose ?—A. That passage refers to a single circuit. I was assuming that that antennae is arranged in any suitable way, I do not care, so that it substantially leaves the single circuit acting as described in the passage which you asked me to illustrate.

Q. But which would be the suitable way, loose or close ?—A. A relatively loose coupling.

Q. Then if it is relatively loose, would the antennae be in effect tuned ? Perhaps I should say in practice tuned ?—A. Oh, it might be. I did not so show it, but it might be.

Q. It would be immaterial to you whether you showed it tuned or untuned ?—A. Yes. I am assuming that the antennae is not closely associated, and also what was the usual fact that in the sense of the order of selectivity that Alexanderson is contemplating, as he says on page 2, line 42, because of its resistance and spacial distribution the antennae circuit can not be closely tuned, so that the suppression of interferences. in this circuit may be disregarded in the present case. Throughout this disclosure Alexanderson disregards the effect of the antennae as anything else than a means of capturing something from the air and submitting it to the action of the tuned circuit ; and in the passage which you asked me to illustrate, he was referring to what he says is now the process commonly employed, which I take to mean at the date of his disclosure ; and so understanding I have drawn the single circuit in exhibit " A."

Q. But in practice can not an antennae be closely tuned in ?—A. Not in a sense that Alexanderson is here contemplating. The antennae having a spacial disposition such as should effectively capture the waves, if I may use that term, has necessarily a high effective resistance and——

Q. You are guided by this phrase ?

Mr. Smart : Let the witness complete his answer.

Witness : I want to continue. And it has therefore, as Alexanderson says, an effect which for the purposes of such a disclosure as his may be disregarded, and which I take it from the language used in the passage you asked me to illustrate, is disregarded.

Q. You are guided then by the expression that you have read from the paragraph opposite which " 40 " appears on page 2,—line 40 is part of that paragraph ?—A. Well, I could say yes, but really I think that the passage you asked me to illustrate implies that he is disregarding any effect of the antennae.

Q. In your experiment, have you ever tried it in another way ?—A. Than what ?

Q. It says here, " Because of its resistance and special distribution the antenna circuit can not be closely tuned." Have you ever tried it to see whether Mr. Alexanderson is strictly accurate there ?—A. Oh, my, yes. Of course I used for years very largely a tuned antennae, and from the point of view of selectivity of those days I would not say that it was not an element in the selectivity. That. however, is a different point of view.

The selectivity of those days is one thing, and the selectivity possible with continuous waves is another thing.

HIS LORDSHIP: Is the antennae always normally tuned to some extent as a physical condition?—A. No. Probably at the present day more often not tuned. But I think that as of the date that Alexanderson was speaking, if I may for example assume that it was 1913, it was probably more common to tune it. The usual thing was, I think, an antennae having a condenser in series with it, or it may be of variable inductance in series with it, acting as a tuning element; and when the secondary circuit always was a tuned circuit.

MR. HENDERSON: Q. I suppose, Mr. Waterman, you would not be suprised if you heard a very practical scientist who had not shown tuning on his drawing saying that that would be taken for granted in those days?—A. I do not think that follows at all.

Q. Well, would you be surprised if he took it for granted?—A. Why, yes, I should, because practical scientists are pretty apt to show what they mean.

Q. You perhaps know the man I am thinking of?—A. I do not know whether I do.

Q. Don't you? But you say, however, that in actual practice in those days the common practice was to tune?—A. Oh, I think that was probably more common than not to tune, yes. I am speaking now of the tuning of the antennae.

HIS LORDSHIP: How was the antennae tuned,—that is different from the circuit?—A. The antennae itself may be considered as a circuit.

MR. HENDERSON: We speak of the antennae circuit, my Lord.

WITNESS: In the Alexanderson patent in all the figures the antennae shows as the elevated wire 1, the primary of the transformer, marked 2, the condenser marked 3, and a symbolically indicated ground connection.

Q. And the junction of the antennae and 3 indicates tuning in Fig. 1?—A. The specification says at page 1, line 65, "The electromagnetic waves received by a grounded antennae 1 are impressed upon a resonant circuit including the primary of a transformer 2 and a condenser 3." In other words there Alexanderson himself describes the antennae circuit as tuned, and he goes on to say——

Q. In all his figures does he not show it as tuned?—A. Am I to finish my answer?

HIS LORDSHIP: Let him finish his answer.

A. "The secondary of the transformer is loosely coupled with the primary,"—and that is referred to again in the other passage that I called attention to on page 2, line 42. So I understand that Alexanderson contemplated that the antennae circuit shall be tuned probably by varying the condenser 3, although it is not shown as variable.

MR. HENDERSON: Q. And in the figures, Mr. Waterman, Alexanderson shows the antennae tuned, does he not, at the point 3?—A. I prefer my answer that he shows the antennae in identical manner in all three figures, in all five figures, and he states that it is tuned.

In the Exchequer Court of Canada.

Plaintiff's Evidence.

No. 7. Frank N. Waterman. Cross-examination —*continued.*

HIS LORDSHIP: The antennae circuit then is the upright aerial wire, the primary coil, and then it continues to the condenser and the ground,—is that it?—A. Yes, my Lord.

MR. SMART: The condenser, of course, is not a variable condenser unless it has the arrow in the symbol.

MR. HENDERSON: Q. Can you speak of any case in practice ten years ago when the antennae was not tuned?—A. Oh yes.

Q. Give me some.—A. Well, I used it.

Q. Where?—A. I do not know.

Q. Experimentally?—A. Yes.

Q. Do you know of any commercial apparatus ten years ago in which the antennae was not tuned?—A. No, I think it was usually tuned, although I have not the matter in mind.

Q. Are we not wasting time. Can not you say that?—A. Oh no, I could not say that broadly; but I have said that I think it was more usual to have the antennae tuned.

Q. But experimenters could experiment, no doubt, could they not?—A. Why, certainly.

Q. Then will you please consider a receiving system including a tuned antennae circuit directly coupled to a detector or very closely coupled to a detector,—you have what I mean. Would such a system give selectivity?—A. Well, that is very difficult to answer, because they have such a different conception of selectivity when applied to continuous waves and when applied to spark signals. Really, in order to answer a question of that kind, one ought to make a rather full explanation. Let me answer it in this way: in the sense in which one would use the term "selectivity" as applied to damped oscillations, yes. In the sense in which it is applied in the Alexanderson patent, for example, to the reception of continuous waves, the effect is a much less important one, and therefore Alexanderson disregards it.

Q. What date are you dealing with in considering that answer, broadly?—A. I have been having in my mind——

Q. I mean as of Alexanderson's date?—A. I have been having in my mind all the time the passage which I assumed you were asking about, and I have been assuming a date prior to Alexanderson's disclosure, which was October, 1913.

Q. Which was in general use at that time, continuous wave or spark?—A. As I remember it, there was almost no, if any, continuous wave. Alexanderson just about that time brought out the completed alternator, as I remember it, although I have not charged my memory with those dates. There may have been at that time some continuous waves, but the general art at that time must be said to be the spark signals, that is damped oscillations.

Q. Well now, insofar as they were continuous waves, assuming an antenna of low resistance used with a tuning system which comprises the major protion of the oscillating circuit, as for example the system coupling the antenna to the grid of the first tube in the defendant's receiver in evidence, would that give selectivity?—A. I do not sufficiently understand it.

Q. I will take it over again. Take an antenna of low resistance used *with a tuning system which comprises the major portion of the oscillating* circuit, as for example the system coupling the antenna to the grid of the first tube in the defendant's receiver, would that give selectivity ?—A. I still do not get your premise, but I can answer without that, perhaps, to this extent, certainly not the selectivity of the Alexanderson patent.

Q. What is the differentiation,—what would it get ?—A. Well, you have not pictured a definite thing, but you have as I understand it limited——

Q. It seems definite to my mind.—A. You have limited your question to a single tuned receiving circuit, and it goes without saying that a single tuned circuit can not give selection by successive repetition.

Q. I have your answer. Then we pass on to this: assume that a tuned circuit is placed between the detector and the tuned antenna and is loosely coupled to the antenna, would you get more selectivity ?—A. Your question describes the sketch which I made in exhibit "A," as I understand it. The Alexanderson patent states——

Q. That is with tuning ?—A. Yes, the secondary is assumed to be tuned.

Q. You see I said a tuned antenna. Let me give it to you again: a tuned circuit placed between the detector and the tuned antenna and loosely coupled to the antenna, would you get more selectivity ?—A. More than what ?

Q. We have just been talking of a single tuned circuit,—more than with a single tuned circuit.—A. Yes, undoubtedly somewhat more, but not an amount more comparable to that obtained by successive stages in the Alexanderson arrangement.

Q. I am coming to it, you see. But would you then have geometric tuning at the last stage that I gave you ?—A. No.

Q. Why not ?—A. I am not sure now that I understand you.

HIS LORDSHIP: Will you put your question again, as the witness says that he is not sure.

MR. HENDERSON: Q. Take your exhibit again,—you have it in mind ? —A. Oh yes.

Q. If you simply tuned both circuits there, you would have more selectivity there, you have told me ?—A. Somewhat.

Q. Would it be geometric selectivity by that time ? I want to find when you get into geometric selectivity ?—A. About the only answer that will convey that state of affairs accurately there is this, that in general the question must be answered No; but that this can be said, that such an arrangement will approach toward a geometric selectivity as the separation of the circuits is increased so that the received signal approaches zero.

Q. Would you differentiate between geometric tuning and geometric selectivity ?—A. Not unless you want me to.

Q. I do not. I prefer to use the terms synonymously almost. Then would you say that you would get geometric tuning at that point ?—A. No, I think I have answered that question about the only way that it can be answered without misleading. I would be very glad to go into an explanation if you want it, but I think that is the answer to the question which you have given.

In the Exchequer Court of Canada.

Plaintiff's Evidence.

No. 7. Frank N. Waterman. Cross-examination *—continued.*

Q. I am content with that answer, although not quite content with it. Now I want you to give me another simple diagram, please. Would you be good enough to let me have another sketch showing the most simple embodiment of the Alexanderson invention, as you understand it, plus a crystal detector ? We had reached the point where Alexanderson stopped short of the detector.—A. Assuming that the crystal detector that I will mark " D " is properly chosen and associated with the circuit, I think that the sketch which I hand you would illustrate the simplest possible circuit.

Q. Just let me ask you again as to this, if the antenna circuit is necessary tuned or does our former discussion apply to this diagram also ?—A. The antenna is not necessary tuned.

Q. Not necessarily tuned, but may or may not be, as you put it before? —A. Provided it is sufficiently loosely associated.

Q. I do not think there is any difference between us, but you will see at the extreme right you have marked the usual symbol of a crystal detector with the letter " D." Below that you have what I took to be telephones ? —A. Yes, they are intended for telephones.

Q. But you see that they may look like a coil ?—A. Yes. They are intended for telephones.

EXHIBIT NO. " B " :—Filed by Mr. Henderson, Jan. 11, 1927. Sketch illustrating simplest possible circuit with crystal detector.

Q. Now then will you be good enough to look at figure 3 of the Alexanderson patent. I am doing as you did, using the United States patent. There you have one relay interposed between two tuned circuits have you not ?—A. Yes.

Q. And of course that is an embodiment of the Alexanderson invention is it not ?—A. Yes, it is so described.

Q. So that in any remarks that you have made, you did not intend to convey to the court the idea that Alexanderson must have more than one relay or more than two joined circuits ?—A. No, I have not said anything about the matter so far as I remember.

Q. I do not doubt your intention, Mr. Waterman, but I ask that question because you said something that might have been so interpreted, that is all, and I just want to make it plain that it is not necessary to have more than one relay or more than two tuned circuits.—A. Whether it is necessary or not in any case depends upon circumstances.

Q. Pardon me for interrupting you : I am simply dealing within the Alexanderson invention.—A. I do not understand that more than that are necessary. I call your attention to the passage at page 3, line 89 and following as containing what Alexanderson himself said about the figure that you are now inquiring about in that regard.

Q. What he says there, to make that plain is :—

" The operation of the system shown in figure 3 is similar to that shown in figure 1, and therefore only two resonant circuits connected by a relay have been shown here for the purpose of illustration, but it should be understood that any number of circuits may be used

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No. 7. Frank N. Waterman. Cross-examination —*continued.*

with the same advantage of suppressing disturbances in geometric ratio with the number of circuits used."

The more you use, in a sense, up to a certain point, the better. That is what we mean, is it not ?—A. If the order of selectivity required demands it, yes.

Q. Infiltration and you keep on filtering until you are satisfied. That is what you mean, isn't it ?—A. Well, yes. As supplied here of course the filter analogy is a little defective, because in filtering you are filtering the same thing over and over again, whereas in this arrangement here, you are initiating a new signal each time.

Q. In the broad sense you are and you are not. But filtration is a very excellent word to use, is it not ?—A. As long as we understand one another, yes.

Q. A very excellent analogy. We are not differing on that.

HIS LORDSHIP : The inventor is not limited to the one tuned circuit, that is quite clear.

MR. HENDERSON : No my Lord, but he gets so much of what he is after in the one tuned circuit. If he goes into another circuit, as Mr. Waterman says, it depends on what you want at the moment, but he probably gets it a little better.

Q. Just to test it, Mr. Waterman. If somebody did use one relay and two tuned circuits, you would say that infringed on Alexanderson ? —A. If you used them in the way described by Alexanderson, yes.

HIS LORDSHIP : What is that again, Mr. Henderson ?

MR. HENDERSON : I am putting it the other way about. If somebody used one relay and two tuned circuits only, Mr. Waterman could very well say that infringed Alexanderson. You do not have to have the greater number of circuits in order to infringe Alexanderson.

Q. Is it necessary to have an independently tuned antenna system in order to have the Alexanderson arrangement ?—A. No, I see no necessity for it.

Q. Would you still have the Alexanderson arrangement if an untuned antenna system were used coupled to a tuned grid circuit ?—A. Certainly. Assuming that the system is otherwise in compliance with the Alexanderson arrangement.

Q. I think we have always got to assume that if you are going to use Alexanderson, you are using Alexanderson and not something else. Now speaking of the audion, Mr. Waterman. Sometimes we speak of audions and sometimes of valves and sometimes of vacuum tubes. These are interchangeable terms, are they not ?—A. At the present time, yes.

Q. Are there any others you have not thought of ?—A. I presume you could collect twenty.

Q. My recollection is that there are some others, but those are the three names ?—A. Yes.

Q. And I did not want his Lordship to be confused. Were the audions available to Alexanderson during the first months, say February to May of 1913. Uni-directional coupling devices. You have talked about uni-

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No. 7. Frank N. Waterman. Cross-examination —*continued.*

directional devices ?—A. Yes, I think so. They were not very perfect, but I should call them so.

His Lordship: Why not call them "valves ?"

Mr. Henderson: Well, my Lord, we fall into habits, I do not want to pose as an expert in the art but even I find that I cannot help getting that habit.

His Lordship: You have been trading on one word for some weeks now, and it will put you off your gait if we change, will it ? What did you use, Mr. Smart ? You used them all I think.

Mr. Smart: I think in opening I said "audions" or "vacuum tubes," both together.

Mr. Henderson: I find, my Lord, that if I am speaking to some Englishmen whom I have met, I have to use their word : and if I am thinking of a really good pure and simple American word I think of it as an audion. And over here, in Canada, we speak more of tubes. Over in the Old Country I heard more of valves.

His Lordship: Just use your own word.

Mr. Henderson: It was really by way of apology to your Lordship and because of that that I wanted to have it in the record that these were interchangeable terms.

Q. Then what would you say as to the present-day vacuum tubes; are they in effect uni-directional coupling devices ?—A. Yes.

Q. You, I think, Mr. Waterman, have expressed yourself as familiar with the different types of radio sets now on the market: not all of course, but I think you have a real familiarity with those that are sold by the associated group of companies who are concerned with this litigation. I am speaking of the four suits here.—A. Some of them.

Mr. Smart: There are only of course the three companies.

Mr. Henderson: There is nothing antagonistic in this, Mr. Smart, I am only trying to clear things up.—A. Do you mean the Canadian companies as distinguished from the American companies ?

Q. I am going to ask you to tell me in a perfectly friendly way and informative to the court,—and I may be slightly in error, but I understand the Radio Corporation of America sells sets generally, do they not ?—A. I don't know what you mean by generally. They sell sets.

Q. Take the super-heterodyne receivers that we know about. By whom are they sold in the United States ?—A. The Radio Corporation I think sells in the United States through jobbers and dealers.

Q. I know, but I am getting at the central embodiment, and the Radio Corporation operates several patents, does it not ?—A. I don't know what you mean by "operate a patent."

Q. What word would you use ? The super-heterodyne sets have in them to a greater or lesser extent the embodiment of different patents, have they not ?—A. Yes, I would say so.

Q. And quite a number ?—A. Yes.

Q. Then the super-heterodyne receivers are sold by whom in Canada ? —A. I don't know.

Mr. Smart : I concede that some are sold by the Northern Electric Company.

Mr. Henderson : And the Canadian General Electric. And I think we have a stipulation somewhere, I do not want to come to it for a moment, this is a time saving invention ; the reason I am limiting this, Mr. Waterman, is, I think that you know that heterodyne and super-heterodyne has come to be in use as a somewhat general term.

His Lordship : Descriptive of what ?

Mr. Henderson : Descriptive of a type of receiver. And there are different sets on the market that are called super-heterodyne or heterodyne ; different makes by different distributors, but I am only dealing now with those put on the market by the Radio Corporation of America in the United States and by the Northern Electric or the Canadian General Electric in Canada.

Mr. Smart : Both of those companies sell sets which are known as superheterodyne.

Mr. Henderson : And which are as I would call them, the real super-heterodyne embodying in whole or in part certain patents which I think Mr. Waterman will have in mind. We understand one another don't we, Mr. Waterman ?—A. I understand the super-heterodyne sets put on the market by the Radio Corporation of America to a greater or lesser extent, certainly. I know nothing whatever about the Canadian sets.

Q. Let us admit that they are the same as those put on the market by the Northern Electric or the Canadian General Electric in Canada.

Mr. Smart : For the purpose of this examination.

Mr. Henderson : For the purpose of this examination, yes.

Q. Now do those sets embody your understanding of the Alexanderson patent ?—A. Yes.

Q. And will you be good enough to particularize as to the manner in which they do, and the portion of the particular circuit in which you find the Alexanderson invention ?—A. Well, of course, you recognize, Mr. Henderson, that those are extremely complex circuits and I can only answer so far as I have them in mind and memory.

Q. Perhaps we could do it by a diagram. It would be more convenient would it not ?—A. It depends on whether the diagram happens to be one that I have studied out. One cannot instantly interpret a diagram of so complicated a thing as a super-heterodyne.

Q. I think perhaps we can use an old friend of yours, Mr. Waterman. I think if I am not mistaken this is a set of diagrams that you have seen before ?—A. Some of the diagrams shown me seem to represent super-heterodynes and others do not.

Q. May I ask you, Mr. Waterman, if you recognize those as a set of photostats of a set of diagrams introduced as plaintiff's Exhibit No. 7 in the Splitdorf case and referred to by you in your evidence in that case ?—A. They have a very familiar look but I could not swear to their identity.

Q. I would be quite content, Mr. Waterman, because this is of some little importance, if you will check them up overnight.

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No. 7. Frank N. Waterman. Cross-examination *—continued.*

Mr. Smart: If my learned friend produces them from the record, I will raise no point about that being a copy of the Exhibit in the Splitdorf record.

Mr. Henderson: It is.

Q. Then can you point out, by reference to those diagrams, any of the particular circuits, and in what portions of those circuits you find the Alexanderson ?—A. No, not without studying them. They are so complex, and so closely drawn and so difficult to unravel without error, that I would not undertake to do that.

Q. We have only a few minutes more tonight, and you might take those and check them over tonight. My learned friend has copies of those no doubt, and you can check them up tonight. But is there any general statement you can make about them now so that we will not get out of our line of thought ?

Mr. Smart: I am in error in stating that we have copies, so if you wish Mr. Waterman to study those you might let him have the copies.

Mr. Henderson: I want Mr. Waterman to be specific. I think you know what I want, do you not ?—A. I presume so, I can only know it so far as I can infer it from your question.

Q. Then will you be good enough to prepare to tell me in the morning also of the different makes of these sets; the Radio Corporation sets are the ones with which you have familiarity—in which you find Alexanderson ? —A. I have a general recollection of that matter now.

Q. Will you speak generally now and then I will ask you to be specific, perhaps the first thing in the morning.—A. My recollection is that the one known as Radiola Super Eight and the one known as Radiola Super-Heterodyne Second Harmonic, the mechanisms of which are substantially identical, have the Alexanderson selectivity in first and second stages of intermediate frequency. The same is true of Radiola 25. That Radiola 28 has it in the first two stages of radio frequency, and in at least two of the stages of intermediate frequency, and I am not sure whether in all three or not.

Q. What about the Radiola " Ten " or " X " ?

His Lordship: I do not see why you should not agree on this. This is only a description of a well known thing is it not ? We should not be wasting time over that. You surely could agree upon that. You might as well ask the witness to describe something we all know.

Mr. Henderson: I just want to call the witness' attention to Radiola " X " or "Ten." It is a Roman Letter.—A. That is not a super-heterodyne at all.

Mr. Smart: I have given my learned friend a diagram of the Radiola made by the plaintiff in this action, which I think covers the ground that he is asking about.

Mr. Henderson: We similarly want to check that.

Q. And then you will be prepared to talk about the Regenoflex ?—A. The Regenoflex and the Radiola Ten are essentially the same, and they are, neither of them, a super-heterodyne.

His Lordship: What is a super-heterodyne ?

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Mr. Henderson : I think your Lordship will have to use the diagram to understand that.

His Lordship : Is it a method of construction ? Does it contain any elements that are peculiar or is it a trade name or mark ?

Mr. Henderson : I would prefer Mr. Waterman to tell your Lordship that. It is not a trademark ; it is a trade name. Is it registered ?

Mr. Smart : I do not know what the situation is in regard to that.

Mr. Henderson : There is a distinct description of it, and before you get through, your Lordship will have to understand it.

Q. Will you be good enough to tell his Lordship that ?—A. The super-heterodyne is a receiver in which advantage is taken of the fact that these tubes amplify more effectively at the relatively lower radio frequencies than at the high broadcast frequencies. Therefore what happens in the super-heterodyne is as follows :—The signal is received in one or more radio frequency tubes, at its transmitted frequency. Its frequency is then changed by what is known as a heterodyne system, into a lower frequency ; as, for example, the signal may be received at 1 million cycles per second : its frequency is then changed, to say, 40,000 cycles per second. It is then further selected, amplified, and detected, and the final detected audio frequency output is, as in most receivers at the present time, again amplified by ordinary telephone tube amplifiers. The peculiarity is the change of frequency in the set itself after its initial reception.

Q. And the operation on intermediate frequency ?—A. Yes.

Q. There is where you get the phrase " intermediate frequency " ?—A. Yes.

Q. Specifically applied ?—A. Yes. There are two radio frequencies and one audio frequency. The second radio is called second radio frequency or intermediate frequency.

Q. You told his Lordship, I think it was this morning, or perhaps yesterday, of the distinction between radio frequency and audio frequency, and you spoke of a commonly accepted line of demarcation. Then you are now introducing a new thought—not new to you no doubt,—of an intermediate frequency which comes in, a point between the two, overlapping a little of either ?—A. No, you have entirely the wrong impression.

Q. Have I ?—A. Entirely. No, the term " intermediate frequency " merely means a frequency intermediate between that at which the signal is received and the audio frequency at which it goes out. That intermediate frequency might be a very high frequency if you choose to have it so, but we usually choose a radio frequency of readily amplifiable magnitude.

Q. What is the frequency band covered by the intermediate frequency transformers ?—A. Well now let me be sure of that, that you are using terms in the same way that I would. The intermediate frequency is any given super-heterodyne receiver is some definitely chosen thing. It is not variable, at any rate in the forms of super-heterodyne that we are talking about.

Q. And I do not want to talk about any other.—A. Let us say it is 40,000 or 100,000 or anything you choose. If you choose one, it is fixed. Now of course the frequencies that come in are those brought in by the signals. And if the carrier frequency is transformed from a million say to 40,000 or 100,000 or whatever it may be, it carries with it the speech frequencies, let us say from 70 to 3,000, and therefore the radio and the intermediate frequency both have the carrier wave, plus or minus say 3,000.

Q. That is what I understand ?—A. Well, all right, I could not tell it from your question, and I wanted to be sure that we understood one another.

Q. My question may have been unskilfully put, but that does not answer my question as to what is the frequency band covered by the intermediate frequency transformer ?—A. I answered explicitly, probably about 3,000, plus or minus.

HIS LORDSHIP : It is the hour of adjournment now, Mr. Henderson, are you contending that the method of selectivity which you call the Alexanderson, is not the subject matter of a patent or patents ? Do you go that far ? I understand you to say it was known to the art before Alexanderson's patent ?

MR. HENDERSON : Yes, my Lord.

HIS LORDSHIP : I know that is one of your points. But supposing someone behind Alexanderson had developed and given to the public this method. Would you say it would have subject matter ?

MR. HENDERSON : Oh yes I think so. That is, I am speaking broadly now.

HIS LORDSHIP : My reason for putting that question is this—I do not want to catch you at all.

MR. HENDERSON : No I know your Lordship likes a square answer and I was trying to give it. What we are going to develop to your Lordship is that there was a development in the art in the course of which there were certain patents issued, and properly issued, and there were certain things happened which I do not think, as I am instructed, would have amounted to invention. And when I say Alexanderson, I am not going to say that there was nothing in Alexanderson which might not have been the subject of invention, if Alexanderson had been the inventor. I am speaking very broadly.

HIS LORDSHIP : My only reason for putting that question is that it would save considerable time if we understand that Alexanderson represents invention. I do not say he invented it, but that thing which we call Alexanderson, that method,—I suppose it is a method,—if it were absolutely new and given to the world today, would it represent invention ?

MR. HENDERSON : If it came as a bolt out of the blue, I think probably the answer would be Yes.

HIS LORDSHIP : I should think it would.

MR. HENDERSON : But when your Lordship hears more about it, I do not think that Alexanderson was so far up at the head of the electrical profession as Mr. Waterman said, but Alexanderson was a man of undoubted standing.

HIS LORDSHIP : I am not speaking of Alexanderson personally at all, but of the thing done.

MR. HENDERSON: But your Lordship will find it was a sort of development, and it would be very difficult for me with my inadequate facility of expression, to put it quite to your Lordship now: I would prefer to unfold it in the story.

HIS LORDSHIP: I would not ask you for that. Eleven o'clock tomorrow morning.

THE REGISTRAR: The court will adjourn until 11 o'clock tomorrow morning.

12th January, 1927.

MR. HENDERSON: Your Lordship suggested that we call attention at the opening of the court each day to any inaccuracies. I gather from my friend that he is hardly prepared.

MR. SMART: Mr. Waterman was engaged in going over the matter which Mr. Henderson asked for.

HIS LORDSHIP: You can arrange that in any way.

MR. SMART: There is one mis-statement which perhaps might mislead your Lordship. On page 142, Mr. Waterman in the answer beginning on line 6 is reported to have said, " The subject matter of these other patents that are involved in these other cases, namely the Hazeltine and Hartley " —those should be Hartley and Rice.

MR. HENDERSON: I think that is correct.

There are a few things that perhaps I might call attention to, in the first day. In the index, on page 3, " Operation of an audio frequency current in a microphone "—I think it is probably telephone.

Then on page 4 of the index, dealing with page 77, " audition ranges of frequency " is not accurate. I think the word " audition " should be eliminated there, or perhaps it might be made " audible ranges of frequency." " Audition " has a technical meaning.

Then on page 2, near the top of the page, in noting the appearance. It may interest your Lordship to know that the word " Fada " is coined from the initials of Mr. Frank A. D. Andrea, who is head of the American Company F. A. D. Andrea, Incorporated. And perhaps your Lordship may be interested to know that the Independent Radio Manufacturers, Incorporated, is a separate company, the stock of which is owned by, I think I am right in saying, 14 different manufacturing companies which are licensed.

HIS LORDSHIP: It corresponds to the Radio Corporation of America, except that they are hostile.

MR. HENDERSON: The chain of history is that Mr. Hazeltine, commonly called Professor Hazeltine because he was Professor in the Stevens Institute of Technology when he went into this work, made certain inventions which he assigned to a Company which he himself formed, the Hazeltine Research Corporation, and in turn that company gives to the Independent Radio Manufacturers, Incorporated, the exclusive right of licensing others. They license their own stockholders as it were. That is the usual way of doing things, and that is the way it works out.

In the Exchequer Court of Canada.

Plaintiff's Evidence.

No. 7. Frank N. Waterman. Cross-examination —*continued.*

MR. SMART: We are not concerned with all those companies here, my Lord.

HIS LORDSHIP: No, but I asked about it myself yesterday.

MR. HENDERSON: At page 13, line 12, it says "Telefunken System of wireless"; it should be the Telephonic System, as I understand.

Then on page 14, lines 13 and 14, a statement by Mr. Smart which I would ask Mr. Smart to look at. He says "The invention of course has other utilities"—is that the correct phrase?

MR. SMART: In a general way, yes.

MR. HENDERSON: Then in the second day, page 96. I think perhaps I will leave this, as I am told that this has not been completed.

MR. SMART: I think we can perhaps more readily do that out of court, by making a list of all the corrections.

MR. HENDERSON: Yes. I do not see why we cannot do it out of court with the stenographer.

HIS LORDSHIP: Certainly. At the close of yesterday's proceedings, what I meant to say about the method of selectivity was that there can be no question but that there is utility in selectivity as practised, without discussing who was the inventor, when it was novelty or when it ceased to be novelty.

MR. HENDERSON: There is no question about the utility of it; but as I said to your Lordship yesterday I hesitate somewhat to define it, not myself being an expert, but my understanding of our position is this, if I may put it in this way. My friend and the witness seemed to look at the picture as if Alexanderson had got something which is brand new, that being geometric selectivity. We say No, that geometric selectivity was a gradual development in the art, and there was not even a new step here. That all that can be done under the Alexanderson patent and even more was already done.

HIS LORDSHIP: Yes, I understand that. That goes to the novelty.

MR. HENDERSON: It really goes to the question of novelty, so that the result will be that we claim it is open territory. That is illustrated very well by the fact, as said yesterday, that it is in practically universal use by hundreds and hundreds outside of the Radio Corporation and the Independent Radio Manufacturers, Incorporated.

HIS LORDSHIP: But grant that geometric selectivity in radio work has utility and is practised generally, that would avoid the necessity I would think of going into a detailed description of selectivity. It then gets down to this, did Alexanderson invent anything.

MR. HENDERSON: Mr. Waterman described selectivity.

HIS LORDSHIP: Then there is no need of going into that again.

MR. HENDERSON: No, and I am going to call Professor Hazeltine.

HIS LORDSHIP: He is to be one of your witnesses?

MR. HENDERSON: Yes, we propose to call him. Without him I could not go very far. He is here to tell for himself what he meant and what he did; not what someone else reads him to mean: and also to tell what he says Alexanderson did. We have also the evidence of others, and we say that as far as geometric selectivity is concerned it is open territory.

HIS LORDSHIP: I understand that, I was very glad to hear Mr. Smart's opening on that, and the witness' description of selectivity. It was necessary and important to have it, but I think it may pretty well rest where it is, and now you are at the question of who was the inventor, or if there was an invention, whichever way you put it.

MR. HENDERSON: Precisely, and I may say with respect to the opening, it was admirably opened both by my friend and Mr. Waterman.

I may proceed now with the witness, my Lord?

CROSS-EXAMINATION, Resumed by MR. HENDERSON:

Q. We were dealing last night, if I recollect rightly, Mr. Waterman, with the question of these different sets which I will call, roughly speaking, Radio Corporation sets. You desired an opportunity overnight of studying the photostats which I handed you. May I ask if you have done so?—A. I have.

Q. And what do you say as to these now?—A. I find that each one of the photostats handed me illustrates the Alexanderson geometrical selectivity substantially in the manner of figure 2 of the Alexanderson patent.

Q. May I ask if you recognise those photostats as the—perhaps not the same pieces of paper—but you know what I mean when I say the same photostats as you referred to in evidence in the Splitdorf case?—A. Yes.

Q. That helps us a little in covering the ground. Could you name these different sets by the trade names that were spoken of yesterday?—A. Yes.

Q. Are they marked?

HIS LORDSHIP: No, I do not think so.

A. This copy that you have handed me bears a mark on one sheet but many of them are not numbered.

MR. HENDERSON: My understanding is that as a whole they were Plaintiff's Exhibit 7 in the Splitdorf case?—A. I think that is right.

Q. That is what you refer to?—A. I think so, yes.

Q. Then you might just take sheets 1, 2 and 3 and so on. This will be marked as an exhibit but just speak of them as sheet 1 and so on.

HIS LORDSHIP: What is the number of the Exhibit?

THE REGISTRAR: Exhibit C, my Lord.

HIS LORDSHIP: Call the different sheets C1, C2 and so on.

MR. HENDERSON: Then this will be Exhibit C?—A. Shall I number them in order?

Q. Yes, number them in order as you go along.

EXHIBIT C:—Filed by Mr. Henderson, 12 Jan., 1927. Photostats, illustrating Radiola sets.

Q. Page 1 illustrates what?—A. The Radiola Super Eight which has also the circuit of the Radiola super-heterodyne second harmonic.

Page 2 illustrates the set known as Radiola 20.

Page 3 illustrates the set known as Radiola 25.

Page 4 illustrates the set known as Radiola 28.

Page 5 illustrates one of the forms of the sets known respectively as Radiola Ten and as Regenoflex, being the particular form in which is a so called "push-pull" amplifier is employed.

Q. To avoid any possible misunderstanding, when you speak of Radiola "Ten" that "Ten" is usually a Roman numeral?—A. More often written as the Roman numeral "X."

Q. And therefore sometimes called Radiola X, that would be the same thing?—A. I do not know, but that is quite likely.

Q. And the next one then?—A. Sheet C-6 represents a modified circuit arrangement used in the same sets, just mentioned, namely Radiolas X and Regenoflex.

Q. Which are essentially the same I gather?—A. They are substantially the same in their circuits.

Q. For our present purposes they are substantially the same?——A. Yes.

Q. And not in the super-heterodyne?—A. No, they do not use the super-heterodyne principle.

Q. Am I right in understanding that they do not use the intermediate frequency principle as you described it yesterday?—A. That is correct.

Q. And when you say that you find Alexanderson in all these sets that is in the sense that you say that you find the principle of Alexanderson as you had found it for ten years or more back in different sets?—A. I find the combination of apparatus and the method of operation disclosed in the Alexanderson patent, embodied in all of these and as I said, in substantially the general form of figure 2.

Q. You yourself did not design any of these?—A. I did not.

Q. You did not have to do with the designing of any of these?—A. I did not.

Q. And you can merely look at them and say, I see there what I call Alexanderson?—A. I have used them all: I know how they operate, and I have seen them built and I have seen them go through their laboratory tests, so that I know them in a more intimate way than your question might imply.

Q. I am not suggesting lack of intimacy, but it is just because of your intimacy with these sets that you said in the Splitdorf case that you had that very marked intimacy with Alexanderson—this and other sets?—A. These and others, and arrangements that I have set up myself, and that I have seen used in other connections.

Q. There is no commercial set anywhere called "The Alexanderson Set"?—A. Not that I know of, no.

Q. For instance someone speaks of a "Hazeltine Set." You know what that means?—A. There is no set on the market called "The Hazeltine set."

Q. I know there is not, but you hear them spoken of. They are called neutrodyne, but you hear them spoken of as Hazeltine sets, do you not?

—A. Not so often as I hear them and others spoken of as Alexanderson sets.

Q. You think not ?—A. No.

Q. Can you tell me of any set that is ever spoken of as an Alexanderson set ? Name one commercial set, that is called in the market an Alexanderson ?—A. In the same sense in which they are called Hazeltine sets, they are all called Alexanderson sets.

Q. Can you tell me of any one which is advertized as an Alexanderson product ? As we saw them here yesterday the set in suit was advertized as a Hazeltine product ?—A. I do not know to what you refer yesterday but they are not advertized so far as I know.

Q. You saw the booklet here ?

His Lordship : It will not help us to determine this issue, to hear what the public call a thing. I am not concerned with that and it will not prove anything.

Mr. Henderson : Q. The point is, you say you find what you call the Alexanderson principle in these, and that is the principle of geometric selectivity is it ?—A. Yes, I have said so.

Q. With relay ?—A. Yes.

Q. And you have told his Lordship, or have you told his Lordship that Alexanderson was in your opinion, the true and first inventor of geometric selectivity ?

His Lordship : I do not care very much what he says about that, because I have to find that.

Mr. Henderson : Yes, my Lord.

Q. But is that the impression that you seek to convey ?—A. I am seeking only to answer the questions asked me, Mr. Henderson. I am not an advocate.

Q. I know, but his Lordship has to reach a conclusion. Are you seeking to convey to his Lordship the impression that Alexanderson was the true and first inventor of geometric selectivity ? That is a fair question ?—A. If you will pardon me, I am not here as an advocate ; I am seeking to answer the questions asked me truthfully and honestly.

His Lordship : Even if he said so, how would that be evidence ? If Mr. Smart put that question and you objected, I think I would have to rule it out.

Mr. Henderson : He is stating his opinion, and your Lordship has to find the result, I quite agree.

His Lordship : It is not relevant for the witness to tell me whether or not Alexanderson's idea is invention. He cannot do that. If that was the function of the witness there would be nothing left for me to decide. I would be very grateful of course. You may be sure, Mr. Henderson, that he believes that it is, and he may be willing to say so if you press him, that he believes Alexanderson is the inventor.

Mr. Henderson : I should be very glad to hear him say so, my Lord.

His Lordship : What good would it do you to have him say so ?

In the Exchequer Court of Canada.

Plaintiff's Evidence.

No. 7. Frank N. Waterman. Cross-examination *—continued.*

MR. HENDERSON: Just the pleasure of hearing Mr. Waterman say something which would be a real live statement. Your Lordship is on a point that is always difficult. I remember years ago discussing it with the present Chief Justice of the Supreme Court of Canada: what is the line of demarcation in evidence, where you have an opinion witness. There is no doubt it is for the court to find.

HIS LORDSHIP: There cannot be much difficulty about this question, because I do not want to hear a witness say directly that Alexanderson was or was not the inventor. That is what this contest is about.

MR. HENDERSON: I will not press it.

MR. HENDERSON: Q. Now then getting back to the use of the vacuum tube, I want to ask you again something that I touched upon yesterday. Is Alexanderson limited to the use of a vacuum tube relay in his patent? —A. I do not know how I can determine that.

Q. I am not asking you as a matter of law, but as a matter of reading the patent as a practical man.—A. Well, I would so understand. I know of no other relays than those which he describes and others of their ilk which would serve the purpose.

Q. Let me understand that, and I do not care which way you put it. We had the three electrode relays described in Alexanderson, did we not?—A. Yes, and also a six electrode.

Q. And you quoted a paragraph where he said his relay was preferable to the vacuum tube, and he went on to describe it as containing three electrodes, did you not?—A. I was asked about it, yes.

Q. And you called attention to the fact that in the other figures he showed a six electrode tube?—A. Yes, I was asked to give my understanding of what the word "preferably" referred to.

Q. I am seeking to emphasize it, and your understanding was that he, having described the three-electrode type of tube and also the six-electrode type of tube, expressed a preference for the three-electrode type over the six-electrode type. Is that seriously your understanding of the reading of his specifications?—A. Yes, when taken in connection with the rest of the answer that I gave, namely, that there are still other forms of tubes, and were still other forms of tubes known in which, for example, there were three elements, but one of them was not a grid, and he expressed a preference for the grid form.

Q. When you say one of them was not a grid are you speaking of the perforated plate?—A. No.

Q. You know there is such a thing as a perforated plate acting as a grid? I am using the word plate in the broad sense.—A. I know grids have been made by perforating plates.

Q. Grids have been made by using perforated plates?—A. Grids have been made by perforating plates.

Q. As a matter of fact the operation of the grid is something of a sieve action, the constituent parts of which are sufficiently close together not to allow too much to escape through without being attracted by the metal. I am putting that from a layman's point of view. Do not smile, because I am right and you know it. It says a regulator, and you have described it.—A. From a layman's point of view I think you have described it.

Q. I mean a common horse sense point of view, shred of refinements. Am I not right?—A. I do not think I understand what the inquiry is.

Q. Is there any difference in the operation of the perforated metal grid and the type of grid, the wire grid we have been talking about, which is a grid, is it not?

HIS LORDSHIP: Do you mean the effect of it?

MR. HENDERSON: *I mean the principle of operation.* Each is there for the purpose of intercepting the flow of electron.

HIS LORDSHIP: Is the flow of electron the same?

MR. HENDERSON: I do not mean that each will operate exactly the same. Take for instance a grid the wires of which are far apart, it will not operate identically the same as a grid the wires of which are close together. I think it is rather obvious that you may accomplish the same object in principle by using a perforated plate as by using a sort of coil of wire?—A. Yes, broadly speaking, and I would include that as a grid. I was not thinking of differentiating. I was not speaking of that.

Q. We are getting away from the point. Mr. Alexanderson shows in his device a three-electrode type of tube and a six electrode type of tube, and he speaks of each in his specifications. That is true, is it not? —A. Certainly.

Q. I understood you to say yesterday that when you read of Mr. Alexanderson expressing a preference for the vacuum tube you read that as expressing a preference for the three-electrode tube over the six-electrode tube. I ask you, are you serious? Did I understand you rightly? —A. May I state precisely and concisely——

Q. Is that not a simple thing to which you can answer yes or no? Did I understand you that that was the preference as between those two tubes?—A. That is part of what I have said, and I think you understand it correctly. What I said was that he expressed a preference for the three-electrode tube having a cathode, a grid and an anode.

Q. That is what I am talking about. I am speaking of the three-electrode tube which he showed on his figure and described.—A. I pointed out that that distinguished on the one hand from a tube which contains a cathode, an anode and controlling plate, and on the other distinguishes from a tube which has a cathode, two anodes, two controlling grids, and a shielding grid.

HIS LORDSHIP: That is as shown in Fig. 3.—A. Yes, your Lordship.

MR. HENDERSON: Q. But there were in existence and in use at that time other forms of relay than the tube relay?—A. I do not think so.

Q. You do not know of any other form of relay other than the tube relay in existence at that time?—A. As far as I know there were none that would serve Mr. Alexanderson's purpose or that had ever been successfully used. Of course, there were experimental forms of mercury tubes that people desired to use, but I do not know that anyone ever succeeded.

In the Exchequer Court of Canada.

Plaintiff's Evidence.

No. 7. Frank N. Waterman. Cross-examination —*continued.*

Q. It would be a little too much to expect you to know all that.—A. I think I know the art as well as most people; I have grown up with it.

Q. Well, I do not know about that. I want to know just what you do know about relays then available.—A. I do know that there were no relays then available——

Q. That you know of?—A. That would serve——

Q. That you know of?—A. I think I can say there were no relays then available which would have served Alexanderson's purpose, serving as a one-way coupler for tuned high frequency circuits.

Q. And you emphasize there "as a one-way coupler"?—A. I did not intend to emphasize that more than any other part of my statement.

Q. But you do now describe it as a one-way coupling?—A. If you object to that term I will put it the other way.

Q. I do not object to it.—A. I mean the successive selection by repetition which requires that a new signal be furnished for selection at each stage.

Q. But getting back to the point which I have spent nearly half an hour trying to get you to answer, is Mr. Alexanderson limited in this patent to the use of a vacuum tube relay?—A. I hardly know what you mean by the expression, "Is he limited," but I understand there is nothing else he can use.

Q. Suppose for instance that there is a slight possibility of Mr. Waterman not knowing everything, and that some one else did have another relay, not of a vacuum tube relay, I do not care whether it is a six-electrode or three-electrode or what kind of a grid, but that there was a relay other than the vacuum tube relay which could be used with the Alexanderson device, would he be infringing Alexanderson's patent? I am not talking as a matter of law but as a matter of practice.—A. If there is another relay which will act to enable one to carry out the process as described by Alexanderson, I can personally see no reason why he should not use it.

Q. For once you are involved. I do not understand you. You cannot see why who would not use it?—A. Alexanderson or anyone practising his invention.

Q. But would he have a right to use it and say that it was not covered by Alexanderson?—A. That is a question of law.

Q. I am not speaking as a question of law. I am talking to you as a patent expert reading Alexanderson's patent; do you think he limits himself to the vacuum tube relay?—A. Yes, I understand his description is so limited; whether his patent is so limited I do not know.

Q. We have geometric selectivity plus relay, have we not?—A. No, you are entirely wrong. We have not any such thing. I see where your difficulty is. We have geometric selectivity on account of the relay. If you have the other impression I can see where you are wrong.

Q. I am quite content that you can put it that way if you like. You have geometric selectivity, and I want to emphasize that very definitely. What I am trying to do is to get your position definitely so that we can think and talk about it, not in that nice, easy, offhand way in which you can go back and say, "I meant something different." You say

Alexanderson has geometric selectivity because he has a relay ?—A. Because he initiates each time a new signal.

Q. Do you say he would not have geometric selectivity without that ?—A. I certainly do.

Q. Was there ever any geometric selectivity before Alexanderson ?—A. No, *except in the sense which I stated yesterday*——

Q. These exceptions and reservations——

HIS LORDSHIP : Let him finish.

THE WITNESS : I stated that with the arrangement, which I have forgotten, which you were asking about yesterday, that geometric selectivity existed as the theoretical limit which would be attained when you lost your signal altogether.

MR. HENDERSON : I know what you mean, and I think we have you fairly clear. Have you sufficiently to your own satisfaction defined a relay as the term is used in the Alexanderson patent ? Is there anything else you want to add to that ?—A. No, I have no desire to add anything.

Q. Can you now concisely define a relay as used in the Alexanderson patent ?—A. I think so.

Q. Please do it.—A. A relay of the Alexanderson patent is one which is affected by electromotive force, developed in the tuned circuit by a desired signal, governs a local independent source of energy, initiates a new signal, repeating the desired signal and again selecting in another circuit tuned to the same desired signal.

Q. Will you answer this question, please ; is the Alexanderson patent limited as to frequency ?—A. It goes directly to the selection of a high desired frequency, radio frequency signal from undesired radio frequency signals.

Q. Can Alexanderson's system be usefully employed with oscillations as low as 12,000 cycles per second ?—A. I do not know.

Q. What is your opinion ?—A. Well I should say that wherever you could not hear them directly, wherever they are above the range that the ear will respond to——

Q. I do not follow you. Can Alexanderson's system be usefully employed with oscillations havin a frequency as low as 12,000 cycles a second ?—A. What you have done is to ask me whether if I am straddling the international boundary line, I am in Canada or in the United States. That is all the difficulty. You are taking a frequency that some people can hear and some people cannot hear.

Q. I am dealing with the frequency which my next question will show to you means something exceedingly real, and therefore I ask you for an answer to my question.—A. Assuming that 12,000 cycles is, as I believe it to be, a radio frequency for the operators concerned, and assuming that there can be at that range governing signals of such wave lengths as to be considerably removed in frequency from 12,000 cycles, I would answer the question in the affirmative.

Q. With all that assumption, that *is an answer to the question* ?—A. Yes.

Q. You know the frequency with which the Lafayette station at Paris operates ?—A. No, I do not remember.

In the Exchequer Court of Canada.

Plaintiff's Evidence.

No. 7. Frank N. Waterman. Cross-examination —*continued.*

Q. Do you know that it operates at about 12,000 cycles a second? —A. No, if I did I would tell you.

Q. I am surprised at that. I thought you did know all these things. Perhaps I give you credit for being too much of a human encyclopaedia. Let me give you this proposition: Alexanderson gives you two examples in his patent: one describes conditions when the effect of a signal is the same in successive stages; the other when the effect increases from stage to stage. That is right, is it not?—A. I do not follow it.

Q. I will repeat it. Alexanderson describes conditions when the effect of a signal is the same in successive stages, and again when the effect increases from stage to stage?—A. I do not recognize that as a correct technical description, apart from its context.

Q. If you have the patent there, will you look at the paragraph commencing at line 118 on page 2 of the specifications, which reads:

> "It will be readily understood that instead of adjusting the grid potential of the relay devices, the potential of the battery in the plate circuit, and other variable features, to initiate oscillations in which the waves of the desired frequency are reproduced with undiminished intensity, the same relative result may be secured by magnifying the oscillations."

and so on. Now, is that not a case of describing conditions when the effect of a signal is the same in successive stages?—A. Certainly, but I simply do not connect that statement at all with your former question. Answering what I think you are after——

Q. I read that statement and then I read the first part of my former question, so why do you say you do not connect it, Mr. Waterman?— —A. Because I do not. But I can tell you the fact very quickly. The essential idea of Alexanderson is the idea of repetition, and until we get down to the passage that you point out, he is describing the selection on the assumption that the signal is repeated exactly as received without change of intensity up or down. That is, he is paying no attention to the matter of intensity, so long as it is sustained. Now, having pointed out how selectivity is gained, when the signal is repeated at, as he says, a uniform intensity from stage to stage, he says you may also at the same time amplify it from stage to stage, and the rest of the specification is devoted to that.

Q. You use the word "intensity" and I use the word "effect" and I prefer your word.—A. I took the word from line 124 on page 2.

Q. Precisely. When I am talking as to the effect, I am talking of the effect as to intensity, because we are considering intensity. Following that and following what you have said, does Alexanderson in your opinion cover the case where the effect of a signal decreases from stage to stage, having again intensity in mind?—A. I think it would be rather a poor way of using it, if you do not have to.

Q. Do you find it there,—does he cover it?—A. He does not describe it, no.

Q. Of course if he does not describe it and does not cover it, no question of infringement would arise. That would be a matter of law, of course?—A. I do not understand your use of the word "cover."

In the Exchequer Court of Canada.

Plaintiff's Evidence.

No. 7. Frank N. Waterman. Cross-examination —*continued.*

Q. You understand what I mean when I use the word "cover" do you not?—A. No, I do not, because that has a legal significance, I have been told.

Q. We have not all your facilities for making lengthy statements,—I do not mean that offensively, but your meticulous accuracy, shall I call it? Can he claim patent right in the case that I mentioned for the moment?

MR. SMART: *How can he say?*

HIS LORDSHIP: He can not answer that.

MR. HENDERSON: If he can not answer it I will not pursue it.

Q. You have already told us you were an expert in the Kilbourne and Clark case?—A. Yes.

Q. That was an action brought for the infringement of the Marconi patent No. 763,772. Will you let me see that patent, please? You were not clear yesterday as to that being the precise patent?—A. I told you that I thought I recognised the number as being the number of one of the patents involved in that litigation.

Q. If I show you the drawing you will recognize it at once, I have no doubt. Just to refresh your recollection of the number by a glance at the drawing, that was the patent that was there in suit, was it not?—A. It was one of the patents that was there in suit, yes.

Q. And Mr. Marconi himself gave evidence in that case, did he not?—A. I think there was a commission issued.

Q. Exactly. His evidence was given by commission?—A. I believe so.

Q. Did you yourself have anything to do with the taking of his evidence on commission?—A. I did not.

Q. You know Mr. Weagant, who gave evidence here, do you not?—A. Yes, I do.

Q. He was associated with you in that case?—A. In the sense that he was there as a witness and so was I.

Q. And you were in conference, weren't you?—A. Oh yes.

Q. *And Mr. Weagant is a gentleman of high standing in the profession?*—A. Very.

Q. Mr. Taylor, who also gave evidence in that case, was associated with you was he not?—A. Only to the same extent that he was there as a witness.

Q. And you were in conference together?—A. I do not remember it; perhaps so.

Q. And Mr. Taylor is also a gentleman of high standing?—A. Very.

Q. What is his present position?—I think he is Chief Communication Engineer, or he has charge of trans-Atlantic communication, I think. I do not remember his title.

Q. For what?—A. For the Radio Corporation of America.

Q. And you know what the points at issue in that case were. You heard Mr. Marconi's evidence read, did you not?—A. I could not say. I was not there all the time and I do not know whether I heard it or not.

Q. Was there anything said by Mr. Marconi in the course of that evidence with which you disagree?

HIS LORDSHIP: I do not care what Mr. Marconi said.

MR. HENDERSON: I want to see what the opinion of the witness is.

HIS LORDSHIP: It is all right to test a witness' testimony; but I do not care what this witness or any other witness said as to Mr. Marconi.

MR. HENDERSON: I want just to ask if he agrees with the opinion given by Mr. Marconi.

HIS LORDSHIP: Put it to him straight.

MR. HENDERSON: I find at question 27, page 43 of the Plaintiff's brief, where the extracts are taken from:

> " How great a distance were you "—that is Mr. Marconi—" able to transmit and receive intelligible messages prior to the invention and utilization of your patent No. 763,772? —A. 82 miles."
>
> " 24. How great a distance have been able to actually transmit and receive intelligible messages due to the utilization and adoption of the invention of your patent No. 763,772? —A. 6,600 miles."

MR. SMART: Before the question is put I wish to make a statement.

MR. HENDERSON: I am going to ask him as to his knowledge of the then state of the art and as to whether or not he knows that that was the Marconi practice at that time as a result of the bringing into effect of patent No. 763,772.

MR. SMART: I have not yet got the question.

MR. HENDERSON: I am stating the question now.

MR. SMART: I can not formulate my objection until the question is formulated.

HIS LORDSHIP: Is there no other way? I will not permit the introduction of Mr. Marconi's evidence into this case or of any other body's evidence into this case; but you probably can put your question in another way and get his opinion upon the fact. I do not want you to commence leading by what took place in another trial.

MR. HENDERSON: If there were a jury here, I would say it would be very dangerous, as it might be construed as an attempt to get Mr. Marconi's evidence into this case. But where your Lordship is sitting without a jury, it surely must be innocuous to state what was said and ask his opinion.

HIS LORDSHIP: You might eliminate Mr. Marconi's name altogether.

MR. HENDERSON: I have to ask him whether he was aware that the Marconi Company was doing this.

HIS LORDSHIP: I am going to allow you to put the question, but do not read from the evidence in another trial as to what anybody said, because you know that is not right.

MR. HENDERSON: I appreciate that if there were a jury here your Lordship might resent my doing it as an attempt to get Mr. Marconi before this court. I may say I have a witness here who will be put in the box.

HIS LORDSHIP: I am going to take this evidence. The witness may not remember what Mr. Marconi said.

Mr. Henderson: He was in the case. He might not remember. I quote from the record the statement that the Marconi Company utilizing patent 763,772 could get a distance of 6,600 miles where formerly they were only able to get 82 miles. What do you say as to that as a practical matter at that time ?—A. I do not understand that Mr. Marconi stated it as a practical matter ; and it certainly was not a practical matter. What was said there, as your reading of the testimony indicates to my mind, was merely that the attained record prior to using that invention was 80 some miles, and the attained record subsequently with the invention was some 6 or 7,000 miles. Not that that was the regular practice, because it was not.

Q. You and I have not differed very much yet, and I do not want to differ. I do not attempt to suggest that they were doing this thing in every day practice. I quite agree with you that they had succeeded in getting these distances, not that every operator would get it every time, but that this was their record, we will say, under patent No. 763,772, whereas 82 miles had previously been their record ?—A. Each being accomplished once.

Q. I accept that. Then I want to read at question 34 following this, and still dealing with the Marconi patent : " To what extent has the invention of your patent No. 763,772 been put into use by you or your companies "—that is the Marconi companies,—" owning corresponding Marconi patents ? "—A. "This patent has been and still is in use in almost all the countries of the world. Beside the companies which commercially exploit this invention in the United States and Great Britain, similar companies also exist in France, Germany, Spain, Italy, Australia, South America, Russia and Canada, all of which carry on a successful system of wireless telegraphy using this invention." What do you say as to that statement of fact ?

Mr. Smart: I think, my Lord, that this form of examination should cease. It is obviously an attempt to import the name of Mr. Marconi into this case. If my friend needed the evidence of Mr. Marconi or any other witness in this case, he can get it. He can not speak for Mr. Marconi. If this witness knows the facts he will freely give the answers, and the question should be put to him not under the name of Mr. Marconi or of any other witness.

His Lordship: Of course, it is highly improper. The way you put it Mr. Henderson, it may be said to have become secondary evidence.

Mr. Henderson: I am distinctly disavowing any attempt——

His Lordship: Any statement in Mr. Marconi's evidence I could not look at.

Mr. Henderson: Surely not until the witness agrees with it. It does not become evidence until he does. I can do it in this way.

Q. Is it not a fact, Mr. Waterman, that the Marconi Company and its allied companies have been and were at the time of the Kilbourne and Clark case still using patent No. 763,772 in all the countries of the world practically, besides the companies which commercially exploit this invention in the United States and Great Britain, similar companies also exist in France, Germany, Spain, Italy, Australia, South America, Russia and Canada, all of which

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carry on a successful system of wireless telegraphy using that invention ?—A. Of course, I have no personal knowledge of any considerable part of those facts; but that corresponds to my understanding; and I might say that they are still doing it.

Q. Of course, one thing you will agree with me on, Mr. Waterman, is that so far as absolute personal first-hand knowledge is concerned, you would be sorry to be limited to it, would you not? You are here being treated as one having knowledge of the art of radio, and knowledge of that kind would be included in that knowledge of yours, would it not?—A. I do not know. I am perfectly willing to tell you all the things I know of my own knowledge and what things I know as of information.

HIS LORDSHIP: That is, it would not be within his province, necessarily, to know the commercial extent.

MR. HENDERSON: Not necessarily as of personal knowledge; but I am simply asking him for the kind of knowledge which one intimate with the development of the art has.

HIS LORDSHIP: I think that is all right.

MR. HENDERSON: Q. Then would you take this. Did you hear Mr. Weagant's evidence in the Kilbourne and Clarke cases?—A. I certainly heard some of it and, I presume, most of it.

Q. Did he speak of the patent No. 763,772?—A. I have no recollection now as to just what the substance of his evidence was.

Q. Do you agree with this statement, which I suggest to you was made by one skilled in the art, that tuning the transmitters and receivers of the couple tuned circuit type is an essential necessary thing and that no usefulness in the modern day sense is obtainable without it?—A. I certainly do. That is my experience.

Q. And that would still apply to-day, would it?—A. Certainly.

Q. Is it not a fact, and again of course I must ask you to speak as one skilled in the art and not confine yourself to what your own eyes have seen. Is it not a fact that substantially all commercial radio transmission and reception apparatus to-day make use of the fundamental arrangement and the invention of Marconi, as shown and described in the patent No. 763,772?—A. Why, yes, in the sense in which I am testifying here, that is perfectly true. In other words, may I just state my position and I may save you a great deal of time. I understand that this patent which you are now asking about is the basis of our modern art, and that Alexanderson built on to it.

Q. What did he build on to it?—A. The idea of selection by successive repetition, initiating each time a new signal.

Q. You think that that added something to it?—A. I am certain of that. That is a matter of fact.

Q. I am trying to be just as meticulously accurate as you are. Is there any distinction between building on to it, which sounds to me like using it as a foundation, and adding something to it?—A. I do not know how you use those words. What I mean is that Alexanderson did not throw away the art which went before him. Alexanderson is in that line the culmination. He added the final big step which has made selective reception.

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His Lordship: In other words, Alexanderson did not invent what Marconi invented ?—A. Quite right.

Mr. Henderson: Where did he start ? You say Alexanderson proceeded along and added another stage of development to the art,—is that it ?—A. Yes.

Q. Where did he start,—what was his starting point ?—A. This Marconi patent which you are asking me about represents the big step that was made from the early art in which transmission was effected by a spark in the antenna, and reception by a detector in the antenna.

His Lordship: May I ask this question: Assuming Alexanderson represents a development, was it the initial development after Marconi's work, or did somebody intervene, in your opinion only ?—A. There were a vast number of workers between. It would take perhaps a judicial survey of the art to classify them in magnitude; but the Marconi patent and things that were obviously developments of the same idea constitute, according to my understanding, the foundation from which Alexanderson started.

Q. Do you say that Marconi laid the foundation of selectivity ?—A. I think Marconi laid the foundation of everything we know as practical reception and transmission to-day. I want to say that patent has two aspects. It revolutionized not merely the first antique type of reception but equally the first antique type of transmission. It applies to both transmitters and receivers.

His Lordship: Do not be misled by my asking a question. You are just touching a field which unfolds the whole issue here. Probably Mr. Smart intends to examine this witness farther along that line. Do you ?

Mr. Smart: It would come more properly in reply, my Lord, after the case is put to the witnesses.

Mr. Henderson: Surely not. I am purposely opening this up because to my mind it must go into chief and not in reply; and I suggest now that I shall most strenuously object to my friend taking it up later. I am taking it up now.

His Lordship: Of course the patentee presents his case by producing his patent. Prima facie that is valid, say, and proving in a manner some infringement. Of course Mr. Smart may refuse to go into this any further. I am not sure that it is wise not to put his whole case in at once. You are just approaching the point in controversy here, and if you are both going to develop that, I will not ask any more questions, because you can do it much better than I can.

Mr. Henderson: We are pleased, not to say astonished. Your Lordship is sitting here without a jury. I am not going to object at any stage to anything which is going to illuminate your Lordship's mind. We think your Lordship is getting the idea and you are right in what you say now, that we are at the point. We are now at what we have been laying the foundation for. I indicated that at the very outset.

His Lordship: Of course, if this is a combination patent.

Mr. Henderson: My friend emphasized the fact.

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HIS LORDSHIP: That makes it a different case.

MR. HENDERSON: I am quite content. My friend has said that this is a combination patent.

HIS LORDSHIP: I suppose in a sense it can not be anything else.

MR. HENDERSON: It can not be anything else, although I do not know that the phrase—of course I am looking at it through different glasses from my friend.

Q. My last question was, can you tell me the point at which Alexanderson started, assuming that he was contributing a new stage of development to the art, can you state a point at which he started?

Q. I think that is what your Lordship wants to know and I am anxious to get Mr. Waterman's answer.

HIS LORDSHIP: Mr. Waterman may have to write several books on that.—A. There is a pretty large order involved in that question. No way occurs to me of answering the question, except to make a rather definite statement of what I understand was the state of the art which existed and which is referred to in the third paragraph of the specifications.

MR. HENDERSON: Q. Alexanderson himself does describe the state of the art.—A. He refers to the state of the art.

Q. Yes, he refers to the state of the art. Do you see anything in his description, or his reference, that you *offer with?

* *sic?*

MR. SMART: May we not have the first question answered?

HIS LORDSHIP: I thought the witness did answer it.

MR. SMART: I thought he was only commencing to answer it.

HIS LORDSHIP: No, he apparently wished to give it briefly and concisely and he refers to the description given in the Alexanderson patent.

MR. HENDERSON: That was my understanding.

A. I perhaps did not express myself clearly. If you want an elaboration of the state of the art, from which I understand Alexanderson started, so that his Lordship may have a clear and full picture of precisely where Alexanderson started, as you say, then what I said was that I would have to elaborate that state of the art which Alexanderson refers to in that patent.

Q. Indirectly you are asking me what I want, are you not? You are putting a question to me?—A. If I did not, I will.

Q. My answer is No, that is not what I want. I do not want you to give a dissertation on the state of the art. I have read it up to this point in the first thirty pages of a book, and I have seen another book with three hundred pages and still not reaching this point, and I do not want either the thirty or the three hundred pages, and I do not think his Lordship does; but I just want you to say, if you can, that there was a point in the development of the art at which Alexanderson started—if there was such a point; and mind you I am not seeking to stop you from as long an answer as you choose to give, but I would like, inasmuch as you say that Mr. Alexanderson did something entirely new in the art, to know where he started and where he left off in the art.

HIS LORDSHIP: That is quite clear, and there are just two ways of answering it: either very briefly and generally or perhaps at some length.

MR. HENDERSON: I am content with either way, and I think your Lordship would like to know?

HIS LORDSHIP: Yes, I should like to know, but I do not think that question can very readily be answered in a brief manner. Well, Mr. Waterman, you may answer that.—A. I am afraid I do not know how to do it briefly, my Lord.

MR. HENDERSON: Then do it at length.

HIS LORDSHIP: Did you go over this ground before, yesterday?—A. No, sir.

Q. Then you must proceed to answer the question, taking your time?—A. I went over it yesterday only to the very brief extent that it is touched upon in the Alexanderson patent itself.

Q. Speak a little more loudly please?—A. I went into the matter yesterday only to the extent of giving the technical meaning of what the patent itself says. First, I think it must be understood that the problem of selectivity, while faced from the very start, altered completely in character with the development of the continuous wave signals.

Q. Pardon me for interrupting you there. Continuous wave signals follow the spark?—A. Yes, my Lord. The reason for that is that the possibility of selectivity in spark signals,—the limiting possibility—was determined by the spark signal itself. No apparatus could do better than that order of selectivity which the spark itself determined. In the pursuit of such selectivity as was then attainable—and it was not of an order that we would recognize as a great deal today, but it is a very important foundation for all that we know today—Mr. Marconi and other inventors working in the same line, developed the idea of receiving in a tuned circuit—in the case of the Marconi patent that tuned circuit was the antenna—and then transferring magnetically the so received waves into another tuned circuit, so that the energy which came in, which was cumulatively built up, as the patent points out, to an extent determined by the limitations of the antenna —which were very severe limitations—was transferred more or less to the circuit associated with that antenna, and there built up in that associated circuit, which was a more closely tuned circuit. Now the concept that Marconi developed was that the antenna whether for reception or transmission was, tunably considered an inferior thing. It was a good radiator of energy at a transmitting station. It was a good thing to gather, or pick up, energy at a receiving station. In order to build up effectively by resonance he pointed out that the energy could be transferred from that antenna over into an associated tuned circuit. Others incorporated the idea of using more than one tuned circuit. When I say others, perhaps Marconi did it first; I do not know; I have not looked into it; but Marconi himself I know in his receiving sets, or some of them, had another tuned circuit intervening.

Now for the purpose of such selectivity as was attainable in that day, those things constituted enormously great advances over the single vertical antenna with the detector in it. They came however to a very sharp definite limit. If those two circuits were so associated magnetically as to transfer the maximum energy from the antenna,—or whatever circuit we are considering as preceding, to a second circuit, then it developed that the selectivity, regarded as the power of discrimination, was not so great as that of the second circuit alone.

I would like to hedge that a little, because I am not perfectly certain; I would modify or qualify that a little, because I am not perfectly certain that that last statement is rigidly accurate, but at any rate the improvements did not correspond at all to, well, perhaps I might say, to what one might expect from such an association. It was found, however, that if one separated the coils more and more, that better and better results were obtained in point of selectivity, but the signal was progressively lost; so that the indication was that one would get an effective use of the associated circuits when the circuits were so far separated that the signal was not transferred—if I may be permitted that way of putting it.

In other words, the limiting condition was a zero signal when effective tuning was obtained. That is a rather crude and rough and certainly as brief as I can state it, picture of the art as it existed for many years. There were many workers in the field. But perhaps before I proceed, I need one more statement as to the prior condition.

The reason why these effects, useful as they were, did not attain what we would now require as absolutely essential, they did not realize at all what we would regard as the beginning of selectivity now—was that those circuits reacted on one another. The signal received in the first tuned circuit, transferred inductively to a second circuit, was transferred by a mechanism that worked just as well in one direction as in the other; therefore the signal having been transferred progressively inward,—that is from a first circuit to a second circuit—as soon as the second circuit began to operate, it began to transfer back into the first circuit, and the result was that the system regarded as a whole, did not oscillate or tend to oscillate at the frequency of the desired signal, but at two frequencies, neither of which was the desired signal.

Now, as the association was varied, those two frequencies came together and the losses and the broadening of the tuning, in other words the lack of selectivity which they cause, is the thing which gradually disappeared as the signal disappeared. In other words, to get rid of it you had to substantially lose the signal, but it was useful for those damped or spark oscillation signals because it did permit a much greater accumulation of energy from the ether, from the air. Just as the transmitter on that plan permitted the sending out of very much greater quantities of energy so that method of the accumulation of energy in an antenna, which was not limited by the requirements of a detector in it, so that method of reception accumulated energy, and it was because of that striking contrast between what had gone before and the thing accomplished by that Marconi patent, that such a great increase in ranges became possible.

Now coming to Alexanderson's concept. Alexanderson proposed to operate a relay device at the enormous frequencies of radio carrier waves, and to use such a relay, to be governed only by what came in, and to initiate a new signal. There then was no equal effect both ways. The incoming signal, taken in, if you please, in identically the Marconi way, accumulated in a local tuned circuit, just as Marconi and others in the art taught, put through a succession of them if you please, as various ones in the art taught, was then used to govern the operation of the new generator of signals. That new generation of signals, " initiation " is the word I think he uses, was governed by the incoming signal and the incoming signal was used for that purpose only : and the device repeated that signal without consuming its energy.

Now that, as I understand it, is what Alexanderson added. Coupled of course with the idea of again selecting. And that could be repeated. The thought then built on to Marconi—and in this sense I use Marconi as representing the workers in the art, in advancing,—was the thought of not consuming the energy of the signal ; allowing it to develop the full selectivity of the circuit. That is a thought which I have touched on but which is a difficult one and I may not have made it clear. If we utilize the energy that is coming in, we to that extent destroy the tuning. Now the thought that Alexanderson had is not to destroy that tuning, but to utilize it, and use as he says the potentials—I read the passage yesterday but I do not remember just where it is—generated in that circuit by virtue of the full utilization of the tuning, to govern a device initiating new signals from an independent source of energy and that gave an order of selectivity—when with the other features that I have just noted—capable of utilizing the benefits of the continuous waves. I think what I have now said connects directly with what I yesterday explained to your Lordship : I cannot think of any briefer way of stating it, but I could, of course, elaborate it.

His Lordship : Can you illustrate that by distinguishing between the mechanisms or instrumentalities which Marconi used ?—A. Yes.

Q. And which Alexanderson used ?—A. Yes, if I may have a copy of the Marconi patent that will serve the purpose, or I can draw a picture.

Mr. Henderson : Just draw a sketch. I want it in your own way. This appears to me to be an important point ?—A. I will draw a sketch of it. (Witness draws sketch.) I have made a sketch which is a very much simplified diagram of what, according to my recollection, is shown in one of the figures of this Marconi patent that I have been asked about.

Q. Then again, for greater certainty, at the extreme right are telephones ?—A. Yes. If your Lordship desires I will put letters on the various parts in that sketch and describe it, or I will make another diagram.

His Lordship : Q. What are these things I am pointing to ? Are they batteries ?—A. That is a condenser. The two parallel lines represent a condenser. When the line is drawn diagonally across it indicates that the condenser is variable.

Q. The DeForest tube had not been invented at that time ?—A. At which time ?

Q. In 1913 ?—A. Yes, it had.

Q. Was it used by Marconi ?—A. No, not until later than 1913, but this Marconi patent is 1904, and it represented the state of the art with additions all the way up to Alexanderson's time.

Q. In 1913 were they using in the Marconi device the valve ?—A. That is the convention which Marconi uses in that patent to illustrate a

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detector, and it is carried out in this way (Indicating), and it actually represented what was known as a co-herer.

MR. HENDERSON: Referring to the portion now marked "detector."

EXHIBIT D:—filed by Mr. Henderson, Jan. 12th, 1927. Sketch drawn by witness of Marconi patent.

Q. I understand you to say that you do not feel that you can fairly attempt to condense what you have said as to the point at which Marconi commenced?—A. I do not see how it is possible.

Q. You have referred to Marconi's coils reacting back on one another unless they were separated widely. How did Alexanderson prevent his coils from reacting on one another?—A. Which coils do you refer to?

Q. The same coils you spoke of as reacting on one another in the case of Marconi? That is the coils including two tuned circuits.—A. Of course, he did not. The antenna he specifies twice should be very loosely coupled, and then he says that its effect as an improver of selectivity is to be disregarded.

Q. But he specifies "very loosely coupled"?—A. Yes.

Q. Just generally, how far apart does he say to place the coil or does he say?—A. The idea of loose coupling in connection with that state of the art, which as I have said was the state of the art for nearly ten years prior to Alexanderson and known and used by everyone who worked in the art, meant——

Q. I think you are answering something I did not intend to ask. I intended to refer to the coupling between the tuned input and output of the relay.—A. You have said exactly the opposite thing.

Q. I think I did.—A. You said the circuit corresponding to Marconi——

Q. I think I did inadvertently. I am referring to the coupling between the tuned input and output of the relay.—A. Well, that is a very different question.

Q. That is the reason I stopped you, because I did not want to waste your time.—A. I take it that the question that refers to the association of the two coils of each transformer, the primary of which is in the plate circuit of the relay and the secondary of which tuned with a condenser furnishes the difference of potential, governing the next relay by way of its grid and cathode.

Q. What I am referring to is the coil in circuit 6 and the coil in parallel with condenser 15. I refer to this coil which is in parallel with 8, and the coil which is in parallel with 15 of this exhibit.

HIS LORDSHIP: Your queston is: what did Alexanderson do to prevent that reaction in the Marconi which the witness spoke about.

MR. HENDERSON: Q. How did Alexanderson prevent these coils reacting one upon the other? You spoke of a difficulty in the prior art, and I want to see what the practical effect was. How did Alexanderson prevent those two coils from reacting one on the other?—A. Those two coils do not have any tendency to react one upon the other. They are not coils associated in the way that the two coils of Marconi, which are the two coils shown in Exhibit 8, are associated. Of course, if these are so placed that in the magnetic field they reach round and react, there might be some slight action, but I take it that what you are really getting at is a wholly different question that has not any bearing on what we have been talking about at all.

Q. You say they do not react on one another. Is that obvious in the Alexanderson disclosure ?—A. Yes.

Q. And that is your considered opinion. I am quite content, whichever it is, but what I am wanting to do now is to leave nothing in doubt as to what your considered opinion is ?

HIS LORDSHIP : In the Marconi you say there was this reaction which was undesirable, and you say that Alexanderson has eliminated that ?—A. Yes.

HIS LORDSHIP : Mr. Henderson wants you to point specifically to the thing that effectuates that improvement.

MR. HENDERSON : As there may be reaction between different pairs of coils, I ask him how Alexanderson eliminates reaction between the two coils to which I have referred. He says there is nothing to prevent that, and he says that is his considered opinion, and that the Alexanderson disclosure so indicates. I am quite content to leave it at that for the moment. I think we will demonstrate to your Lordship that he is entirely wrong.

MR. SMART : If the witness could answer your Lordship's question, I think the matter would be made clear as to what in Alexanderson's patent prevents the reaction which the witness objects to in Marconi.

MR. HENDERSON : My learned friend may take the witness when the time comes.

HIS LORDSHIP : Better have it over now. The witness is endeavouring to show that the Alexanderson device is some improvement on Marconi and I want to know just how Alexanderson improved on Marconi. Can you tell me how he did it ? Is it capable of demonstration ?—A. Experimentally ?

Q. Yes.—A. Yes.

Q. Practically ?—A. Yes.

Q. Let me see it.—A. Of course, I will have to set up an apparatus to make a demonstration.

Q. Just state it.—A. Take this portion of Exhibit 8. It is, or may be considered to be taken out of the Marconi patent, we will assume if your Lordship pleases that the antenna, which is indicated here in dots and included in coil 2, is tuned as the Alexanderson patent describes and as the Marconi patent describes, and that it is associated by virtue of the more or less intimate relations of those coils bearing the numeral "2." The coil 2, traversed by all the cycles that come into the antenna, generates a rapidly varying magnetic field. What we call magnetic lines of force are sent out and pass through the coil associated therewith.

Now if that association is close so that a large percentage of the lines of force produced in the coil 2 thread the associated coil, then we have to a very marked degree the reaction, the effect of which I spoke. Now what the art did prior to Alexanderson was to separate the coils more and more,

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No. 7. Frank N. Waterman. Cross-examination —*continued.*

and as they were more and more separated fewer and fewer of the magnetic lines sent out, streaming out from coil 2, got into the associated coil, and that is what we call loose coupling. By making the association so loose that relatively few of the lines produced in the antenna coil 2 got into the associated coil, we get a weak signal, but the two frequencies came close enough so as to eliminate the effect of the reaction between the two coils. That was the prior art.

For the purpose of starting the process of selectivity—that is just where Alexanderson starts—he did not add a thing to the prior art. He emphasizes making this association loose. Now, however, instead of trying to get selectivity—because for Alexanderson's purposes this combination at the left in Exhibit 8 does not produce any tolerable degree of selectivity for the purpose of getting the selectivity that is demanded, that Alexanderson was after, instead of causing the second one to react on the third, and the third to react on the fourth, thereby drawing energy from the second coil, and thereby largely destroying its selectivity, he said: "I will use the voltage developed here to cause a device, as to which I prefer a form of tube having a cathode and an anode and a grid to initiate a new signal derived from a separate source of energy, *b* battery, and select that signal in an associated circuit."

Now I have no doubt your Lordship at once inquires, how about this association of circuits as Marconi stood in the art as it was at that time, this association of circuits is not the association of two tuned circuits. This circuit embodying the plate coil 12 for example of the first tube in Exhibit 8 is not in a tuned circuit. It does not have that retroactive effect of producing two waves instead of the one desired wave. It merely supplies the reproduced signal to the second tuned coil. Now the question that perhaps arises in your Lordship's mind is, does this tube device, this audion or electron tube marked, itself transmit from this tuned circuit—I will call it 15—some effect back through itself to the first circuit which is connected in the grid. That was the question Mr. Henderson asked. The answer is that speaking as of the same order of effect that we had in mind when we spoke of the destruction of selectivity due to the co-operation of these coils, the device is a one-way coupling device. The energy passes this way: no appreciable part of it passes from the output towards the input, but this very device is not perfect. There is a little so passes, but it passes not as an imperfection, causing the production of two waves, but it has a remarkable faculty of sharpening the desired wave. It improves the selectivity, but as I pointed out to your Lordship yesterday, it may have the effect, if pushed too far, of causing the tube itself to persistently oscillate. Now, I take it that Mr. Henderson's question went outside the substance of this point we have been considering, and inquired, in effect, how did Alexanderson prevent oscillation. That I assume is what he meant. Briefly, the answer is by the adjustment of the three batteries.

Mr. Henderson: Q. And you no longer say there is any reaction to prevent that?—A. I emphasize the fact that there is no reaction of that type which prevented obtaining selectivity.

Mr. Henderson: I think really your lordship was asking questions.

His Lordship: I think I am through.

Mr. Henderson: I see in your answer to the last question, being a somewhat lengthy answer, Mr. Waterman, there is an apparent misapprehension. I am quoting from what you said, and you said " Now, the question which perhaps arises in your lordship's mind is, does this tube device, this audion or electron tube, marked 1, itself transmit from this tuned circuit, well I will call it 15, some effect back through itself to the first circuit which is connected in the grid. That was the question Mr. Henderson asked, and then you proceeded to answer that. Now that is a misapprehension, Mr. Waterman, I was not referring to that I was referring to from the coil itself to the other coil around the tube, and was not referring to any reactance through the tube itself. What is there to prevent reactness between those two coils?—A. That is customarily done by the spacing of the coils, the separation of them by their angles to one another, or if it is desired to bring them close together, by shielding them in metal boxes.

Q. And that was all common practice prior to Alexanderson, was it not?—A. In such cases as made it desirable, yes. That is it was known how one could keep one coil from acting upon another.

Q. That is something which anyone skilled in the art would do?—A. I think so, yes.

Q. And how far apart does Alexanderson say that the coils should be placed?—A. He does not go into that. He makes clear the object that he desires, and the skill of the art would apply the knowledge of how to place the coils so that they did not have the effect that he was designing to avoid.

Q. And I think, if I remember rightly, in the Splitdorf case you told the court how far apart that would be. Can you tell his lordship now?—A. I do not see how I could have made that statement. Would you mind calling my attention to it, because I do not see how it could have been made.

Q. What do you think it could be now?—A. It could not be stated in feet and inches. They might be very close together if constructed or shielded in one way, and they might have to be very much farther apart if constructed or shielded in another way.

Q. Assume without shielding?—A. They are customarily placed with the axes at some angle to one another, often a right angle, such that the one coil has no effect upon the next, and so on through the system.

Q. And that is equivalent to a real distance, by placing at right angles so that, as you say, one coil has no effect upon the other?—A. One would not naturally place two coils that he did not want to have affect one another close together, but it does not involve large separations, if that is what you mean.

Q. Can the mere interposing of a relay keep the magnetic field of one coil from having an effect upon the magnetic field of another?—A. No, having reference to what I assume you mean, namely stray fields, the using of the tube as a relay element between them does not of itself prevent stray fields, if that is what you mean.

Q. I must frankly confess I do not know precisely what you mean by " stray fields " and I do not like the expression, so I will deal with it with reference to the figure which we have before us, exhibit " A." Does the interposition of a relay between the two circuits prevent the action of the one on the other, the one being in the one circuit and the other in the other ?—A. I understand you mean circuits associated with condensers 8 and 15 in exhibit "A."

Q. What I mean is the tube, the first tube acts as a relay between the circuit of which the coil we have been calling 15 is a part, and the circuit in which the coil which we have been calling 8 is a part. Does the interposition of that relay affect the connection of those two, the reactance between those two ?—A. You do not ask a definite question now, but I think perhaps I gather your meaning.

Q. Can the mere interposing of that particular relay keep the magnetic field from the coil, which we have been calling 15, from reacting on the magnetic field of the coil which we have been calling 8 ?—A. I understand the question to mean this, assuming that the coil of the circuit 15 is so placed with reference to the coil of circuit 8 that the magnetic lines of force from one stray over unintentionally into the coil of the other, will the interposition of the relay affect such straying. The answer is, No, it will not.

Q. That answer is from my point of view, but may I put it in this way : if in the absence of the relay there would be the reaction, would there be the same after the relay is interposed ? If the juxtaposition of the coils is such that there will be the reactance, does the interposition between the two of the valve affect that ?—A. It does not affect the fact. It may very materially affect the results flowing out of the fact.

Q. Can not you answer that it does not affect the fact ?—A. I did so answer, and you asked again, so I thought you must want something more.

Q. The additions may or may not have some effect, in this case there is no purpose ?—A. It does not affect the fact, but there is an effect which affects the result.

Q. It is a fact that you have already said in this case that in the Marconi system which you sketched, the two coils had to be separated to get away from the reactance effect ?—A. Yes, but you give quite a wrong impression there. To get a strong signal they have to be close together. To get such order of selectivity as that arrangement gives, you must separate them. That does not mean, however, to separate them widely, because then you lose the signal.

Q. I am simply taking Marconi as it was and was used. Would the interposition of a relay have made any difference on the question of reactance ?—A. If I get you——

Q. Oh I think you do.—A. Now, not in the fact of the continued presence of the magnetic lines from one threading the other but in the result of that fact we have quite a different story.

Q. In other words there is no difference between Alexanderson and Marconi so far as that point is concerned ?—A. Oh, I did not say that and I do not think that is what you asked. You said if you take the coils in the relation in which we used to use them for the reception of signals and connect between them in that relation the relay, will you thereby have altered their magnetic relation to one another, and the answer is No.

Q. That is the answer I asked for.—A. But very different effects may follow. I simply want to protect myself.

Q. In further reference to your sketch, exhibit "B," which you recollect, merely having that in mind when I ask you this, will you now please draw for me a sketch showing the most simple arrangement of figure 4 of Alexanderson plus a crystal detector? You have the figure before you, I think, have you not?—A. Yes. I have done so.

Q. Thank you. I am sorry to have to again make the remark that at the extreme right this is not a simple coil but a telephone. I put this in as exhibit "E."

EXHIBIT "E":—filed by Mr. Henderson, Jan. 12, 1927. Sketch showing most simple arrangement of figure 4 of Alexanderson, with crystal detector.

Q. I find at the top of page 160 of your evidence yesterday, where you were speaking of your own experimentation, this question was put to you: You say it was a trans-Atlantic reception. That would be telegraphic, would it not? And your answer was, It would be a continuous wave telegraph reception. You recollect that, do you not?—A. Yes.

Q. Would you tell me how you used the arrangement of figure 2 of Alexanderson for the reception of continuous waves?—A. The circuit arrangement was substantially as shown in figure 2, although I do not remember how many stages were used. I was thinking the matter over last night, and my recollection is that I took the circuit from a paper by Doctor Langmuir which was published in the Institute of Radio Engineers along in 1915 or 1916; and I think two stages only, instead of three as shown in figure 2, were used; and associated with one of them, I do not remember which, was a heterodyne.

Q. That paper was known to those familiar with the art at the time?—A. Yes, it attracted wide attention.

Q. And that was the paper from which you took your information, not altogether perhaps?—A. Yes. My recollection is that that paper gave me the first knowledge I ever had of the Alexanderson invention.

Q. Did you have an oscillator in it?—A. We had an oscillator at one side associated with one of the coils, but I do not remember which.

Q. What was it?—A. It was a tube oscillator.

Q. Of what type, do you remember?—A. I am not sure that I get your point. I said a tube oscillator and it was a tuned circuit.

Q. But even then there were different tubes?—A. You mean what the make of the tube was?

Q. Yes.—A. Oh, I think it was a Western Electric tube.

Q. You think it was a Western Electric tube at that time?—A. Yes.

Q. Now we seem to be quite agreed, Mr. Waterman, that the function of a receiving system is to render intelligible to the sense the waves received and also to separate out the waves from different stations?—A. Yes.

Q. Now, did not Marconi do that?—A. Yes, certainly, to a certain extent.

Q. I am talking now of under patent No. 763,772?—A. To a certain extent, he did, not to any extent that would be very useful to-day.

Q. There have been improvements in recent years?—A. Yes, notably in the patent in suit.

Q. You have before you the United States Alexanderson drawings? —A. I have.

Q. And I think we are agreed, Mr. Smart, as a matter of convenience, that they are identical with the Canadian drawings. You probably know that, do you not?—A. So far as I have noted, they seem to be.

Q. I ask you to look at the drawings of what I show you to be the Langmuir patent No. 196,390, Canadian, and say if the figures in that patent, 1 and 2, are not identical with the Alexanderson figures?—A. This patent I am familiar with, and unless I am mistaken it is one of the patents in issue in these actions.

Q. It is the so-called co-pending application, you know?—A. As to figure 1, the answer is No.

Q. I am not saying that they are identical in their tracery. If you were to simplify each, you would have the same, would you not?—A. No, not as to figure 1.

Q. As to figure 2, then?—A. Figure 2 is substantially the same as figure 2 of the Alexanderson patent with the exception,—by Alexanderson I mean the Alexanderson patent under consideration,—that one tube is added and that the telephone is replaced by an audio frequency transformer with which the extreme right-hand tube is associated. In other words, one stage of audio frequency amplification is added.

Q. So I understand, but do you not find the whole of Alexanderson there?—A. So far as the drawing displays, I do.

Q. In the drawing you find the whole of Alexanderson, plus something else with which I am not concerned at the moment?—A. Yes.

MR. HENDERSON: I will file this patent as Exhibit F.

EXHIBIT F:—Filed by Mr. Henderson, 12 Jan., 1927. Langmuir Canadian Patent Number 196,390.

HIS LORDSHIP: What is the date of the Langmuir Patent?

MR. HENDERSON: It is the 20th January my lord. I may say that there are some slight inaccuracies in some of the dates I gave you yesterday, but they will be given again. Your lordship will remember that the Alexanderson application was filed in Canada eight months after that patent was issued. That is the Alexanderson application in Canada was eight months after the issue of the Langmuir patent.

HIS LORDSHIP: Alexanderson was filed on February 17th, 1920 and Langmuir filed in October, 1919?

MR. HENDERSON: Langmuir filed in October 1919, and issued on the 20th January 1920.

Has your lordship that sheet of dates before you? Might I correct it at the moment? I made one or two slight errors in giving it to your lordship. The Langmuir issue I gave your lordship as 1919. That should be in the United States. The date is 22nd October, 1918 and not 1919. The other error was that the Alexanderson filing in Canada was September 17th, 1920. I gave it as February.

HIS LORDSHIP: Is there a point in the fact that Alexanderson did not apply in Canada until a year after he was granted a patent in the United States?

MR. SMART: That was during the war period, and the Canadian General Electric were, like all other manufacturing concerns in Canada, very much occupied with war work. The period was extended and they applied within that period.

MR. HENDERSON: There is the point there that there was no compliance with the provisions of the then Act. It will appear, although it is not yet before your lordship, that it was filed as an original application, saying nothing about the prior patent in the United States, and as will appear elsewhere. Then there is a question as to the right to the issue under the circumstances.

MR. SMART: I understand my learned friend has some technical defences to allege; that there was some slip in the procedure; but we will deal with that.

HIS LORDSHIP: I had forgotten about the war period. I could not quite understand why there was that hiatus there.

MR. HENDERSON: While we do not abandon any of the legal defences, we are very desirous that the merits should be gone into.

That is all I have to ask Mr. Waterman.

RE-EXAMINED BY MR. SMART:

Re-examination.

Q. Mr. Waterman, in response to my learned friend you made some reference to a paper read in the Institute of Radio Engineers in 1915 as forming the basis disclosed or the first knowledge of the Alexanderson circuit, and that was the basis of your knowledge for that Belmar installation?—A. That is my recollection, yes.

Q. Can you identify the portion of the paper referring to it?—A. I think it is page 283.

MR. HENDERSON: Of course, my lord, I do not want to seriously object to this, but technically it seems to me it can only be evidence of the fact that certain information was gained from the paper.

MR. SMART: That is all it goes to, yes.

MR. HENDERSON: I presume that is all it goes to. Of course it cannot be taken that the contents of the paper itself is evidence. I wonder if my learned friend will pardon me if at this moment I ask him—because it may save a good deal of time—if he intends to call Mr. Alexanderson or Dr. Langmuir? If he does I would reserve a great deal until my cross-examination of them, and not anticipating what they will say; and as they have been called in what we are taking as more or less the precedents of these cases, I presumed they would be here, but I do not see them here yet.

MR. SMART: I do not think I can say any more than this: that if it is necessary to call them, I will call them in reply.

MR. HENDERSON: If my friend cannot go farther than that, the responsibility of course will not be mine if I take up your lordship's time,

In the Exchequer Court of Canada.

Plaintiff's Evidence.

No. 7. Frank N. Waterman. Re-examination —*continued.*

but I would say my friend should know whether he is going to call them or not.

MR. SMART: I have not heard my learned friend's case, and I cannot say.

MR. HENDERSON: I have no technical right to ask, and I am only doing so as a matter of courtesy.

HIS LORDSHIP: I cannot give directions upon that.

MR. HENDERSON: I quite appreciate that.

HIS LORDSHIP: I do not know whether Mr. Alexanderson can be called.

MR. SMART: He is in Schenectady and willing to come here if required. Now whether or not the case as made by the defendant will require his presence, is a fact which I cannot undertake to answer at the present moment.

MR. HENDERSON: I will tell my learned friend now that it would simplify matters very much if he were called and if we might have an understanding as to whether he will be here.—A. I recognize the article shown me as the one which I had in mind, and particularly pages 282 and 283; that is the text on page 282, and the text and the drawing on page 283, where a diagram quite similar to the figures of the Alexanderson patent is given; more particularly figure 1 perhaps; and reference is made to Mr. Alexanderson's work. Do you desire the passage read?

MR. SMART: Perhaps you could read the passage into the record?

MR. HENDERSON: I do not think it should be read into the record.

MR. SMART: I intended filing a photostat copy of it. It might save doing that if the witness read a short passage.

MR. HENDERSON: How can you make that evidence?

MR. SMART: I will ask the witness to read the passage.

HIS LORDSHIP: Having been cross-examined upon it, I see no objection; but why not put the whole document in as an exhibit? You may not refer to it again; it may not be of importance.

MR. HENDERSON: I do not know what is in it. I have not read it myself. I think those with me know. But perhaps your lordship might receive it subject to the objection? The objection may or may not be pressed; probably not; I do not know at the moment. It seems to me technically that it is not proper, in the same way as your lordship very properly checked me this morning on giving Mr. Marconi's evidence.

HIS LORDSHIP: Except that you introduced it as an independent document.

MR. HENDERSON: No, my lord, I did not introduce it.

MR. SMART: Reference was made to it.

MR. HENDERSON: The witness gave it as his recollection of the date of his first knowledge of Alexanderson; he read of it in this paper, that is all. If I had doubted him as to that, I might have asked to look at it in corroboration, but I did not ask to look at it.

HIS LORDSHIP: I think he is entitled to put it in, although I do not think it will be of any importance one way or the other, because as you say he got his knowledge there. Technically speaking, reference having been made to it, and coming out of your question, I think he can do that.

MR. HENDERSON: Your lordship takes it subject to the objection?

HIS LORDSHIP: Yes.

MR. HENDERSON: That will probably be the more convenient way.

HIS LORDSHIP: You can put it in, Mr. Smart.

MR. SMART: I think I will only put photostat copies of two pages in, as I borrowed this book from the library; I will have them made over night.

HIS LORDSHIP: How many pages are there altogether?

MR. SMART: The article is a long article.

MR. HENDERSON: If any of it is going in, the whole should be put in. I do not know why two pages should be taken out.

MR. SMART: They are the only two pages dealing with the Alexanderson patent.

HIS LORDSHIP: Are those two pages distinct from the rest?

MR. SMART: Yes.

HIS LORDSHIP: Then I will receive those two pages subject to objection.

MR. HENDERSON: I do not want to have my friend do unnecessary photostating. Perhaps my friend will discuss this with my friend who is with me and they will doubtless agree as to what is to go in. Each of us has associates here who are en rapport with these things.

EXHIBIT No. 11:—Filed by Mr. Smart, 12th Jan. 1927. Pages 282 and 283 of a paper read before Institute of Radio Engineers in 1915.

MR. SMART: Now my friend asked you with respect to figure 4 of the Alexanderson patent, and I would ask whether you have had occasion to study any of the infringing apparatus involving the particular arrangement of circuits shown in that?—A. No, I have not. I know that there have been sets upon the market which have used this but they have not happened to come under my observation.

Q. Now my learned friend asked you with respect to interposing a relay device of the kind shown in the Alexanderson patent, in a Marconi circuit, and you gave an answer to that question and I would like you to explain just how you had in mind the relay would be used?—A. I understood that I was asked to consider a Marconi receiving set of the patent referred to, the number of which has escaped me—763,772, Mr. Henderson informs me—and I understood him to ask me to picture that receiving set in exactly the condition in which it would be used in accordance with that patent, to receive the signal; and then he asked me that I assume that without alteration there be added to it a relay, and the reply which I made was that the adding to that circuit of a relay connecting the two tubes, did not alter the magnetic physical relation that had previously existed. In other words that adding it to that is a very different thing from substituting it for that. When Alexanderson made his arrangement, he took those coils apart and he substituted for the magnetic field that had previously associated them, the relay, and he thereby got a wholly different result.

Q. In the receiving set which is produced in court, this booklet was on the inside and I suppose should be part of the Exhibit? It was in the set.

Mr. Henderson: I presume it was.

Mr. Smart: I take it that is the instruction book which usually accompanies it?

Mr. Henderson: Whether it was included or not, it is our literature and may be used.

Mr. Smart: I will file that as an Exhibit.

EXHIBIT No. 12:—Filed by Mr. Smart, 12 Jan. 1927. Instruction book given with defendant's set.

Mr. Henderson: Is that in this particular set?

Mr. Smart: Yes.

Mr. Henderson: They vary a little from time to time.

Mr. Smart: For convenience, I might read a sentence or two contained in this instruction book. On page 7 one finds these two sentences:—

> "In the neutrodyne receiver all three dials must be considered and tuned to the given wave length. Then real selectivity is apparent."

Then on page 17:

> "FADA neutrodyne receivers, even when within a few miles of such broadcasting station, as is entirely possible in the larger cities such as New York City, Philadelphia and Chicago, can be so tuned that one may reach out through local interference and still be able to listen to distant broadcasting programmes."

That is all.

His Lordship: Were Alexanderson's and Langmuir's filed jointly?

Mr. Smart: No, the Langmuir patent is directed to detection, and in the patent your lordship will find a reference to Alexanderson and a statement that the system of selective tuning is Alexanderson's invention.

His Lordship: On this paper there is a statement that both were filed in the United States on the same day.

Mr. Henderson: But two separate applications, and your lordship will remember each one speaks of the other as a "co-pending" application. Now whether by accident or design, throughout that phraseology was maintained, even in the Canadian applications. Each one speaks of the other as a co-pending application. That is the Canadian application was simply copied from the American.

His Lordship: I do not see the word co-pending in this.

Mr. Henderson: They were in the United States.

His Lordship: Why were they called co-pending?

Mr. Smart: They were filed simultaneously.

HIS LORDSHIP: Without any specific relationship.

MR. HENDERSON: Yes, each refers to the other.

MR. SMART: With this relation, that they were two inventions designed to be used together, and one in explaining the way his invention was to be used, explained another feature which was the subject matter of the other invention.

HIS LORDSHIP: I suppose every patent in the United States which was applied for about that time, was co-pending?

MR. HENDERSON: As originally prepared, there were certain numbers left blank, to be filled in. I am not sure at the moment whether they were filled in.

HIS LORDSHIP: I think this is quite clear. I may be wrong, but I do not see why one person chooses to use the word co-pending in reference to the application of another. If it were his own application I could understand that it was co-pending. Every application that was before the Department then was co-pending.

MR. HENDERSON: I think your lordship will find, as the case progresses, that these applications were both filed by the Canadian General Electric Company, which owned both.

HIS LORDSHIP: I suppose so, but really I do not see why one person in his application can refer to the application of another party as a co-pending application. It is used but the word cannot mean anything.

MR. SMART: Nothing turns on it here that I see.

MR. HENDERSON: A great deal turns on it here. Each of the patents issued to the General Electric as assignees of the inventor, so that even in your lordship's sense they would be co-pending in that case.

HIS LORDSHIP: There is no difficulty about that.

MR. HENDERSON: Yes, we submit there is a legal difficulty there my lord.

MR. SMART: We will have to face all these serious and not serious difficulties.

MR. HENDERSON: Yes, and really face them.

MR. SMART: I suppose that is what we are here for.

HIS LORDSHIP: Then what is the next step?

MR. SMART: The plaintiff rests.

[*This witness was recalled, see p.* 316.]

No. 8.

Discussion.

MR. HENDERSON : Does your lordship think it desirable that before calling evidence I give your lordship a statement of our position ?

HIS LORDSHIP : I think you have already done that.

MR. HENDERSON : It will develop as we go along.

HIS LORDSHIP : Yes, I think so.

MR. HENDERSON : Then I will ask the Registrar for the original return of the evidence taken on commission in Berlin, Germany.

HIS LORDSHIP : Is it voluminous ? And how do you suggest putting it in ?

MR. HENDERSON : It is not voluminous. As a matter of fact, my lord, this has not yet been filed, for this reason : letters of request were sent over but did not reach Berlin as soon as we did, and my friend agreed with me that to save time the intended Commissioner should act as Commissioner, and he did so act. The evidence was taken through an interpreter. That is the question was put in English, interpreted to the witness in German, he answered in German, and his answer was again interpreted into English. We had two stenographers, one German and one English. I do not want your lordship to think that this brief is all evidence to be read ; it is in both English and German and so it will not take any very great length of time. Perhaps my friend Mr. Herridge may read the answer and I will read the question.

HIS LORDSHIP : What does the evidence taken on commission go to ?

MR. HENDERSON : It goes to prior invention and use.

HIS LORDSHIP : Could you not arrange to have it go in without reading it ? I find it very difficult to follow evidence that is read. I can read it more carefully myself. Could you and Mr. Smart not agree to put it in, either in whole or in part ?

MR. HENDERSON : It could be done in that way and then referred to.

MR. SMART : I am quite willing that it should go in and be taken as read.

MR. HENDERSON : May I ask if it is your lordship's intention to ask for written arguments at the close ? If so, I would say let us put it in, following the American practice. I understand it is not the American practice to ever read these things at the trial because after all the judge has the burden of reading it afterwards.

HIS LORDSHIP : I cannot follow the reading very satisfactorily. I can only get the proper sense of it by reading it myself and perhaps more than once. If you put it in I think that would be acceptable, but you might perhaps indicate what is in it.

MR. HENDERSON : We have a photograph of what these men did. I want it in because, while the evidence is being put in, it will be necessary to make reference to this. We will simply treat it as read for the moment, Mr. Smart ?

MR. SMART : Yes.

MR. HENDERSON : Your lordship will understand that I will have to make some references to it as evidence given.

MR. SMART : There are certain objections which I took at the time and which will be reserved ?

HIS LORDSHIP : Yes. Mr. Henderson can refer to any particular part in it.

MR. HENDERSON : My learned friend has very properly said that he took certain objections. Your lordship is not dealing with the objections at this time.

HIS LORDSHIP : No, I reserve the right to rule upon any of the evidence taken.

MR. HENDERSON : Then I think, Mr. Smart, it will be convenient if we use a binder of the prior art patents which we have pleaded, and I think it will be convenient if they are simply put in one binder, and they can be referred to as required.

MR. SMART : That is quite satisfactory.

HIS LORDSHIP : I suppose that includes the German patents.

MR. HENDERSON : It includes German patents and certain publications to which reference will be made, and if my friend desires it can be put in now subject to any objections which he may raise as to any particular document. It seems to me to have all these together in one is obviously convenient.

MR. SMART : Perhaps I may have the opportunity of looking it over this evening, if I may be permitted to take it out.

HIS LORDSHIP : There is no reason why you should not have it.

MR. HENDERSON : We can arrange to go over it with my friend, but perhaps there is no objection to the Registrar letting my friend have the original Exhibit ?

MR. SMART : Yes, if I may have the Exhibit overnight.

HIS LORDSHIP : Yes.

EXHIBIT G :—Filed by Mr. Henderson 12th Jan., 1927. File of documents.

No. 9.

Evidence of Otto Von Bronk, taken on Commission.

Examination of witnesses taken on August 4th, 1926, at Berlin, Germany, on behalf of defendant with the consent of the parties, it being understood and agreed that the evidence now taken is to be used at the trial pursuant to a stipulation already signed by the parties.

By consent of Counsel, Dr. Karl Michaelis was named as Commissioner, and so acted.

Counsel for plaintiff, Canadian General Electric Company, Limited: Mr. Russel S. Smart.

For defendant, Fada Radio Limited: Mr. George F. Henderson, K.C., and Mr. Willis H. Taylor, Jr.

OTTO VON BRONK, CALLED BY DEFENDANT
TO MR. TAYLOR.

Q. Please state your name, age and residence, Mr. von Bronk.—A. My name is Otto von Bronk, I was born on February 29, 1872, at Danzig, and my residence is 2, Defreggerstrasse, Berlin-Treptow.

Q. What is your occupation?—A. Electrical engineer.

Q. And where are you occupied?—A. At the Telefunken Company.

Q. Tell me the particular duties which you are occupied with in the Telefunken Company.—A. I am the head of the Patent-Department.

Q. As a result of your experience embodied in the patents filed will you say whether or not you are familiar in a general way with the patents granted in Germany relating to the radio art?—A. Yes.

Q. Have you yourself made any contribution to the radio art in the nature of the inventions or improvements which are disclosed and then covered by German patents?—A. Yes, for example, detectors, crystal detectors, photo-electric apparatus, high tension apparatus, telephone connections, photo-radio transmission and everything relating to radio telephony and radio telegraphy.

Q. Will you please refer to German patent No. 271,059 of which I give you a printed copy. That patent relates to improvements in the radio art which improvements were made by you?—A. The first experiments were made in the fall of 1911 shortly before the application was filed. I have brought with me an apparatus. The apparatus has been constructed by the firm of Clausen und von Bronk, Berlin.

Q. And you say that that apparatus was constructed and used some time shortly before the filing of the application on September 2, 1911, which application resulted in German patent No. 271,059 of March 3, 1914? Has anyone besides yourself witnessed the operation of the apparatus, which you have before you, in the course of the reception of wireless signals?—A. No, I don't believe it. I have a laboratory at home, that is the laboratory belonging to the firm Clausen & von Bronk, and it is possible that my wife has witnessed the operation of the apparatus; but she takes only little interest in it.

Q. I have asked you whether or not you demonstrated the model which you have produced at or about the time you mentioned.—A. The apparatus was used only for experimental purposes.

Q. Will you now tell me whether at any time subsequent to the date mentioned you demonstrated or disclosed the apparatus to other persons ? —A. Not this apparatus. Then starts the work with Schloemilch. Then other apparatus were used.

Q. In the other apparatus which you have mentioned will you tell me whether the circuit arrangement shown in your patent No. 271,059 was used ?—A. Sometimes according to this patent, sometimes according to the other patent.

Q. And when you say "the other patent," do you mean patent No. 293,300, filed in Germany on February 8, 1913 ?—A. Yes.

Q. Will you tell me, whether the improvements described in German patent No. 293,300 are improvements in the radio art made by you ?—A. Yes, together with Schloemilch. Schloemilch was the receiving engineer (specialist in the art of receiving apparatus) with Telefunken.

Q. Did Mr. Schloemilch work together with you in the course of the work which resulted in the improvements described and covered by German patent No. 271,059 ?—A. Yes, he had various connection diagrams. As a specialist in receiving apparatus he had all possible combinations available in the laboratory.

Mr. Smart : The question has not been correctly answered.—A. I was in the Patent-Department. I did not always have time to go to the laboratory and consequently Mr. Schloemilch had to resort to himself for the receiving connections. We only could discuss together the connection diagrams and I could not actively participate in the work.

Q. Mr. Smart suggests that you may have referred to the wrong patent, will you please look to the patent referred to in your last answer ?—A. It is this patent No. 293,300.

Q. I am sorry that you misunderstood me, but will you please tell me whether or not Mr. Schloemilch worked with you in the course of the conception and development of the circuit arrangements shown in patent No. 271,059 ?—A. No, Mr. Schloemilch has started to work only at the end of 1912 or the beginning of 1913 with the high frequency amplification. With this connection diagram, I cannot say up to that point I have worked alone.

Q. Will you tell me, whether or not you disclosed the circuit arrangement of Patent No. 271,059 to Schloemilch, and if so, at about what date ? —A. I believe Mr. Schloemilch re-invented the connection diagram at the end of 1912 or the beginning of 1913. More accurate details Schloemilch will perhaps be able to give himself.

Q. Did Mr. Schloemilch see any of your apparatus such as that which you have before you ?—A. No, I do not think so, at least.

Q. Are you quite sure that he did not ?—A. I don't believe it, because I have made the experiments up to 1912 at my home.

Q. Can you tell me whether or not the apparatus which you have used has the same circuit arrangement as that shown in patent No. 271,059, or whether there are slight differences in the circuit ?—A. The apparatus is

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Defendant's Evidence.

No. 9. Evidence of Otto Von Bronk, taken on Commission. Examination —*continued.*

built for this connection diagram but it is possible that the connection diagram—that the antenna—itself can be modified.

Q. Will you please tell me whether by your explanation you mean that the binding post shown at the end of the apparatus adjacent the vacuum tube ought to be connected to the antenna and earth ?—A. Yes. but it is also possible that a tuned intermediary circuit can be inserted between the antenna and the apparatus.

Q. Did you ever show Mr. Schloemilch the patent application which resulted in patent No. 271,059 at any time before the patent was published ? —A. Yes.

Q. Could you tell me at about what time ?—A. I can only say at the end of 1912 or at the beginning of 1913.

Q. Would you please refer now to patent No. 293,300 and refresh your recollection of the filing date and tell me whether or not you showed the patent application for patent No. 271,059 to Mr. Schloemilch before February 8, 1913 ?—A. This has certainly been the case, because we have applied for this patent as a patent of addition to patent No. 271,059 and consequently we had to discuss together the connection diagrams.

Q. And can you tell me approximately the time during which the application for patent No. 293,300 was in the course of preparation ?—A. The preparation of an application usually requires 10-14 days and consequently the application has been prepared probably at the end of January or the first days of February, 1913.

Q. Can you tell me, by reference to the model apparatus you have produced and to the various physical and electrical devices fastened on the panel, what they are and by reference to the patent drawing identify those devices by reference to the letters appearing on the circuit diagram of the patent No. 271,059 ?—A. I will try. Here is the de Forest tube, a very old model (Mr. von Bronk points to one end of the apparatus where there is mounted an old de Forest tube).

Q. And this is referred to in the patent diagram by what letter ?—A. By the letter *a* in the drawing. (Mr. von Bronk points with the finger to the crystal detector.)

Q. And this is represented in the diagram by what reference letter ? —A. By *l*. (Mr. von Bronk points to two pin jacks) for the telephone *m* one pair and on the other side for a second telephone. I must observe that this apparatus has been modified from an old apparatus, from a so-called photo-chemical recorder. The apparatus was designated in 1908 for another purpose. For this purpose a switch is provided on the upper panel, and here is a resistance (Mr. von Bronk points to a resistance) which is inserted at *b* for the cathode to vary the potential. Here are two terminals for the heating batteries (Mr. von Bronk points to two terminals), and here are two terminals for the anode batteries (Mr. von Bronk points to two terminals). And here are two terminals for the antenna and the oscillatory circuit.

Q. Will you tell me where the coil *g* is located in your apparatus ?—A. It is not in the apparatus, it is attached to the apparatus.

Q. Will you describe for me the type of coil arrangements which you used in 1911 for the purpose of completing the system as shown in the drawings of the patent and which you have said were connected to the apparatus you have before you ?—A. I have an entire collection of coils for all wave lengths and also variable condensers. All these apparatus could be attached. According to the wave length coils were attached with high or low inductivity.

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Defendant's Evidence.

No. 9. Evidence of Otto Von Bronk, taken on Commission. Examination —*continued.*

Q. Will you tell me in the apparatus that you used whether or not the antenna was tuned and if so, will you indicate by reference to the drawings of patent No. 293,300 what variable electrical unit was controlled to produce the desired tuning ?—A. A rotary condenser and exchangeable coils together.

Q. In the apparatus that you used will you tell me whether or not the circuit connected to the cathode and grid was tuned ?—A. No, at that time it was not tuned. Only later on, until Schloemilch came into the matter.

Q. And when you say, when Schloemilch came into the matter, do you refer to your joint work with him as described in patent No. 293,300 ?—A. Yes.

Q. Will you kindly indicate by reference to the drawings of patent No. 293,300 the tuning you referred to ?—A. The tuning of the grid circuit.

Q. And was that tuning independent of the tuning of the antenna system ?—A. It could be modified independently of the tuning of the antenna circuit.

Q. Did you operate an apparatus in which you used the circuit arrangement you have just referred to and in which the antenna tuning was independent of the grid circuit tuning ?—A. Yes, it could be modified independently of the tuning of the antenna circuit.

Q. And at about what date did you so operate the arrangement you have referred to by reference to Fig. 1 of patent No. 293,300 ?—A. I cannot say that to-day any more, at any rate prior to the date of the patent application.

Q. And would you say that that would have occurred prior to the day of the beginning of the preparation of the application ?—A. First the experiments were made and then on the basis of the experiments the connection diagrams were drawn.

Q. And can you say definitely whether or not the experiments which preceded the drawing of the diagrams were before the time at which the preparation of the application was begun ?—A. Yes, I can say that definitely. I can say that definitely because it requires a certain time before the drawings I ordered have been prepared.

Q. Have you any papers with you that might refresh your recollection and if so, please produce them.—A. Yes, I have a drawing of February 8, 1913. In this drawing is shown the connection diagram which was used together and before. In Fig. 6 of the drawing which I have here is shown a connection diagram which has been used by Schloemilch before the filing of patent No. 293,300 in the laboratory of the Telefunken Company. Of course, we have discussed together the connection diagrams.

Q. May I refer to the blue print which you have just looked at ?—A. It would perhaps be better if Mr. Schloemilch would give the explanations concerning this diagram.

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Defendant's Evidence.

No. 9. Evidence of Otto Von Bronk, taken on Commission. Examination —*continued*.

Q. Will you tell me what the arrangement shown in patent No. 271,059 is called which involves the secondary coil *g* and a corresponding coil in the antenna system ?—A. They are called primary and secondary coils.

Q. And are they in electrical relation with one another ?—A. They are coupled together.

Q. Can you tell me the character of the coupling which you used in your early work in 1911 ?—A. In the laboratory the coils were placed loosely together, and consequently one could choose at will any kind of coupling. The testing was done by means of the telephone. By the loudness of the telephone one could ascertain the most favourable coupling.

Q. And did others besides yourself know or see the coil arrangement which you have said could be varied between loose and close coupling ?—A. Not in connection with the apparatus, the coils themselves of course everybody could see.

Q. Will you tell me whether or not the arrangement you employed was a common one at that time ?—A. It was merely a laboratory apparatus, loose coils and loose rotary condensers which had to be connected together by wiring.

Q. But they were the ordinary apparatus which were available at that time ?—A. They were simple cylindrical coils made of compressed cardboard which could be inserted one into the other or one alongside of the other as they were used at that time for laboratory purposes.

Q. And is the same explanation true of patent No. 293,300, referring particularly to Fig. 1 and the coupling coil shown at *g* ?—A. In the patent No. 293,300 Schloemilch used the laboratory coils of the Telefunken Company and these have special taps for varying the coupling as well as the wave length.

Q. I notice that in the diagram by means of which you have refreshed your recollection, No. L. 898, and which is dated February 8, 1913, that Fig. 6 thereof shows a variable condenser across the secondary coil which is not shown in Fig. 1 of patent No. 293,300 in addition to a variable tap on the coil. Will you please explain why the condenser was omitted from Fig. 1 of patent No. 293,300 ?

Mr. Smart objects to this question.

A. At that time it was assumed that the tuning by the variable coil was sufficient. In the first patent drawing the variable condenser was included, but with a view to simplify the drawing it was cancelled. I have the original of the first drawing in my file. It can be seen that the condenser which was originally shown, has been eliminated.

Q. Can you tell me the date of the sketch that you are now referring to ?—A. Unfortunately not, I can only say that the preparation of the application papers requires 10-14 days.

Q. With reference to the file which you have before you, can you ascertain on what date the preparation of the application began ?—A. Unfortunately not, because no dates are given on the papers.

Q. Can you tell me whether at any time you operated an apparatus which used the arrangement of Fig. 1 of patent No. 293,300 and if so, will you please tell me the date ?—A. Regarding this point Mr. Schloemilch can perhaps give information because at that time he made the experiments for the Telefunken Company.

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Defendant's Evidence.

No. 9. Evidence of Otto Von Bronk, taken on Commission. Examination —*continued.*

Q. And did you witness those experiments?—A. Sometimes, yes.

Q. Did you witness in particular the operation of Fig. 1?—A. I can no longer state that to-day.

Q. In your work with your circuit arrangement shown in patent No. 271,059 did you ever use a vacuum tube detector in the position indicated schematically by blue print No. L. 898 in that circuit?—A. Yes, instead of the crystal detector I inserted a second de Forest tube of the same type as the high frequency tube, but I found out that the crystal detector was more sensitive than the de Forest tube and consequently I believed the detector to be more suitable.

Q. At about what date did you use the vacuum tube detector which you have spoken of?—A. First I used the tubes in 1908 in a combination with other receiving apparatus as detector and at that time already I found out that the crystal detector was more sensitive than the vacuum tube. The subsequent experiments with high frequency amplification confirmed my assumption. As a result of these first experiments I struck the idea to separate the function of the vacuum tube, that is to say, to separate the amplification from the rectification. In that way the problem of high frequency amplification was solved and in that way the invention of the high frequency amplification was made.

Q. You omitted to tell me the date at which you used the de Forest vacuum tube as a detector at the position noted by *L* in your patent. Will you please tell me the date?—A. I cannot state that definitely at this moment, at any rate shortly after the filing of the patent application, because I made many experiments after that date.

Q. Will you tell me once more when those experiments were made with the de Forest vacuum tube detector?—A. I cannot give the date exactly.

Q. Can you give it approximately?—A. A short time after the filing of the application for the patent No. 271,059.

Q. That is shortly after September 2, 1911?—A. Yes.

Q. Now, will you please refer to your patent No. 293,300 and particularly to page 1, lines 48-50, incl. beginning "Natürlich," and tell me whether you have ever constructed other apparatus, in which further stages of amplification were used?—A. These apparatus were made by the Telefunken Company. Concerning this point Mr. Schloemilch will be able to give further information.

Q. Did you yourself see much apparatus in operation?—A. It is possible, but I cannot say exactly when.

Q. Can you say approximately?—A. Approximately during the year 1913. At the time when Schloemilch made the experiments in the big sending station at Nauen.

Q. Can you tell me whether that was prior to the preparation of the application which now has resulted in German patent No. 293,300?—A. As far as the so-called cascade connection is concerned I cannot say so because Schloemilch mostly made these experiments alone.

Q. Do you know, whether in the course of employing further stages

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Defendant's Evidence.

No. 9. Evidence of Otto Von Bronk, taken on Commission. Examination —*continued.*

of amplification the additional vacuum tubes were placed in the high frequency circuits or in the low frequency circuits or in both ?—A. In this case I cannot speak from personal experience but only on the basis of Schloemilch's statements and the papers which are still available at the Telefunken Company.

Q. Are you or are you not a collaborator with Mr. Schloemilch in the work described in the German patent No. 293,300 ?—A. I already stated that I was the director of the Patent-Department of the Telefunken Company and that Mr. Schloemilch was the man who worked the receiving apparatus for the Telefunken Company. Consequently I could only occupy myself from the theoretical point of view with the connection diagrams and Schloemilch on the other hand carried out the practical experiments. Up to the end of 1912 I had, as already mentioned, made the experiments in my private laboratory alone. After that date Schloemilch continued the experiments at the Telefunken Company.

Q. Can you tell me what the words beginning with the word "Natürlich" mean to you ?

Mr. Smart objects to this question.

A. Perhaps I can give an explanation. At that time the cascade connection was known in other amplifiers, for instance the microphone amplifiers of the Telefunken Company, and consequently it seemed quite obvious to me that for securing further amplifications one could use further tubes. This use could refer both to high frequency and to low frequency.

Mr. Smart objects to the latter part of the answer.

Q. What is the purpose of the circuit *n* in the arrangement in Fig. 1 of patent No. 293,300 ?—A. I must first ask whether I am to answer that as an expert or as user of the connection diagram.

Q. As you used it.—A. In that case it is better to ask Mr. Schloemilch because at that time he always worked with that apparatus.

Q. Did you ever operate an arrangement using the circuit connections of Fig. 1, and if so, for what purpose did you vary the condenser in the circuit *n* ?—A. I said already that not I myself, but Mr. Schloemilch worked with the connections at the end of 1912 and the beginning of 1913 and that it would be preferable to ask him concerning what he had done.

Q. Can you tell me, if you know, whether or not the arrangement shown in Fig. 1 was used by the Telefunken Company in its commercial stations ?—A. Concerning this point Mr. Schloemilch can give information also, because at that time I did not occupy myself with these questions.

Q. In the course of referring to some of the papers which you have brought here this morning to refresh your recollection in addition to the blue print L. 898, I have noticed a photograph of a cascade system. Is this the picture of the cascade system to which you have referred ?—A. In order to refresh my memory I have looked through the photographs of the Telefunken Company and found photographs dated April 30, 1913, and April 30, 1913.

Mr. Smart: I object to any evidence being given about the photographs insofar as he has not taken them himself.

Q. Have you actually seen the apparatus which is shown in the photograph ?—A. The apparatus of February 6, 1913, yes.

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No. 9. Evidence of Otto Von Bronk, taken on Commission. Examination —*continued.*

Q. And how about the other photographs ?—A. I have seen them later.

Q. Do you know of your own knowledge whether or not the apparatus shown in the photograph of April 30, 1913, was in existence prior to or at the time of the photographs ?—A. I know of my own knowledge that the date shown on the photographs is the date at which the photographs were made and consequently the apparatus must have been present at that date.

Q. Can you tell me whether the apparatus shown in photographs Nos. 233 and 2,995 were used by the Telefunken Company for commercial operation ?—A. Concerning that point Mr. Schloemilch can perhaps give information because out of my own knowledge I cannot make any definite statement.

Q. I ask you with reference to photograph No. 233 what the expression means in the small square of the rubber stamp on the back thereof ?—A. The words mean that the photograph illustrates a four step high frequency amplifying apparatus.

Q. And No. 2,995 ?—A. This photograph shows a type with a two step high frequency amplifying apparatus.

Mr. Smart has agreed that photographs of the apparatus which the witness had produced will suffice for the purposes of the final hearing and copies of the photographs Nos. 2,995 and 233 may be used with the same force and effect and copy of the blue print No. L. 898 may be substituted and used with the same force and effect as the original. Mr. von Bronk kindly offers to give Mr. Taylor the copies to which he had referred during the course of his examination, and therefore the understanding as to photographs would be limited to the apparatus. (Mr. von Bronk hands over to Mr. Taylor the photographs and drawings.)

CROSS-EXAMINATION by MR. SMART :

Cross-examination

Q. Please refer to your patent No. 271,059, which you described with reference to the model which you have produced and say whether or not the transformer *K* in the plate circuit is present in the model ?—A. I already mentioned that a transformer is not present between the tube and the detector. The detector has been inserted in the anode circuit as shown in Fig. 2 of the U.S. patent No. 1,087,892.

Q. Did you personally make any of the photographs which you have produced ?—A. Naturally not, I have taken them from the archives of the Telefunken Company.

Q. Did you ever see the apparatus from which the two photographs Nos. 233 and 2,995 were made ?—A. No.

Q. Did you make the tracing of blue print No. L. 898 ?—A. No. I have had researches made in the Telefunken Company to find the original of the drawing and this blue print has been made by the photostat printing department of the Telefunken Company.

Q. When was that done ?—A. About 2-3 weeks ago: when I got information from Dr. Michaelis to the effect that this matter would be questioned I caused the blue print to be made.

Q. Was that the first time you saw the tracing ?—A. That I cannot say I don't know.

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Defendant's Evidence.

No. 9. Evidence of Otto Von Bronk, taken on Commission. Cross-examination —*continued.*

Q. Did you ever see the apparatus represented in Fig. 6 of tracing L. 898 before the date of the blue print?—A. I cannot recollect that.

Q. As to the figures of your patent No. 293,300, did you or did Mr. Schloemilch invent the circuit shown in Fig. 1?—A. That can be stated only with difficulty, because the connection diagrams resulted partly from discussions, partly from experiments.

Q. Referring to Fig. 1 of patent No. 293,300, what was the purpose of the variable connection to the coil of the transformer *K*?—A. Concerning this point only Mr. Schloemilch can give information on his account because, as already stated, the practical work was done by Mr. Schloemilch. To me Mr. Schloemilch stated that both the variable coils and the variable condenser were used for tuning purposes. I can only add that these two variable elements fulfil two purposes, that is to say, for coupling purposes and for tuning purposes. But this, of course, is only an expert's opinion.

Q. May I take it with respect to your answers on direct examination as to the apparatus shown in Fig. 1, that you have no direct knowledge of the operation itself but only by what Mr. Schloemilch said?—A. The question must be replied to in this way: Schloemilch has made the experiments and has incidentally shown to me the connections and let me hear the effects. The purposes he had in mind with the various tuning circuits I am not in a position to state to-day. If I were asked in the quality of an expert, I would, of course, say that the tuning means served for the tuning.

RE-EXAMINATION BY MR. TAYLOR:

Re-examination.

Q. Have you or have you not seen the original tracing from which this blue print was made?—A. Yes, I have myself searched for and found the original tracing.

Q. And the original contains the date shown in the left hand corner of the blue print? Can you tell me by reference to the initials by whom the original tracing is made?—A. I can still ascertain that definitely.

Q. Where is the original now?—A. In the Construction-Department of the Telefunken Company.

Q. Can you say whether this blue print is a correct copy of the original drawing?—A. Yes, I can state that with certainty.

No. 10.

Evidence of Wilhelm Schloemilch, taken on Commission.

CALLED BY DEFENDANT TO MR. TAYLOR.

No. 10. Evidence of Wilhelm Schloemilch, taken on Commission. Examination

Q. Will you, please, state your name, age and residence?—A. My name is Wilhelm Schloemilch, I was born in 1870 and my residence is Kallinchen near Königswusterhausen.

Q. Will you tell me what your occupation is?—A. I am an engineer with the Telefunken Company and have been occupied there for the last 20 years as an inventor, mostly in the laboratory.

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Defendant's Evidence.

No. 10. Evidence of Wilhelm Schloemilch, taken on Commission. Examination *—continued.*

Q. How long have you then been associated with the Telefunken Company ?—A. A little more than 20 years.

Q. And you know Mr. Otto von Bronk ?—A. Yes.

Q. Have you been associated with him in the course of your work with the Telefunken Company, and if so for what length of time ?—A. I have been connected with him, but for how long I am unable to state.

Q. Would you say your association with Mr. von Bronk would date from the beginning of your employment with the Telefunken Company or some time thereafter ?—A. Yes, I made the acquaintance of Mr. von Bronk only a few years after having entered this firm.

Q. Tell me, have you made any contribution to the radio art in the nature of improvements and inventions in the course of your experiments ? —A. Yes, I have developed an entire series of patents which constitute part of the patents of the Telefunken Company.

Q. And are you generally familiar with the progress of the radio art in Germany as shown by the various patents which have been granted in Germany ?—A. Yes.

Q. I now show you a copy of German patent No. 271,059, application filed September 2, 1911, and ask you whether or not that patent relates to any of the improvements or inventions which you have made in the radio art ?—A. Yes, the patent relates to a cathode tube connected as high frequency amplifier and naturally I have also worked with combinations of this type.

Q. Will you tell me when you first operated a radio apparatus which used the circuit arrangement shown in the drawings of patent No. 271,059 ? —A. With cathode tubes I have worked as early as in the fall of 1912 and more specifically with cathode tubes with high frequency amplification connections.

Q. In the use of radio apparatus in 1912 which employed the circuit arrangement of patent No. 271,059 for high frequency amplification, did you demonstrate the apparatus in working condition to any other person ? —A. I have developed the apparatus in the laboratory and for all I know Graf Arco has also seen it. Moreover the apparatus is shown on the photograph.

Q. When you say "photograph," have you particular reference to something which you have recently seen ?—A. No, that is a photograph, which must also be available here, of 1913.

Q. Do you refer to the photographs Nos. 233 and 2,995 dated April 30, 1913, and April 30, 1913 ?—A. Yes. The two apparatus have been developed by me and tested by me.

Q. And tell me, did you use the apparatus shown in those photographs in any of the commercial stations of the Telefunken Company ? —A. I cannot say that. The apparatus has only been developed in the laboratory and whether it has been used by the Telefunken Company in its commercial stations, I do not know.

Q. Will you tell me, if the apparatus shown in the photographs is in a commercial form ?—A. Yes, it was this apparatus that I carried out receiving experiments with.

Q. And can you tell me approximately the date at what time the

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Defendant's Evidence.

No. 10. Evidence of Wilhelm Schloemilch, taken on Commission. Examination —*continued.*

apparatus was first built after the system shown in the photograph ?—A. That I cannot state definitely, because the apparatus were first set up by me in the laboratory, then the drawings thereof were made and then only constructed in the shop, therefore the laboratory type of the apparatus dates much farther back than the date shown on the photograph. It may be a matter of several months.

Q. I now place before you a copy of German patent No. 239,300 and would ask you to tell me whether or not this patent including its drawings describes an improvement in the nature of inventions made by you ?—A. Yes, the patent relates to a high and low frequency amplification with one cathode tube. I have also done work with this connection. The cathode tube was not a high vacuum tube, as here shown, but was a tube of the so-called Lieben-type which was used first as a receiving tube.

Q. When did you first operate an apparatus which used the circuit arrangements of Fig. 1 ?—A. This connection here is a special case, I cannot exactly remember when.

Q. Would you say whether before or after the day of the filing of the application, February 8, 1913 ?—A. Naturally I cannot state it definitely, to all appearances it has been before, but when, I cannot know. Of this connection diagram there must be another sketch available here, where the high frequency is amplified through the tube, but then is passed back into the tube and is re-amplified.

(The witness points to Fig. 2 of patent No. 293,300.)

Q. I will now ask you to refer only to Fig. 1 and tell me when you used the circuit arrangements there in an actual apparatus, and what tuning adjustments you actually made in the course of reception of signals ?—A. Fig. 1 shows a tube connected as high frequency amplifier and a second tube connected as a low frequency amplifier. A tuning of the oscillatory circuits before and after the high frequency amplification (witness makes reference to the photographs Nos. 233 and 2,995) I have proceeded with long before April 30, 1913. I have used the connection shown in Fig. 1 only in the laboratory type of apparatus, but I have not used it in a commercial apparatus.

Q. When you say you have not used the arrangement of Fig. 1 in a commercial apparatus, will you tell me, how the commercial apparatus differed from the apparatus shown in Fig. 1 ?—A. I cannot state that so accurately, that is impossible.

Q. Can you tell me whether the antenna circuit of your commercial apparatus was tuned and which system corresponded to the system *f* including the coil *g* and variable condenser shown in Fig. 1 of the patent ?—A. Yes, without a tuned antenna one would have had a bad reception.

Q. Was the circuit, which I shall refer to as the grid circuit, tuned in the commercial apparatus ?—A. I do not know what you mean by " commercial apparatus " (Verkehrsapparat). Does it mean an apparatus which was available on the market, or does it mean an apparatus with which one can practise radio telegraphy ?

Q. You may answer with respect to what you did.—A. The tuning of grid circuits in cathode tubes was something obvious, because we were

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Defendant's Evidence.

No. 10. Evidence of Wilhelm Schloemilch, taken on Commission. Examination —*continued.*

used to that already from earlier receiving even with the detector. I have always tuned the grid circuit in cathode tubes.

Q. I refer now to the vacuum tube *a* in Fig. 1 of your patent No. 293,300, and I ask you to tell me whether or not it was arranged to amplify to high frequencies?—A. Yes.

Q. As shown in Fig. 1, can you tell me whether or not the grid circuit of the tube *a* is tuned in independently of the antenna?—A. I have carried out the tuning of the grid circuit independently of the antenna, but I cannot state when.

Q. Would you say that that was before or after the date of your application filed February 8, 1913?—A. It was before that, quite certainly.

Q. Now, again referring to Fig. 1 of patent No. 293,300, can you tell me whether or not the circuit referred to in the patent by the letter *n* was tuned?—A. Yes, the circuit was tuned because it would have been impossible to otherwise obtain the optimum of efficiency of the tube.

Q. To what frequency the antenna circuit, the grid circuit and the circuit *n* of the vacuum tube *a* were tuned when you operated the arrangement?—A. I can remember that we did not go much below 500 mtrs, wave length, because at that time we did not operate any otherwise. As a rule the waves were longer than 500 mtrs, for example 1,000 mtrs, 1,500-2,000 mtrs, etc.

Q. But you have not told me, when you were for example receiving a 500 mtrs wave signal, by what frequency the antenna system, the tuned grid system and the tuned circuit *n* were tuned?—A. The antenna circuit, the grid circuit and the anode circuit were always tuned to the same wave.

Q. And the antenna circuit too?—A. Also, I said already that the antenna circuit, the grid circuit and the circuit *n* were tuned to the same wave length.

Q. *At about what time did you disclose your experiments with reference* to the filing day of the application, namely February 8, 1913?—A. Quite accurate details it is impossible to state. As a rule improvements in connection diagrams were communicated at once to Mr. von Bronk, provided they were of value from the patent point of view. To give an accurate date is impossible for me.

Q. Can you tell me whether you knew of the existence of any drawings, sketches, blue prints, photographs and the like by means of which you could refresh your recollection with particular reference to the preceding question?—A. As documentary proof, that about that time, that is to say, ten years ago, I did work with these connection diagrams, the photograph No. 233 of April 30, 1913, serves, likewise also a blue print must be available somewhere here.

Q. Can you tell me whether or not the blue print I now hand you is the blue print in your mind?—A. Yes.

Q. And if you will look at the date in the lower left-hand corner and say whether or not that refreshes your recollection as to the date when you told Mr. von Bronk of the results of your experiments?—A. I have myself carried out and tested out the connection diagrams shown here on the blue print L. 898. As to when I spoke to Mr. von Bronk concerning them, I am unable to state. The date shown in the left-hand corner is

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 10. Evidence of Wilhelm Schloemilch, taken on Commission. Examination —*continued.*

going back thirteen years and it is impossible to recollect verbal communications made so many years ago.

Q. Was any one in connection and association with you in working out the arrangements shown in your patent No. 293,300 ?

(Mr. Smart objects.)

A. At that time I had in the Telefunken Company a laboratory in which I worked alone. Who amongst the employees of the Telefunken Company was acquainted with or got an insight in my experimental work, I cannot to-day state with exactness. As a rule I have reported upon my investigations and successes directly to the directors.

Q. Do you know who prepared the patent application filed February 8, 1913, which resulted in German patent No. 293,300 ?—A. I am unable to state that accurately, Mr. von Bronk has been the head of our Patent-Department since many years. The year when he took charge of it I am unable to state.

Q. Did you alone invent the arrangements shown in your patent No. 293,300 ?—A. The arrangements shown in Fig. 1 and Fig. 2 were worked out by me alone, because I can state that at that time there existed only one laboratory of which I had charge.

Q. Did you ever tell anyone about the work you have done with the particular reference to the circuit arrangements shown in Figs. 1 and 2 ? —A. As far as I can remember, Graf Arco was continuously acquainted with the development of the progress of my work and I had to report verbally to Graf Arco concerning the progress of my work.

Q. Can you tell me the difference between the tube shown in photograph No. 1,744 and the tube as shown in photograph No. 233 ?

(Mr. Smart: I object to the photograph No. 1,744 now being shown, the photograph has been shown already to the witness.)

A. The tube shown in photograph No. 1,744 is the so-called Lieben-tube, whereas the tubes shown in photograph No. 233 are high vacuum cathode tubes.

Q. Did you ever work with a radio apparatus at any of the commercial stations of the Telefunken Company which embodied the invention of your patent No. 293,300 ?—A. Yes, I have worked with these apparatus in Nauen.

Q. At what date ? Approximately ?—A. That goes a little bit too far back in my memory.

CROSS-EXAMINATION by MR. SMART:

Cross-examination.

Q. Have you retired now from the active work in the Telefunken Company ?—A. No, I am still working with the firm.

Q. Do you work in the Telefunken Company or are you active at your home ?—A. The Telefunken Company has built a small laboratory in my house at Kallinchen where I am still active for them.

Q. I want you to refer to Fig. 1 of patent No. 293,300 and particularly to the variable connection of the transformer K and tell me what was the purpose of that variable connection ?—A. The circuit K, n is a weak damping circuit. Coupled parallel to this circuit is a detector l. If one

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 10. Evidence of Wilhelm Schloemilch, taken on Commission. Cross-examination —*continued.*

were to couple the detector parallel to the entire circuit, then the circuit would be damped so much that only a weak tuning would result as well as a smaller intensity of sound. Consequently one is forced to couple the detector *l* loosely as we call it now, that is to say, to place it in parallel to part of the self-induction.

Q. Where was the laboratory where you first carried out your experiments with reference to the patent?—A. The laboratory was situated at the office of the Gesellschaft für drahtlose Telegraphie m.b.H. (Telefunken) 9, Tempelhofer Ufer; the main building is 12-13, Hallesches Ufer, Berlin.

Q. Did you have anything to do with the invention of the circuit shown in German patent No. 271,059?—A. Yes, I also had something to do with it. Because I am a so-called receiving-engineer in the Telefunken Company, I had also to do with the development of this circuit arrangement.

Q. Had you anything to do with the development before September 3, 1911?—A. I cannot state that, I cannot remember it.

Q. I want you to look at Fig. 6 of the blue print No. L. 898, and tell me what the purpose was of the variable connection to the second coil of the transformer which connected the antenna?—A The Lieben-tube used in Fig. 6 has a considerably lower internal resistance than the cathode tubes used nowadays. Consequently, if one were to couple the tube in parallel with the entire oscillatory circuit, this would likewise result in unsharp tuning, likewise the intensity of the receiving (incoming) sound would be also impaired. Consequently one is forced to connect the Lieben-tube likewise in parallel only with part of the self-induction.

RE-EXAMINATION by MR. TAYLOR:

Re-examination.

Q. Will you tell me whether the same reason applied when you used the type of tube shown in photograph No. 233?—A. No, the tubes shown in this photograph are high internal resistance tubes. At that time we started to use this type of tubes.

EXAMINATION CLOSED.

No. 11.

Evidence of Louis Alan Hazeltine.

MR. HENDERSON: I will call Professor Hazeltine.

LOUIS ALAN HAZELTINE, Sworn, Examined by MR. HENDERSON.

No. 11. Louis Alan Hazeltine. Examination

MR. HENDERSON: I understand the witness prefers to be called Mr. Hazeltine, but with all deference, I think I will continue the common practice and call him Professor Hazeltine.

Q. Where do you live?—A. At Hoboken, New Jersey.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 11. Louis Alan Hazeltine. Examination —*continued.*

Q. Will you state your qualifications to give evidence in this case, without my leading you in detail, in the electrical art? —A. I graduated from Stevens Institute of Technology in 1906. The following year I spent in the Testing Laboratory of the General Electric Company at Schenectady, gaining a broad, practical experience with electrical apparatus. From the following year until a year and a half ago I was engaged in teaching electrical engineering at Stevens Institute of Technology.

Q. Your position being what? —A. I went through all grades from assistant to professor of electrical engineering having the latter rank beginning in 1917.

Q. And until when? —A. Until a year ago last summer. I began a special study of radio in the winter of 1914-15, that being particularly directed to the vacuum tube which was then beginning to excite a great deal of general interest. I undertook a mathematical and experimental investigation in vacuum tube circuits, which work culminated in a paper which I presented before the Institute of Electrical Engineers in 1917, and which gave, I believe, for the first time a general mathematical method for treating oscillating vacuum tube circuits. Much of my time from then on was specifically devoted to radio, which became my speciality. In the summer of 1918 and the following fall, winter and spring, I was connected, as consulting engineer in radio, with the United States Navy Department at the Washington Navy Yard. During that time I assisted generally in the development of radio receiving apparatus, and particularly designed a radio receiver for the navy which was adopted as a standard and has been very widely used since that time.

I have done a certain amount of consulting engineering work in radio, including the design of other radio receivers. During my work in connection with the Navy Yard, and the period immediately following I made certain inventions in radio which have matured into patents, and which form the basis for the neutrodyne receiver. This neutrodyne receiver came out in the spring of 1923. The previous winter and the previous fall I devoted to a very intensive study and development of radio receiving equipment. I was a member of the first three radio conferences called by the United States Secretary of Commerce, Herbert Hoover, to make general recommendations in regard to the control of the radio situation on this continent, the last of these three conferences including active participation by Canadian and Mexican representatives.

I have the highest grade of membership in the following national scientific and engineering societies; the Institute of Radio Engineers, the American Institute of Electrical Engineers and the American Physical Society.

Q. You have omitted reference to the Standardization Committee.—A. In the Institute of Radio Engineers I am a manager and also a member of the Standardization Committee and chairman of the sub-committee on vacuum tubes.

Q. And you speak of having ceased connection with the Stevens Institute a year ago last summer?

HIS LORDSHIP: Where is that Institute? —A. Hoboken, New Jersey, which is right across the river from New York.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 11. Louis Alan Hazeltine. Examination —*continued.*

MR. HENDERSON: It is on the high ground, just opposite the Cunard Line.

Q. And what is your present occupation?—A. I am a Research Engineer.

Q. With what?—A. Independently. I am interested personally in the continuing success of the Neutrodyne situation, and I devote my time to quite informal connections with that development. I do a great deal of theoretical study along those lines, and some of the results of that study are tried out in the laboratory of the Hazeltine Corporation.

Q. Which is situated where?—A. That is situated on the grounds of the Stevens Institute of Technology.

Q. At Hoboken?—A. At Hoboken.

Q. And you are the inventor under certain patents issued?—A. Yes. I referred to those as the neutrodyne patents.

Q. Will you be good enough to refer to the Alexanderson patent in suit and outline your understanding of Mr. Alexanderson's purpose and of the relation of his proposal to the art of radio reception as it existed at that time? That is, in 1913.

MR. SMART: The witness is not proposing to construe the patent.

MR. HENDERSON: Oh, no.

MR. SMART: But generally to compare it with the prior art.

MR. HENDERSON: Yes, we do not want to go over any ground covered by Waterman, unnecessarily, except so far as will give an understanding of what is outlined.

A. I have examined this patent very carefully and have endeavoured to picture the radio art as of the date of 1913 and particularly from the point of view of the inventor, Doctor Alexanderson, so that I can most clearly express my understanding particularly of his comparison of what he believes to be his invention with his understanding of the prior art.

MR. SMART: May I caution the witness at this stage that if he speaks of the prior art he must confine himself to his own knowledge of the prior art?

MR. HENDERSON: I do not know what my learned friend means.

HIS LORDSHIP: I think the witness understands it.

MR. SMART: The point raised in my mind by the witness' own statement was that he was to paint a picture of the art in 1913. As I understand it, he was not in the art in 1913. He can deal with the documents which have been filed.

HIS LORDSHIP: He can say whether there was an art or not then.

THE WITNESS: I am not sure that I made myself clear in stating some of my experiences. The beginning of my special study of radio was not until 1914, but my teaching experience involved all branches of electrical engineering. I was not specializing in one branch, and I had to keep generally informed on all branches, which, of course, included radio. As I remember it, I first read a complete treatise on radio the year I graduated from Stevens, so that I have a general familiarity from 1906. I also mentioned that I was in the testing department of the General Electric Company in that year, and it was at that time that I first became acquainted with the work of Doctor Alexanderson. In fact, as a test man I assisted Doctor Alexanderson in two developments ; in the development of what was known as the self-excited alternating current generator, and in his work on alternating current commutator motors.

Doctor Alexanderson would not know of this, because I was a man in corduroy trousers and black shirt and merely a test man, but I had a chance to observe his work, and I had a general acquaintance with his work at that time, and I knew him as being closely associated with that type of high frequency alternating current. Dr. Alexanderson, as I have indicated, was essentially, in that period, a power electrical engineer, and he came into radio from being called upon to develop this high frequency generator. He did not start, as so many radio engineers have done, as a radio operator. He started as a highly trained general engineer, and took up radio later on. I have mentioned that because it seems to me that in reading the introduction to his patent he was not very conversant with the general art of radio reception at that time. His view, as I see it, was essentially limited by his own speciality, and what I have in mind in making that statement is the quotation which Mr. Waterman has already read from page 1 of the Alexanderson patent.

Q. United States patent ?—A. Yes. I am using the United States patent, as Mr. Waterman did.

HIS LORDSHIP : It is always understood as the American patent.

MR. HENDERSON : Yes.

THE WITNESS : On page 1, line 18, he says, " The method now commonly employed "—I will not read it again, but he refers to the single-tuned circuit. I think that if he had been acquainted more particularly with the radio receiving art he could hardly have explained it as being limited to such a single-tuned circuit. He also goes on, beginning at line 30, with the following statement which I think I had better quote :—

> " In accordance with the present invention, selective tuning is secured by the use of a plurality of resonant circuits arranged in cascade in such a manner that the selectivity of the system increases in geometric ratio with the number of circuits employed."

Evidently Dr. Alexanderson considered that as his invention, and yet that is the precise description of the prior art, not merely the prior art of a few years before, but the prior art of many years before. Alexanderson did not invent geometric selectivity. Geometric selectivity appears to have been first invented by Marconi. Another inventor who worked almost simultaneously and independently was Mr. Stone. Those two men seem to be responsible for geometric selectivity, and that work commenced about the year 1900, and went into very general, and I might say standard use in the years immediately following. Geometric selectivity has already been referred to by Mr. Waterman, but I do not think in an accurate way. Mr. Waterman indicated that the geometric selectivity was merely approached as the signal became indefinitely weak. I have made a mathematical and experimental investigation which I will merely refer to at this moment, which indicates that that is not at all the case, that the geometric selectivity of Marconi and Stone was attained without any serious loss on any signal strength, and therefore that was not Dr. Alexanderson's contribution.

Then Dr. Alexanderson goes on to say:—

"The selective circuits are respectively interlinked by a relay controlling a separate source of energy to initiate oscillations corresponding to potential oscillations impressed upon the relay."

That is something which was not in Marconi. Alexanderson cannot therefore be accused of not knowing of that element as having been used in the standard Marconi system, but it will appear that the relay itself was a very old device and it will also appear that the relay used in the way that Alexanderson used it was also old, not nearly as old as the geometric selectivity of Marconi, but nevertheless some time prior to Alexanderson.

The next statement of Alexanderson, continuing at line 40, is a statement that applies again to the Marconi system, dating as I have said some dozen years before Alexanderson's time and reads:

"As each tuned circuit is more or less opaque to disturbing oscillations differing in frequency from the oscillations to be selected, a certain percentage of the disturbances is eliminated in each circuit of the series, so that the purity of the incoming train of oscillations progressively increases as it is successively relayed."

If I merely omit that last word "relay" and substitute "transfer" that would be a perfect description of the standard Marconi system as it existed for years prior to the Alexanderson device. Do you wish me to go into detail at this time?

Q. You are outlining at the moment—and I think you had better follow on as you are doing at present.—A. I have referred to the relay. There was in the art, the general electrical art, before the advent of the vacuum tube, a relay of the mechanical form. That relay seems to have first been introduced by Edison back in the eighties. It came into use in wire telephony. It might be what was called a repeater, that word "repeat" being used in essentially the same way as Waterman has used it in connection with his description of the Alexanderson disclosure. That mechanical relay had much in its broad features in common with the vacuum tube, although the structure was totally different. It received oscillations that were relatively weak. It used those oscillations for control purposes. What was controlled was the current of a local battery such as the so-called B battery in the vacuum tube. That control varied the resistance of the relay and caused pulsations in the current of that battery. All of that is common to the vacuum tube. However, in place of acting as the vacuum tube relay does on a stream of electrons emitted from a hot filament, it acted by mechanical pressure produced by the electrode on granular carbon; in other words, it was the combination of the well known telephone receiver and the equally well known telephone transmitter. That really took a weak incoming oscillation or alternating current and controlled the local source of energy to give a strong outgoing current, exactly the functions of the vacuum tube.

That relay went into use also in the radio field. As used for telephony it was not tuned, for the reason that Waterman has explained, that the frequencies involved in the voice and in music cover a wide range, and if we should tune a circuit carrying such current we would cause a great deal of distortion, but that relay was taken, and its ordinarily undesirable tendency towards resonance was accentuated and made useful, and that formed the basis of a device which was introduced by the German Telefunken Company beginning about 1910, and which was known as the sound intensifier.

Q. Explain what you mean by the German Telefunken Company.—A. I have forgotten the full name, which is a long one. It is the leading radio company, I understand, of Germany, and has been for a good many years, and has done a great deal of early pioneering work as well as present day work. That relay was tuned to a frequency which ordinarily was within the audible range, and it was arranged just as certain of the Alexanderson figures, such as 1 and 2, with several relays in cascade. The relays were tuned relays. They were quite sharply tuned. They were tuned for the purpose of giving geometric selectivity, which they did. They gave that geometric selectivity ordinarily however for audio frequencies. That is, for the frequencies which one hears. They also gave amplification and they gave increase in sensitivity.

That apparatus has seemed to have gone into very considerable use. It was noted in text books and photographs and descriptions were published, and this was all known generally some years prior to 1913. There were other developments of such relays. The relays to which I have referred was patented by Schloemilch & Leib. It might be well possibly for me to refer specifically at this time to those patents.

The first one that I find chronologically of these inventors does not mention their names. It is British patent No. 10210, of 1910, which was granted to Thompson as agent for the German inventors. There is a corresponding Canadian patent with identical disclosure which does identify the inventor. That is patent No. 156,452. I have not the date in front of me, but it was a later date than the British patent.

Q. That was issued to——A. That was issued to Schloemilch & Leib.

Mr. Henderson: Your lordship has in mind the British practice to issue a patent to a British subject for an invention made by a foreigner. Mr. Thompson was a patent agent who had funds to invest in that way, because he litigated a couple of cases in regard to broadening his right in that respect. The first patent in Britain was issued to him in his own name and not in the name of the inventor.

The relay of Schloemilch & Leib was made resonant by mechanical tuning; that is, the moving element had inertia, and it was supported elastically. The two elements of inertia and elasticity, as explained by Mr. Waterman, being necessary for giving resonance. If they are the ordinary mechanical properties of inertia and elasticity, we have the mechanical form of resonance; but we may have the electrical properties corresponding, and get electrical resonance. Now, the mechanical method of getting resonance in an electrical relay makes that relay also electrically resonant. That is a phenomenon that is very well known to-day, because it has been accentuated in a rather recently developed device known as the Piezo-electric crystal. It is indeed possible to get a far higher degree of selectivity or sharpness of resonance by such a mechanical device than is possible in an electrical circuit; and when that is done the electric circuit itself becomes very sharply resonant, and in fact behaves exactly as if it had a combination of inductance and capacity, which are the usual elements of an electrically resonant circuit.

Now, the next reference that I will make shows what might be called that transition. That was a contribution to the mechanical relay, which consisted in tuning it electrically in place of mechanically. That was disclosed in a German patent to Lorenz Incorporated.

MR. SMART: What is the date.

WITNESS: No. 258,478, of October 6th, 1912.

MR. HENDERSON: Which country?—A. Germany.

This patent shows a mechanical relay having a tuned input circuit and a tuned output circuit, each of those circuits being tuned or made resonant by inductance and capacity, just as in the Alexanderson patent. The purpose was to obtain geometric selectivity. In the specification the patent refers to his arrangement of a relay with tuned circuits as an improvement over the prior art and which coupled the tuned circuits reactively. That reference might well have been in the inventor's mind to a system for identically the same purpose which was one of the Marconi geometrically tuned systems. I refer to British patent No. 18,922 of 1909. The reason I make this comparison is that both patents, the British patent to Marconi and the German patent to Lorenz, were for tuning at audio frequency, so that they are directly comparable. This shows that the step of going from geometric selectivity with reactive coupling, that is we say magnetic coupling, to geometric selectivity with a relay coupling was a recognised step taken prior to Alexanderson.

Lorenz took the reactive coupling of Marconi and substituted a relay. That is exactly the comparison that we can make with the disclosure of the Alexanderson patent and the prior radio circuits of Marconi.

Q. You have not yet reached the vacuum tube, have you?—A. No.

Q. Before you do so, I want you to go over those different ones you have mentioned, with reference to the diagrams.—A. I can refer to the Alexanderson patent, which in its diagrams shows a vacuum tube relay, but whose specification indicates that it is not so limited.

Q. I do not want to go into that yet. Before we come to the question of the vacuum tube, will you first state in general terms the essential electrical properties of a radio receiver which measure its usefulness to the user?—A. The essential properties of a radio receiver which measure its usefulness to the user are sensitivity and selectivity.

Q. Will you elaborate a little on sensitivity?—A. Sensitivity is nowadays very often spoken of as amplification, for the reason that the receivers that we use nowadays always amplify, that is they always increase the intensity of the signal that might be received directly. But when we wish to make a comparison with receivers of the older form, we can not very well speak of their amplification, because they did not amplify; and therefore we have to use a word which is not so popularly current but which is used by radio engineers, and that is we speak of their sensitivity which is a measure of the intensity of the signal as received, say, in a telephone or some other part of the circuit, referred to the intensity of the wave which is received at the antenna.

I might also define terms at this point, and particularly the general term "signal." That word is used in a very broad sense in the radio art. In the first place, it is not restricted as one might think, to the code of radio telegraphy. It is used in addition to refer to music and speech as received from a broadcasting station. I know that it seems unnatural to speak of that as being a signal; but the radio engineers have not been able to find just the right word to describe that thing which has been received, and they call the thing which is being received a signal, whether it is radio telegraphy or radio telephony; and they call it a signal in any place in its path. It is a signal as it is received in the antenna; it is a signal as it goes through the vacuum tube; and it is a signal as it is finally heard in the telephone receiver or loud speaker. And the intensity of signal, after it has passed through the radio receiver, as compared with what is received in the antenna is what measures sensitivity.

Selectivity, I think, has already been very completely discussed. It is a measure of the ability to exclude what is not wanted. Sensitivity is the ability to receive at the greatest strength what is wanted.

Q. With which is Alexanderson concerned,—do you find he is at all concerned with sensitivity?—A. No. On the contrary I find that he appears to be not at all interested in sensitivity. He appears to be interested only in selectivity. I think that that is most briefly and clearly brought out in page 2 of his patent in the quctation which has already been read, which is as follows:

> "It will be readily understood that instead of adjusting the grid potential of the relay devices, the potential of the battery in the plate circuit, and other variable features, to initiate oscillations in which the waves of the desired frequency are reproduced with undiminished intensity, the same relative result may be secured by magnifying the oscillations."

That is he says you need not amplify. You may amplify or you may not amplify, but in either case selectivity is the object, not sensitivity.

Q. Now, Professor, did the introduction of relays, such as vacuum tube relays, into radio frequency circuits, improve sensitivity or selectivity as compared with the prior art?—A. The improvement was entirely in sensitivity. The introduction of relays gave no improvement whatsoever in selectivity, so that the very thing which Alexanderson aimed at in this patent as an improvement he did not attain.

Q. I want you to explain that.—A. I can explain that perhaps best by reference to certain charts which I have prepared.

Q. Then will you be good enough, in a sense going over what you have said. The first chart which I ask you to look at, I think, has been prepared by you, has it not, a simplified diagram of the Marconi patents? —A. Yes.

Q. Is that what you are going to refer to first?—A. Yes.

EXHIBIT "H":—Filed by Mr. Henderson Jan. 12th, 1927. Simplified diagrams of Marconi patents, etc.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 11. Louis Alan Hazeltine. Examination —*continued.*

A. (Cont'd)—I have first a chart, which I have marked chart No. 1, which is now exhibit "H," which shows in simplified form certain of the circuits to which I have made general reference in my previous answers; and there are three circuits on this chart, marked respectively, "Marconi, 1899," "Marconi, 1900," and "Marconi Company, 1907," possibly the latter might better have been marked "Franklin and Marconi Company," the patent to which I will refer in a moment having been taken out jointly by the Company and by Mr. Franklin.

Having this chart in front of me, I will refer more specifically to the Marconi work, as indicated by his patents and by the Franklin patent.

First we have the early single tuned circuit of Marconi, as disclosed in his United States patent 627,650, and illustrated for example in figure 2 of that patent. This is represented not in precisely the same form but in equivalent form, drawn to facilitate comparison, in the left-hand figure of my chart No. 1, exhibit "H" and is marked "Marconi 1899," which is the date of filing and of issue of this patent. It indicates generally a single tuned circuit, which, it is my understanding, is the prior art in the mind of Alexanderson as indicated in the introduction to his patent. A reference to the tuning of such a circuit occurs in this United States patent, page 1, line 31, which I will quote:—

> "It is desirable that the induction coil should be in tune or syntony with the electrical oscillation transmitted. The most appropriate number of turns and most appropriate thickness of wire varying with the length of wave of the oscillation transmitted."

The phraseology is a little different perhaps from what we use to-day, but it simply has a reference to tuning, which is all that I have in mind. The geometric tuning may be considered to commence with the Marconi patent that was frequently referred to in the testimony, particularly the cross testimony of Mr. Waterman, U.S. patent 763,772, filed in 1900.

This shows particularly in figure 2, geometric selectivity in two steps. This figure is the general basis, without great regard to detail, of the central figure of my chart number 1. The specification brings out clearly the idea that both the antenna circuit and the secondary circuit are tuned. It is that double tuning that brings in the geometric selectivity.

> I quote from page 2, beginning at line 118:—"The capacity and self induction of the four circuits, i.e., the primary and secondary circuits at the transmitting station, and the primary and secondary circuits at any one of the receiving stations in a communicating system, are each and all to be so independently adjusted as to make the product of the self induction multiplied by the capacity the same in each case, or multiples of each other. That is to say the electrical time periods of the four circuits are to be the same."

That again is in slightly archaic language, if I may say so, and one of his ideas, the use of multiples, has not persisted in the art: but nevertheless the other alternative making the electrical time periods or the frequency the same for the two receiving stations,—I mean for the two receiving circuits—is the basis of geometric selectivity.

Q. Would it be convenient there, Professor, if you yourself would give an explanation of geometric selectivity, what the term means?—A. Yes, and I think that my explanation would be essentially the same as I remember Mr. Waterman giving.

If we have one tuned circuit, that will cut down an interfering signal in a certain proportion as compared with the signal we desire to hear, and then we have a second circuit which will cut down the interfering signal again in a certain proportion, then if those two circuits are associated together properly we will have geometric selectivity, if the signal that interferes is cut down in the proportion which is the product of the first two proportions. Now that perhaps sounds rather involved, and probably Mr. Waterman put it much better than I did, but I think the idea is very much the same. I will perhaps give some values just to make it a little more concrete.

Q. And in doing so bear this in mind, we have been talking about ten times, I take it by way of illustration, and Mr. Waterman I think did say at one time, but did not emphasize it perhaps, that it did not necessarily depend upon the number of times chosen. You have my idea?—A. Yes.

Q. Will you explain that to his lordship?—A. That is if one joined circuit cut the interference down to one tenth, then two such circuits if they are alike and properly associated will cut it down to one one-hundredth.

Q. Not necessarily one tenth?—A. It is one tenth times one tenth, for two circuits, as an example: and for three circuits it would be one tenth times one tenth times one tenth, or one thousandth. Now that is if they are all alike. If they are not all alike the values will be different. I think I remember Mr. Waterman using these figures which are also representative. If for one circuit the interference might be cut down to one fiftieth, and in the next to one twentieth individually, then with the two of them together, the interference would be cut down to one twentieth times one fiftieth, or one one-thousandth. That is the general idea. Now that is accomplished not only by the arrangement of Alexanderson where he specifically discusses it, but it is accomplished equally by the arrangement of Marconi, if adjusted as was the practice and was generally known both practically and theoretically in the early 1900's to be the method of operating the Marconi system.

I might say, referring to the quotation which I have just read, that the engineers' method of determining the proper values of the two circuit constants, inductance, which Marconi calls self induction, and capacity, to tune a circuit, are exactly what was indicated in the quotation. That is we make the product of those two constants a certain value, depending on the frequency or wave length we have more inductance and less capacity, or vice versa, and that is the relation that is always used by the radio engineer, so that Marconi's statement is not only a general indication of what was wanted but it is a complete quantitative indication.

The next development along this line of geometric selectivity was the introduction of a third circuit or more circuits. As soon as the idea of introducing a third circuit came in, of course the continued addition of circuits became essentially the same problem. That may be illustrated, for example, in British Patent Number 12960 of 1907, to Marconi's Wireless Telegraph Company Limited, and Franklin, a patent to which I have already made a general reference.

That patent shows in its single figure essentially the arrangement at the right of my chart Number 1, Exhibit H. In this case I have not made any modification of the tuned circuits from that shown in the patent. That is, there is an antenna circuit having inductance, and a variable condenser in series. Then there is an intermediate circuit which in the patent is denoted by the letters h, l, k, which consist of two parallel inductances and a variable condenser; and then there is a secondary circuit or we might call it a tertiary circuit which is also tuned by a variable condenser. The first circuit is loosely coupled to the second, and the second to the third.

MR. SMART: I would like to make sure that I am looking at the right British patent. Is it 12960?—A. Yes.

HIS LORDSHIP: What is that symbol at the extreme right hand on that?—A. That is referred to in the patent as a receiver, if I remember correctly. That is the symbol denoted by the letter small r, your lordship. I understand that to be a combined telephone receiver and detector represented symbolically. Evidently the type of detector is a low resistance type because it has been connected in series with the circuit, which is the method used in such a type of detector. That might have been, as I understand it, the so called magnetic detector in use in the earlier days of radio.

MR. SMART: Professor Hazeltine said he had not made any change in that.—A. I stated that there had been no change so far as the tuned circuits were concerned, in my chart. I have represented a crystal detector in my chart used in connection with telephone receivers. I have done that because I knew that it did not have any effect on the selectivity and I thought it would be of greater simplicity for the court, to use the same symbol and the same mode of connection in all the various charts for like elements. I am not in any way attempting to make any distinction and all of my remarks will apply equally either to my chart or to the patent itself.

This patent then gives us geometric selectivity in three stages, so that we have the product of three factors in the way that I indicated a few moments ago, and gives sharper and sharper selectivity. The adjustment of the circuits is covered mainly on page 3 of the patent beginning with line 9. I will not read that as it is rather long, but it brings out the fact that the circuits, each of the three circuits, is tuned by a variable condenser, and that the coupling is adjustable. It is also brought out in the specification.

My last reference was wrong. It should have been to page 4 beginning with line 23. That covers adjustment. The other reference which I made covers the general idea of successive reactive or inductive couplings, and particularly the fact that the coupling must be loose. I think I might emphasize that point at this time, that the reactively coupled system of Marconi and others is capable of giving geometric selectivity. It will

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not always give geometric selectivity if it is not used for that purpose. It will give geometric selectivity when the coupling is very loose, and that was the ordinary way of operating such circuits, but if a coupling is made quite close or moderately loose, then we get disturbing features that detract from it. That is not a proper way to operate the system and it is not the way in which it was operated, and the theory of that and the practice is very thoroughly discussed in texts of that time as well as in certain evidence. I have in mind a very full discussion, that I will not refer to in any detail, in the United States Patent to Stone, Number 714756, which was filed in 1900 and which shows geometric selectivity in a large variety of circuits, where we have two tuned circuits, or three tuned circuits or four tuned circuits or more all arranged in cascade and coupled loosely each one to the following.

I also can refer to a very simple and clear discussion of the selectivity matter bringing out broadly what the selectivity is for and how it is attained by those reactively coupled systems of Marconi and others. That is given on page 806 of the well known textbook of Fleming.

MR. HENDERSON : What is the date of Fleming, the edition you refer to ?—A. I have not the date in front of me, but I believe it was 1910.

Q. Will you look at the book and compare it ?—A. I have now the book in front of me, and that shows that it was published in 1910. The title of the book is : "The principles of electric wave telegraphy and telephony."

Q. We had spoken of a Fleming who was the first man in the vacuum tube line. Is there any identity ?—A. Yes, that is the same man.

Q. Who was he ?—A. He is an Englishman who has been for many years one of the leading figures in the radio art. He has written a great many books of the highest authority some in radio and some in other branches of electrical engineering. He co-operated very closely with Marconi in Marconi's early work.

Q. And you are now reading from his book at the page you noted ? —A. I am referring to it. Unless you wish I will not read it. It is rather long. I merely mention it as being a very simple discussion and yet very accurate and complete.

HIS LORDSHIP : A discussion of what ?—A. It is a discussion of the Marconi selective system. He does not use the words "geometric selectivity." He describes what is geometric selectivity. Dr. Alexanderson, perhaps because he came into the field not as a radio engineer, uses in his patents several original terms, some of which have stuck and some of which have not. Dr. Alexanderson, so far as I know, was the first to use the term "geometric selectivity" although the idea was very completely described long before his time. He also uses another term which I think I quoted a short time ago, and that is "opaque." That is a term that I never heard anyone else use in that sense. That term did not stick in the art, but the term geometric selectivity has to some degree stuck in the art.

HIS LORDSHIP : It is a peculiar word to use, but it is a great thing to invent a new term.

Mr. Henderson: I find a great many words used in a sense other than the ordinary sense.—A. My reference to Fleming is of particular interest in that the general description beginning on page 806 is immediately followed on page 807 and the top of page 810 by a description of the actual apparatus of the Marconi and Franklin patent, which I have just discussed.

Q. That is referred to in a footnote at page 807, is it not?—A. Yes. I find that footnote referring to this British Patent Number 12960. On that page there is a picture of such a receiver, there called a tuner; and again on page 808 is an elementary diagram of connections, entitled, "Circuits of the Marconi tuner." *This diagram is identical with the figure* of the patent except that in place of showing a circle, which in the patent is marked by the letter small r, it here shows a coil. I understand that, as I mentioned before, to represent a coil in the now obsolete magnetic detector. It is referred to simply as a receiver, three lines above the drawing in the Fleming book. Then on page 809 is a detailed diagram of connections of this same Marconi tuner, so that we see that it not only was the subject of a patent but it actually was a piece of commercial apparatus. I might make just one more reference to this subject of geometric tuning as used in these early reactively coupled systems and that is to an article in the Electrical Review Vol. 46, Number 12, page 502. I make particular reference to this as showing knowledge of this subject in Canada, for the footnote to the title states: " Read before the Electrical Section of the Canadian Society of Civil Engineers, Montreal, Canada, March 9, 1905."

I will not need to refer to it in detail, except to point out that Fig. 11 on page 506 shows three successive tuned circuits very similar to the Marconi-Franklin arrangement, or the right hand figure of my chart No. 1, and this discussion is my John Stone Stone, the patentee to whose patent I previously made passing reference.

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Mr. Smart: Before my learned friend proceeds with the witness, may I say with respect to the binder containing Exhibits G-1 to G22, that the printed and photostat copies of the patents contained in that binder, by virtue of our consent are proved by the production of those copies for *prima facie* purposes, and that the dates of issue of the patents shown there are to be regarded under the consent as the dates of issue.

I observe with respect to certain of the foreign patents, that there are translations, and I would ask my learned friend to let me have copies of the translations so that I may compare them with my own copies. I think there will be no difficulty in agreeing that such translations as my learned friends have offered are translations of the patents in question.

There is one point, however, that I observe, and that is that the translations of some of the German patents give the date of filing as the date of issue. A German patent issues some time after it is filed.

Mr. Henderson: Don't you mean that it is issued some time after it is passed upon?

Mr. Smart: Yes, after it is filed. The same thing.

Mr. Henderson: Approved.

MR. SMART: Yes. And the printed copies bear both the date of filing and the date of issue. I note that Mr. Hazeltine fell into a mistake, which is readily understood, by reference to the typewritten copy; in speaking of the Lorenz German patent 258478, he spoke of it as being the 6th October, 1912; which was the filing date: whereas it issued, according to the printed copy, on April 5th, 1913. Something in each of the cases may turn on the difference between the date of issue and the date of filing, and I would like the translation to indicate both dates. The translation in the case of the German patents seems only to indicate the date of filing. And otherwise I think it would be desirable that I should compare the translations and I have no doubt my learned friend will agree to that.

HIS LORDSHIP: I assume you will arrange that.

MR. HENDERSON: I agree with everything my friend has said, but may I say this word as to the translations; that quite obviously I expected them to be checked, like everything else, and the necessity for translation I presumed was obvious; I do not know to what extent your lordship is a linguist, but I assumed that they were necessary, and they will all be subject to checking, and that can be done. We will try to do that at once. Perhaps we have them, or if not we will make them.

L. A. HAZELTINE, Examination resumed by MR. HENDERSON:

Q. Mr. Hazeltine, you had covered what I might call the earlier chapter of your evidence. Will you be good enough just to say in a word, not going over it again, what you have covered yesterday?—A. I think perhaps I had best refer simply to the Marconi system of geometric selectivity, because that is the only thing which I discussed in detail yesterday.

Q. What you might call the Marconi system of geometric selectivity? —A. Yes. You wanted me to summarize that?

Q. Yes, if you will condense it, so that we may pick up yesterday and connect it with to-day?—A. The Marconi system of geometric selectivity was introduced into the radio art about the year 1900. That is, 13 years before Alexanderson's time. And this was not introduced merely in a theoretical way, in the form of a patent or other publication, but actually became standard in the radio art, and became used almost universally for radio communication.

This system had the same properties exactly that Alexanderson discloses as the object of his work. That is, to enable a selection of a desired radio signal and the exclusion of undesired radio signals, even in cases where the undesired signal was very much stronger than the desired signal. And the method was, so far as its selectivity is concerned, essentially the same as Alexanderson's. That is it involved the use of several tuned circuits, these tuned circuits being coupled to one another in cascade. The coupling that was used, however, may be called a reactive coupling, whereas Alexanderson used a relay coupling. The result was exactly the same. The result was geometric selectivity. In fact, I can show that the selectivity that was obtained was practically the same as Alexanderson's quantitative. It might even be better. The apparent advantage of the Alexanderson system, therefore, was not real. He made it selectivity, and he got no more selectivity than was standard practice at his time.

His Lordship: In what respect are the devices for accomplishing selectivity similar ?—A. The Alexanderson system employed relays and the Marconi system did not. It employed a reactive coupling which, as commonly used, was a magnetic coupling: that is, an association of coils or inductances, so that the magnetic field of one would in part link with the other.

Q. Marconi used the tube ?—A. He did not use a tube as a relay. He used a condenser.

Q. He used a condenser as Alexanderson uses it ?—A. In exactly the same way. The two elements of tuning were the condenser and the inductance and Marconi used both of them in every one of his tuned circuits just as Alexanderson did.

Q. Do you put disturbances in the same class as undesired signals ?—A. Yes, your lordship.

Q. It is part of the function of selectivity to discard disturbances as well as undesired signals ?—A. Yes. The disturbances may be the natural disturbances known as atmospherics, and sometimes colloquially static. Then there are disturbances particularly in a city from trolley lines and other electrical devices, a selective receiver——

Mr. Henderson: A leaky transformer ?—A. Yes, that is another form of disturbance.

His Lordship: I suppose you can get selection by exclusion ?—A. Yes, they are essentially the same, but differ somewhat in detail. It is possible to exclude a broadcasting station almost completely if it is reasonably separate in frequency, but it is never possible to exclude random disturbances, such as these leaky transformers and atmospherics completely. They might be excluded to a considerable degree at the receiver, but never completely.

Q. Does Marconi still use his system of selectivity ?—A. In the form in which it was originally used, having this reactive coupling, it is not now in general use. However, Marconi being the pioneer in selectivity, and having a broad disclosure principle, is in my opinion in use to-day; that is in my opinion the arrangement, the Alexanderson, or the arrangement that is generally used to-day is broadly Marconi.

Mr. Henderson: Q. Does Marconi use anything that reads on Alexanderson any more than it does on Marconi ?—A. I do not think I understand your question.

Q. Could you say that Marconi has adopted Alexanderson ?—A. Do you mean Marconi——

Q. The Marconi Company ?—A. Oh, the Marconi Company!

Q. That is what we mean by Marconi. You say Marconi has continued the Marconi system ?—A. I mean the Marconi system broadly as used by everyone to-day.

His Lordship: Yes, I understand that.

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Mr. Henderson : It would follow from what you have said.—A. Yes, and that would include the present English Marconi Company, if that is what you mean.

Q. Has Alexanderson as such been used commercially by the Marconi Company, or are they still using Marconi ?—A. I think perhaps if I should answer that I would come under the objection that Mr. Smart raised yesterday, as interpreting Alexanderson's patent, and that is beyond my function.

His Lordship : I understood the witness to say that whatever system of selectivity anybody uses is based on Marconi.

Mr. Henderson : Yes.

His Lordship : As a matter of actual practice Mr. Henderson wants to know if the system used by Marconi to-day approximates in arrangement and set-up the Alexanderson more than it did the original Marconi.—A. I am not sufficiently familiar with the practice of the Marconi Company to-day to answer that well.

Mr. Henderson : Q. Does that cover your resume ?—A. Yes, I think so.

Q. Look at your two charts. These are charts prepared by you, are they not, 5 and 6 ?—A. Yes I have prepared two charts which are marked chart No. 5 and chart No. 6, for the purpose of showing quantitatively the geometric selectivity in the original Marconi form and in the Alexanderson form.

His Lordship : I see on the right hand side of No. 6 you disclose a tube ?—A. Yes.

Q. That is the Alexanderson on the right hand side ?—A. Yes, your lordship.

Mr. Henderson : Q. Will you follow on with your explanation ? —A. I will describe these charts, beginning with chart No. 5.

His Lordship : They will be marked Exhibits " I " and " J ".

EXHIBIT " I " :—Filed by Mr. Henderson, Jan 13, 1927. Chart comparing geometric selectivity in Marconi and Alexanderson—Two Resonant Circuits.

EXHIBIT " J " :—Filed by Mr. Henderson, Jan. 13, 1927. Chart comparing geometric selectivity in Marconi and Alexanderson—Three Resonant Circuits.

The Witness : On these charts, Exhibits " I " and " J " I have plotted in the centre resonance curves such as were explained generally by Mr. Waterman in connection with plaintiff's Exhibit No. 2. At each side of the chart I have drawn an elementary diagram of connections and have marked numerical values on each, using the ordinary abbreviation simply for convenience of the experts on the other side, in case they wish to check the calculations. The diagrams are not intended to do more than show how the calculations were made. They introduce simply an elementary circuit such as I have already discussed generally. The values that are chosen are those which I consider very representative of both the Alexanderson system and the original Marconi system.

I have chosen in effect exactly what I believe Mr. Waterman chose in preparing Exhibit No. 2. Mr. Waterman, I believe, stated that he would give the numerical value, but I do not remember that he did so. I have however, examined Exhibit 2 and believe that he used what is called the reactance resistance ratio of 100 to 1, and that is the exact value I have used for each combination of coil and condenser in every circuit except the antenna circuit where the resistance is naturally higher, as has been brought out and was particularly referred to in the Alexanderson patent as characteristic of conditions in the antenna. I should like to be corrected if I have not properly calculated the value that Mr. Waterman used, but I am confident that it is correct.

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MR. HENDERSON: Mr. Waterman says that it is correct, so that you will proceed on that assumption.

THE WITNESS: For the antenna circuit I have assumed an added resistance of 40 ohms in addition to the coil and condenser, which my experience indicates is a fairly representative value, and a value which is often actually used in general calculations for this purpose.

MR. SMART: Mr. Waterman says *his curve is calculated on a resonant* value of 100.

THE WITNESS: That ratio of 100 is just what I have used for my coils and condensers outside of the antenna.

MR. HENDERSON: If the witness uses any expression, as he goes along, that your lordship would like to have explained to make it more intelligible, he will explain it. I do not like to interrupt him.

THE WITNESS: These are mainly for the convenience of the other side, as they may want to check my calculations and I may want to indicate my reasons for the choice of values.

I have chosen for the Marconi systems couplings which I think an engineer would choose as part of his judgment, that giving a compromise between sensitivity and selectivity. In all kinds of engineering designs we have conflicts of various desirable features; and it happens that sensitivity and selectivity have a tendency to conflict. Now it also happens that you can get a compromise in which the sensitivity is nearly as great as it could possibly be, and you also have a selectivity which is nearly as great as it could possibly be; and I have chosen such conditions.

I *have done the same thing for the Alexanderson arrangement.* I have a choice in the transformer design that will enable a compromise to be attained between those same quantities, sensitivity and selectivity, and I have chosen a relation that gives nearly the maximum sensitivity and nearly the maximum selectivity.

With that general explanation, I will now refer specifically to chart No. 5. This shows the comparison between the resonance curves of the original Marconi system and of the Alexanderson system, each employing two tuned circuits.

The resonance curve is shown over a comparatively narrow range of an expanded scale, so that the percentage of resonant frequency as marked at the bottom of the curves is shown merely between the range of 95 per cent. and 105 per cent. This enables me to make a clearer comparison for the reason that the curves outside of this range coincide, so far as one can see; and it therefore would not show anything more to extend them. It happens that the vertical distances I have put on scale with one (1) at the top and 9/10ths just below, and so on; whereas it happens that Mr. Waterman's exhibit 2 had 100 per cent, and 90 per cent. and so on. But, of course, that means exactly the same thing, so that I have essentially drawn my resonance curves in the same way that he did.

MR. SMART: The scale for each curve is different, though, is it not? —A. No, the scale is exactly the same as Mr. Waterman used. That is, it is a scale in percentage in frequency and percentage in signal.

Q. I would like to understand whether the curves are comparative of the detector voltages of each circuit or whether merely each is compared with its own maximum.—A. The latter is the case. That is, the curves are drawn for the purpose of comparing selectivity only, and not for the purpose of comparing sensitivity, which is another question which I am not undertaking to show at this time.

Q. If it were done on the other basis, each curve would be lower? —A. No, not necessarily so. As I understand it, and particularly in view of the example given by Alexanderson, he does not aim to increase sensitivity necessarily, so that I really can not give on the basis of the Alexanderson patent a direct comparison in sensitivity; but I can give the direct comparison in selectivity, which is what I am discussing.

I think the most striking appearance of these curves is the fact that the two sets practically give identical results. It will be noticed that there is a slight discrepancy between the two, perhaps better, a slight difference between the two, but this is a difference that the ear would never notice; and it happens that the difference, as far as there is any, is in favour of the original Marconi system.

The most desirable form of resonance curve would be one that dropped off very slowly from its maximum value for a small deviation in frequency, and for larger deviations in frequency dropped off very rapidly. That ideal condition is not possible of attainment, but it happens that the Marconi original system approaches that ideal condition more closely than does the Alexanderson arrangement; and that is shown by the fact that the curve for Marconi is a little higher and nearer its peak than the curve for Alexanderson. Whereas, when we get to some distance from the peak, the curve actually falls below. It falls below by such a small amount that it is not possible to show it on the drawing; that is the amount would be less than the width of the line; but actually the Marconi curve drops below the Alexanderson curve, and that means that the Marconi system is the more selective of the two. I do not wish to emphasize that difference, because, as I said before, it is too slight to be of any practical importance, but merely the fact that whatever difference there is is in favour of Marconi and not of Alexanderson.

Now, if we refer to chart No. 6, which is exhibit "J"——

MR. HENDERSON: Professor, before you start from that, you have stated that this chart is the result of calculations made by you ?—A. Yes sir.

Q. May I ask if these are simple or elaborate calculations ?—A. That depends a little——

HIS LORDSHIP : I am afraid if they were accurate, they would be very elaborate.

MR. HENDERSON : I think they are very elaborate.

HIS LORDSHIP : I think both parties agree on this, do they not ?

MR. SMART : No. In fact these curves are very misleading because they do not show all the facts. They have selected certain facts and disregarded others, and you can draw a curve on any basis if you disregard certain facts. These two curves do not show the conditions observed in the circuit ; each is drawn on its own——

HIS LORDSHIP : I hoped that when two scientific minds undertook to show a thing, they might proceed along common lines and agree upon it.

MR. HENDERSON : In view of the fact that these charts are the result of very elaborate calculations, we will furnish my friend photostat copies of those calculations and let him check them if he can.

MR. SMART : It would be a long job.

MR. HENDERSON : Yes, and I do not know if he could do it, and I want it understood that this is not a mere statement.

MR. SMART : We have made the calculations ourselves, and the question is not so much on the calculations themselves but what is picked out of the calculation for pictorial representation.

MR. HENDERSON : Not at all. We will not argue that.

HIS LORDSHIP : You will admit that the processes by which the calculation is reached may be identical, but the picture or the interpretation may be different ?

MR. SMART : Quite different, yes.

MR. HENDERSON : Then I understand that my friend does not desire these calculations at the moment. I mention it now because I understood the witness had not brought the calculations with him, but was going to send for them, if desired. If my friend does desire them for the purpose of cross-examination, I would ask him to let me have some reasonable notice in advance.

MR. SMART : I will advise my friend now that I want them. There is this further objection, that the circuit set up is not the circuit in the Alexanderson patent.

MR. HENDERSON : That is a very broad statement.

MR. SMART : So that we are going to get into a very debatable field.

HIS LORDSHIP : I will assume that the calculations are very elaborate.

MR. HENDERSON : Yes.

HIS LORDSHIP : Now, what were you going to ask ?

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Mr. Henderson : I was going to bring out at this stage the fact that they are very elaborate, and to inquire if my friend is wanting them. Thinking, as your lordship said, that scientists would not differ very largely, because mathematics is an exact science. My friend now says he wants them, and we will get them as soon as we can. My purpose has been answered.

Q. My friend Mr. Smart has made certain comments on these charts, and you may bear those in mind as you proceed.

His Lordship : You might let that stand for the present.

Mr. Smart : I am quite satisfied we will have an argument.

Mr. Henderson : If my friend thinks he knows better than Professor Hazeltine, I am quite content with his statement that he thinks so.

Mr. Smart : In mathematics I would not enter into any competition with Professor Hazeltine.

Mr. Henderson : We will see, on my friend's cross-examination.

Witness : I was about to explain chart No. 6, exhibit " J," which is drawn on the same basis as exhibit " I," to illustrate selectivity for the original Marconi system and for the Alexanderson system when each has three tuned circuits.

Again I have used my best judgment in choosing variable quantities in the circuits, still sticking to the reactance ratio of 100 to 1 for the coil and condenser of each tuned circuit, and of course using the same values, as far as they occur in Alexanderson and in Marconi. And this chart, like exhibit "I ," is drawn to illustrate selectivity in the only way in which I know that it can be done.

His Lordship : Exhibit " J " you mean, do you not ?—A. " J " is the same as " I " in that respect. Again the most striking appearance of the curves is that they are sensibly the same, the differences between them being unnoticeable by the ear in practical reception. What little difference there is, however, is again in favour of the original Marconi system ; that is, its curve drops off but at first more slowly, which results in a somewhat better quality in broadcasting reception ; that is somewhat less freedom from distortion, and yet at greater deviations in frequency, where the curves trail out, the advantage is in favour of the Marconi system because its curve drops lower than that of the Alexanderson system, that difference again being of no practical importance, however, and not being capable of being shown on the chart as the difference is less than the width of the line.

The conclusion then from these charts is that Alexanderson added nothing to Marconi in the way of selectivity ; that if there is any difference it is in favour of Marconi.

His Lordship : In this Hazeltine set, does the antenna wire come in contact with the condenser first ?—A. No.

Q. On your sketch there, " J " a tuned condenser precedes the coil, does it not ?—A. In the defendant's receiver, the circuit is not identically the same as in chart " J." In preparing these exhibits " I " and " J " I have taken in each case the simplest possible arrangement, simply for convenience of mathematical computation, the result being essentially the same as if I took a more elaborate arrangement. And in the defendant's receiver the antenna does not go to the tuning condenser as shown but is connected to a separate inductance coil, a primary coil, as shown here in plaintiff's exhibit 8.

MR. SMART: Will my friend pardon me for interrupting. In dealing with the calculation, I wonder if Professor Hazeltine could supply us with the constants of the tube and primary coil and other factors which Professor Hazeltine will know, to enable us to check the calculation ?—A. There are no other factors than are marked on the chart. There is sufficient in the data given to complete the calculations.

Q. The constant of the tube and primary coil are not here, are they ? —A. There is only one constant of the tube that enters, and that is the effect of the plate conductance on the secondary circuit, and you will find at the bottom of the right-hand of each chart a statement which gives the value; that statement being " Plate Resistance of each vacuum tube equivalent to 5 ohms added in series with secondary coil."

Q. I wanted such information as to the constant as would enable us to calculate the actual relative voltage between the two circuits which are compared ?—A. That is quite immaterial. I have no other figures except what are on here. Those are the figures which I have used.

Q. Have you not any figures which will enable us to calculate the actual voltage of the so-called Marconi curve with the actual height of the Alexanderson curve for the same input ?—A. I have no other figures, because those are the only ones which I have made for the preparation of the chart.

Q. Your calculations, I understand, would not enable you to compare the actual height of the curves in that sense ?—A. No, I have indicated in a previous answer to a question of yours that that is a thing which I am not able nor is anyone else able to determine, because the Alexanderson patent leaves that very thing open.

Q. That may be a matter of argument as to what should be in or should not, but I am only asking you as to whether you have the information which would enable us to test this from the standpoint of what we think should be shown, and apparently you have not.

MR. HENDERSON: Is that a fair way to leave it ?

HIS LORDSHIP: Proceed then, witness.—A. I have finished comparing these curves so far as selectivity is concerned, which is what they show. But the question has just been raised by Mr. Smart on the matter of sensitivity, and perhaps I can best add at this time some further explanation along those lines.

Now so far as Alexanderson is concerned, I cannot add anything, because the Alexanderson patent, as I point out, leaves that question entirely open. Alexanderson does not appear to care about sensitivity. He gives an example in which there is an increase of a thousand to one, and he gives another example in which there is no increase at all, and I understand that he therefore does not consider that as part of his invention, and that we may have an increase in sensitivity, or no change in sensitivity,

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or a decrease in sensitivity, when we add successive tuned circuits, and I am therefore not able to add anything in regard to the sensitivity of Alexanderson, but I can make some reference to the sensitivity of Marconi, particularly as Mr. Waterman has indicated that there is a loss in sensitivity in Marconi when we add these successive tuned circuits in cascade to get geometric selectivity.

On that I quite disagree, and I believe from my information of the practical art, that it was the experience with the earlier cascaded systems of Marconi that there was often a gain in sensitivity when these successive tuned circuits were added over the simple system, and my mathematical calculations agree with that, and show that a gain is quite possible.

Using the figures that I have here in my charts, I do find even though I have sacrificed some sensitivity to get a desirable selectivity, I find that in Exhibit "I" there is actually a greater sensitivity with the two tuned circuits than there would be with one tuned circuit. The difference however, is not great.

In Chart Number 6, on the other hand, I do find some loss in sensitivity when we go to a third tuned circuit; but whether there is a gain or whether there is a loss, the amount in each case is too small to be of practical importance. And what is more, even when there is some loss in sensitivity, nevertheless an operator using such a system will actually find the signal easier to read. The reason of course is that the selectivity—as your lordship asked about earlier this morning—helps to get rid of stray disturbances such as atmospherics, and the operator even though his signal may be a trifle weaker, yet has less of a disturbing background. In other words, it is as if he was receiving in a quiet room instead of in a noisy room, and he is therefore better able to read his signal and get his messages when we add the successive tuned circuits than when we use the old single tuned circuit.

MR. HENDERSON: That I think covers that ground, does it not, Professor?—A. Yes sir.

Q. Then will you take up and compare the selectivity of Alexanderson with the selectivity of the prior art?

HIS LORDSHIP: You started on that yesterday?

MR. HENDERSON: Yes my lord, I started at that yesterday and in connection with that may I put it this way:

Q. When the Marconi system was used to give the geometric selectivity of which you have spoken, was its sensitivity seriously impaired?—A. No, it was not. My last answer I think pretty well covers that. The sensitivity might have been improved; it might have been a little worse; but in no case was the change of any considerable degree, and actually the signal would be more readable when the tuned cascaded circuits were added.

Q. Now you have spoken of the Marconi system as reactively coupled, have you not?—A. Yes.

Q. And what do you say as to it having geometric selectivity in the sense used in Alexanderson?—A. It has geometric selectivity in essentially the same sense as Alexanderson.

Q. My friend wants me to ask you which patent you are referring to. It is Marconi, the same one again. Now in view of what you have said as to the lack of improvement in selectivity of Alexanderson over Marconi, will you say why systems employing tuned relays should be used at all? First of all, Mr. Waterman has said that systems using tuned relays are now practically universal. Do you agree with that statement?—A. Yes.

Q. That is the general practice?—A. So I understand.

Q. Then in view of what you have said of the lack of improvement of Alexanderson over Marconi in selectivity, can you give your opinion as to why that universal practice exists?—A. That is entirely to increase sensitivity or to give amplification. The selectivity is, as I have pointed out, essentially the same as in the prior art, but present day conditions require high sensitivity; the ability to pick up very weak signals and to make them audible perhaps on a loud speaker. It is necessary, to get such a result, to introduce relays. That in fact is the function of a relay; to take a weak incoming oscillation, to initiate a new oscillation of the same kind but of greater intensity.

His Lordship: Do you mean greater frequency?—A. No my lord, the frequency is kept the same in a relay, but the intensity is greater. That is, if it is a telephone current, it is capable of producing a louder sound. That is what we mean by a greater intensity of signal.

Now it happens that when the engineer comes to design a relay system, and particularly a system employing a vacuum tube relay, he finds that in order to get this sensitivity he must, to make it most effective, tune his circuits, and that tuning is primarily in that case for the purpose of giving this increased sensitivity, and not for the purpose of giving more selectivity.

Mr. Henderson: I think you have already stated that you have been generally familiar with the radio art, first as a professor and later, as I may say, a practitioner, and have you since in the later days kept in touch with the commercial development of the art?—A. Yes, in a general way that has been part of my interest in the art.

Q. As well as experimentally?—A. Yes.

Q. For instance some reference was made yesterday to the publication of the I.R.E. article. Am I right there?—A. Yes.

Q. You knew of that article at the time?—A. Yes, that is the article I think of Langmuir's.

Q. Yes, Dr. Langmuir's article published in the I.R.E. proceedings. What does I.R.E. stand for?—A. The Institute of Radio Engineers.

Q. Yes, the Institute of Radio Engineers. He read a paper there and I suppose that attracted some attention?—A. Yes. I read that paper shortly after its presentation and I remember it very clearly. In fact I remember checking some of the calculations that were given in that paper and it made quite an impression on me at the time.

Q. Now if you will make a jump forward in date. That was, if I recollect, somewhere around 1913 or 1915 wasn't it?—A. I think it was 1916.

Q. I think the paper was in 1915. Now jump forward and give me the date when neutrodyne came into commercial use, and when I say neutrodyne I am speaking of your patent?—A. The neutrodyne receiver built under my patents came into commercial use in the spring of 1923.

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Q. I just make the broad statement now, as to the neutrodyne in commercial use, and I will give specific evidence as to that and I can give figures——

MR. SMART: I hope not. I can see no relevancy in this as to the inquiry we have now before us.

HIS LORDSHIP: You are not going into this fully, Mr. Henderson.

MR. HENDERSON: I am giving a quick jump forward and I am coming back again.

MR. SMART: It seems to me quite immaterial whether Mr. Hazeltine has put out in the United States one or a thousand neutrodyne sets. We are here suing a company in Toronto who are manufacturing and selling the set now in court. Now, whatever Mr. Hazeltine's activities have been in the United States, however widely his infringements of patents have been there, we have no concern with, and I should think should be excluded.

HIS LORDSHIP: Whatever you say now relates to selectivity, and I assume Mr. Henderson is not going into anything else that comes up in another case.

MR. HENDERSON: My learned friend is naturally worried about this, because it has come up to the detriment of my friend's prospects elsewhere, but I am going to give that evidence later on in this case.

MR. SMART: I hope not, unless his lordship sees the matter in an entirely different way to what I see it.

MR. HENDERSON: It is perfectly pertinent evidence.

HIS LORDSHIP: We will meet that question when we come to it.

MR. SMART: I think this question is too wide and I am afraid of how far the witness may go in answering it. The question is put to the witness to state the commercial use of his receiver in the United States, which is not relevant in any way to this inquiry.

HIS LORDSHIP: Go on, Mr. Henderson. I do not know what your purpose is and I do not see that it can possibly be relevant.

MR. HENDERSON: I am quite willing to say what my purpose is my lord. I am going to ask the witness if the Alexanderson geometric selectivity —what we are now talking about as Alexanderson geometric selectivity— with reacting tube relays—was in any sort of general use until after the successful use of the neutrodyne.

MR. SMART: That is a different matter.

MR. HENDERSON: My learned friend knows there is a distinct line to draw applicable to that.

HIS LORDSHIP: You can put that question.

MR. HENDERSON: You have heard my question. The last question I put was this:—

Q. Was what we now call the Alexanderson system of geometric selectivity with vacuum tube relays in any sort of general use until after neutrodyne had proved successful?—A. No, so far as I know it had never had any general use prior to the neutrodyne.

Q. It had been experimented upon, I presume ?—A. Yes, I heard at various times that people had been trying it out, and I also heard that almost uniformly they had not made a success of it.

Mr. Smart : Surely we cannot take that ? What he has heard ?

His Lordship : That has no force.

Mr. Henderson : No, that would have no force here, unless his knowledge of the art gives it force.

His Lordship : He did not speak positively, from his own knowledge.

Mr. Henderson : No, he has said in a deferential way, I have heard.

Q. Did you make any experiments yourself ?—A. I made experiments in connection with the development of the neutrodyne. Of course at that time, that is just prior to 1923, I had in mind my work on neutralization, so that naturally I had no reason for making experiments that did not include neutralization.

Q. Can you state your present opinion of what appeared to you to be the reason why there was such a long delay in any attempt to put this invention, if it was an invention, into practical use ?—A. Yes, I have that quite clearly in mind. The difficulty that had been found by those who had experimented with such systems——

Mr. Smart : I object to this. He cannot state what others have experienced.

His Lordship : It is not evidence at all unless he connects it with this.

Mr. Henderson : We are going to connect it. We are going to call some of the others here.

His Lordship : Of course a scientist engaged in scientific research, necessarily refers to the work of others, because it appears in publications or he gets it by personal contact. It is like secondary evidence, but perhaps the witness did not deem it to be that. Go on.—A. I think it was the general understanding amongst investigators at that time that these difficulties occurred. I know that I did have that personal contact to which your lordship has referred.

Mr. Smart : That, your lordship sees, is a very unfair way of putting evidence, and I think it should be rigidly excluded.

Mr. Henderson : I think Mr. Waterman gave evidence along the same line.

Mr. Smart : If a witness is to come here and to be permitted to say what is the general understanding among the scientists of the world, it would be impossible to contradict it effectively, because we cannot have all the scientists of the world in court, and that is why the rule of evidence confines him to his own knowledge.

His Lordship : You will cross-examine the witness. Scientific men should know everything that develops in their line from day to day and particularly when it is given to the public. I think that is fair evidence.

Mr. Smart : I submit it is against the rule of evidence. If the witness has publications, expressing the opinions of scientific men, he can produce

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those publications, and they are pieces of evidence; but to generalize in that way, without any foundation for the generalization, is not evidence.

HIS LORDSHIP: A general statement would have no effect unless there is some confinement of it.

MR. SMART: If it has no effect it should not be put in.

HIS LORDSHIP: I do not see how a witness, in a matter like this, can avoid statements of that kind. It cannot be excluded.

MR. SMART: Surely the witness' statement should be confined to his own statement of facts of which he has knowledge himself.

HIS LORDSHIP: Yes, I suppose that is quite true, but a scientific man properly trained and well informed, knows what many other people are doing.

MR. SMART: He can express his own opinion but he cannot come here and tell what is the opinion of others.

HIS LORDSHIP: No, however, go on, Mr. Hazeltine—A. I can refer to my own experience, because incidentally in the development of the neutrodyne of course I operated systems that had these same difficulties that I am about to refer to, the difference of course being that I had available means for overcoming those difficulties, but they were very real difficulties even to me, and in overcoming them I had to do a great deal of experimental work. I can also make reference if it is desired, to patents and statements that have appeared that confirm my views.

MR. HENDERSON: Refer to some of these, please.

HIS LORDSHIP: Let him refer to them in his own way. Let him proceed.—A. I will state first what the difficulty was that we have been talking about. The difficulty that was encountered in attempting to use the disclosure of the Alexanderson patent was that the vacuum tube was not a one-way device, as Alexanderson seemed to think it was, but the vacuum tube had an internal coupling, known as a capacity coupling, which was formed by the natural capacity existing between the plate or the anode and the grid of the vacuum tube.

Now a capacity, broadly, as I think your lordship has observed in the defendant's receiver, consists of two metal pieces separated by insulation such as air or a vacuum or mica, and we have in the vacuum tube exactly that. We have this piece of metal, the plate or anode, and another piece of metal, the grid, and between them is the insulating space, and that is a little condenser; it is true, a very little condenser; but it is an exceedingly important condenser, because it constitutes the source of all of these difficulties, and it constitutes the reason for a number of patents, including two patents in suit,—the Rice patent and the Hartley patent,—and including my own neutrodyne patent, and many others. And that little capacity is the thing that kept this vacuum tube from being a one-way device. And it had this peculiar result: it had the result that the system tended to produce oscillations all by itself. That even when no signal was being received, there would be automatically generated in this system, due to that capacity coupling, a high frequency electrical oscillation, and a rather strong oscillation as compared with the signal that would be received. And that oscillation would get mixed up with the signal in a way that would disturb it and would ordinarily be noticed in broadcast reception, as a "squeal"; a disagreeable sort of a note; a sort of a note that would drown out the signal and would be annoying to the listener, and which would often be transmitted to his neighbours in other houses, because this system would then constitute a small broadcasting station by itself. It would not be broadcasting any music, but it would be broadcasting these squeals, and it would radiate them from its antenna. And those are the difficulties that were found when it was attempted to employ the Alexanderson arrangement. It was those difficulties that I attempted to cure in my neutrodyne development, and which other inventors also attempted to cure, each in his own way.

Now, I have referred to statements made by others in that connection, and I have particularly in mind a statement made in a United States Patent to a Mr. Hoxie; Mr. Hoxie being associated with the General Electric company in Schenectady, and therefore an associate in business of Alexanderson, the patentee. This is United States Patent Number 1,382,914 filed in 1920.

Mr. Smart: I object to the introduction of Mr. Hoxie's evidence by the production of the United States Patent. It may have been written by him or by someone else, a patent attorney; I do not know what it contains. No particulars have been furnished of it. Mr. Hazeltine cannot give Mr. Hoxie's evidence by producing a United States patent with Mr. Hoxie not here to be cross-examined.

Mr. Henderson: My friend has challenged the witness' knowledge and we are simply showing what that knowledge is.

Mr. Smart: It is not knowledge prior to the date of this invention.

Mr. Henderson: It is part of the witness' knowledge of what was going on and of what other scientists were doing.

Mr. Smart: It is not a proper piece of evidence.

Mr. Henderson: It is perfectly proper to refer to it in that sense, that Mr. Hoxie said so.

Mr. Smart: It is not proved that he did say so, that is my objection.

His Lordship: That does seem a very forceful objection, Mr. Henderson, —it may have been written by a patent attorney.

Mr. Henderson: I think that is quite likely.

His Lordship: On the other hand, if the patent was published there is a disclosure of the statement.

Mr. Smart: It was not before the date of the invention in question and is not included in the particulars.

His Lordship: That is another objection, that it is not included in the particulars.

Mr. Henderson: We are not using it as an anticipation but simply using it as a statement made by the General Electric Company to the public through this particular medium.

His Lordship: The General Electric Company?

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Mr. Henderson : Yes my lord. It appears on the face of it : Charles H. Hoxie of Schenectady, Assignor of the General Electric Company.

Mr. Smart : They may have an assignment of it, but that does not commit them to the statements in it.

His Lordship : I will receive it subject to the objection. There is not much of it, is there, Mr. Henderson ?—A. No my lord.

Mr. Henderson : There is one other General Electric patent in the same category.

Mr. Smart : I certainly think I should have had notice of this kind of evidence ; and it is not evidence, as I submit. If Mr. Hoxie was here, we could cross-examine him, and there are about a dozen explanations which would fit in with what he says there in that and a variety of other scientific facts.

His Lordship : I think I will receive it, but with very grave doubt. I think your objection is hard to answer.

Mr. Henderson : I am so thoroughly satisfied with it that I would not even tender it, but I will take it subject to all objections and at my own risk.

His Lordship : I will receive it. It may turn out not to be of great importance.—A. My reference is to United States patent Number 1,382,914, to Mr. Hoxie, and on page 2, lines 44 to 52, he says :—

> " I am also able to secure a marked gain in amplification by tuning the input circuits of the amplifiers by means of variable condensers 22 as indicated. The desirability of such tuning has heretofore been recognized but it has been impossible to obtain the full advantage of tuning because of the fact that it increases the tendency of the system to oscillate."

Mr. Smart : Have you a copy of the patent ?

Mr. Henderson : We have not one at the moment. I will lend you this.

His Lordship : That was your experience also ?—A. Yes, my lord.

Mr. Henderson : That experience is borne out——

Mr. Smart : That is just what Mr. Waterman says.

His Lordship : I was thinking of the principle involved.

Mr. Smart : I think the principle is wrong, but the statement of fact is one with which I will agree.

His Lordship : When did you learn of this patent ? Before or after you made your invention ?—A. After I made my invention.

His Lordship : You see, it does not bear on this invention.

Mr. Smart : I hope there is no more of this class of evidence.

Mr. Henderson : We can go on and show more of it.

Mr. Smart : Suppose I produce a dozen patents which showed exactly the opposite ; if I wanted to prove the facts, I must have the witnesses here who can give the evidence according to their understanding and give evidence of what they saw. If the patent can be produced to show what it did for the art, all right, but as a commentary on the art I submit it has no value.

HIS LORDSHIP: It is not tendered as an anticipation.

MR. SMART: Then as a commentary it is no use.

HIS LORDSHIP: The witness says he has observed in public patents something which indicates confirmation of his own experience. I do not think it is a very good kind of evidence, and I do not think it helps.

MR. HENDERSON: I think the witness is quite competent to give evidence without assistance from other patents. Proceed along your line and do not refer to the other patent.—A. I think I had finished in regard to the previous question.

Q. And the difficulty that you speak about was met by the neutrodyne? —A. Yes.

HIS LORDSHIP: That means that Dr. Alexanderson could not operate as the inventor of this type successfully, and the end which Alexanderson had in view was successfully accomplished later when he invented his patent.

MR. HENDERSON: Yes, and as Mr. Justice Inch says, several patents which were lying in the Archives were then brought to light.

MR. SMART: I think your lordship went further than the witness.

HIS LORDSHIP: Do you think so?

THE WITNESS: Yes, I think you did go a little further than I had intended. The selectivity which was Dr. Alexanderson's invention was not a new thing with him. He did not invent anything that was new and valuable in the way of selectivity, in my opinion. The amplification which might incidentally have been obtained with Alexanderson was something that was not obtainable usefully to any considerable degree on account of this difficulty, and it was that difficulty that the neutrodyne attempted to cure and I believe did cure.

MR. SMART: If I understand Mr. Hazeltine's point of view, it is that the condition of selectivity, so far as disclosed in the Alexanderson patent, could be obtained by the circuit there shown, but if one in addition wanted to obtain amplification and the full advantage of amplification, one would need to add something to it.—A. Yes, I think that is a fair statement.

MR. HENDERSON: Q. That brings us a little more closely back to the supposed Alexanderson invention, and you will remember that I had some discussion with Mr. Waterman as to whether or not in his opinion the Alexanderson patent is limited to relays of the vacuum tube form. I want to get your opinion on that.—A. I do not think, from my observation and study of the Alexanderson patent that there is indicated any limitation as to the type of relay. I find on page 1 of the United States Alexanderson patent, beginning at line 47, the following:

> "The relay preferably used for this purpose is an electron discharge tube having an incandescent cathode, an anode and a grid."

And I also find on the same page, beginning at line 82, the following:

> "However, my invention is not confined to a relay device operating with a pure electron discharge."

Q. I want you very carefully to deal with Waterman's opinion that the preference expressed there was a preference for the three-electrode tube as against the six-electrode tube. Will you explain to his lordship the operation of these tubes and discuss them, bearing in mind what difference there is between the two tubes, so that his lordship may follow.

MR. SMART: Mr. Waterman's evidence was in regard to the first paragraph.

MR. HENDERSON: Will you allow me to proceed? I do not like interruptions.

HIS LORDSHIP: Interruptions are not objectionable if they assist us.

MR. HENDERSON: My learned friend will have the witness later.

MR. SMART: My learned friend is stating my witness' evidence, and if I think he is inadvertently mis-stating it I think I should interrupt, in the interests of saving time. I call attention to the fact that Waterman's statement was based on the first paragraph quoted and not on the second.

MR. HENDERSON: That will be pointed out when the proper time comes.

HIS LORDSHIP: You may now proceed. I really do not see much objection to the interruption.

MR. HENDERSON: Will you proceed?—A. In view of Mr. Smart's interruption, that he referred particularly to the first quotation, in reading that quotation I do not at all agree with Waterman that the distinction is between a three-electrode tube and a six-electrode tube. That is particularly my opinion, because those tubes are essentially alike in their principle and mode of operation.

Q. That is why I wanted you to explain.—A. The six-electrode tube is essentially a duplicated three-electrode tube in its primary function. It is a type which introduces an element of symmetry that might be said to give a double effect as compared with the unsymmetrical three-electrode tube. The fact is that the greater application of the six-electrode tube has not caused it to come into general use. The double effect is not worth while in radio. It is so much easier to introduce a new tube and multiply by ten or some other considerable number; so that this is the idea that appeared attractive no doubt at that time, and I know has appeared attractive to others, which has not come into general use, but it is not a new and distinct thing so far as its primary function is concerned. The six-electrode tube is really a three-electrode tube duplicated and I do not think the patent indicates therefore any intention to distinguish in this way. I believe the distinction that may have been in the mind of Dr. Alexanderson was between a vacuum tube on the one hand and another form entirely of relay, such for example as a mechanical relay. He merely expresses a preference for a vacuum tube relay, but leaves the question open as to whether that or some entirely different form of relay may be employed. I am confirmed in that opinion, I think, by examining the patent as a whole, including the statements of the claim, because certain of the claims refer to a relay without any limitation, whereas others of the claims refer specifically to the vacuum tube type of relay.

HIS LORDSHIP: Will you tell me what statement Mr. Waterman made that you are combating? I cannot recall it.—A. The statement had reference to the following quotation that I have just read:

"The relay preferably used for this purpose is an electron discharge tube having an incandescent cathode, an anode and a grid."

That is at the bottom of the first column on page 1.

MR. HENDERSON: You will remember that I thought Mr. Waterman would have said that the claim of the Alexanderson patent covered other types of relay than the vacuum tube relay. I am going to show your Lordship in a moment what these were. But Mr. Waterman says no. Mr. Alexanderson speaks of two different types of vacuum tube relays, and all he says here is that he prefers the three electrode type to the other which is six-electrode.

HIS LORDSHIP: I have not a distinct recollection of what he said.

MR. HENDERSON: I am simply coming to it, dealing with Waterman's contention. There is always a little difficulty in that borderland, of the Court being assisted by opinion evidence, it being a question for the Court to decide.

HIS LORDSHIP: The quotation you read was:

"The relay preferably used for this purpose is an electron discharge tube having an incandescent cathode, an anode and a grid."

No expert could help me in interpreting that quotation.

MR. HENDERSON: Your Lordship must interpret the quotation.

HIS LORDSHIP: Nobody could help me.

MR. HENDERSON: Of course, your Lordship might ask, what other relay was there in existence?

HIS LORDSHIP: I will assume there were others, but I would like to hear of the others.

MR. HENDERSON: The question arises when you come to his claims. In certain claims he speaks of certain relays and they were relays of the vacuum tube type.

HIS LORDSHIP: I should like to hear what other relays there were.

MR. HENDERSON: Would your Lordship care for the reference to Waterman's evidence? It starts half way down page 119.

HIS LORDSHIP: No, I can find it.

MR. HENDERSON: I think we have come to the next question I wish to put to you, as whether or not there were in fact other types of relays available or adaptable to Alexanderson's apparatus in 1913?—A. Yes; in answering the last question I had that in mind, and particularly the mechanical type of relay which I described briefly yesterday without going into detailed references. A relay of this type seems to have first been introduced by Edison in 1886.

Q. You have a chart, I think?—A. I have a chart here marked No. 2.

EXHIBIT "K":—Filed by Mr. Henderson, Jan. 13, 1927. Chart prepared by Professor Hazeltine.

THE WITNESS: At the left of this chart is represented a single relay of the mechanical form.

MR. SMART: Q. Do these circles round the tube mean anything?—A. No, they are drawn for the same reason that the circles are often drawn round vacuum tubes, simply to represent that the apparatus is placed in a container.

Q. They should be a closed tube?—A. Yes, in that case, and in this case it would be a metal container. A description of this relay is given in United States patent 340,707, granted to Edison in 1887. I have used this reference simply as being an earlier one. I have just taken this one. This does not disclose precisely the form of relay that later on came into most common use, and which is represented at the right of Exhibit "K," because the actuating element which is shown in Exhibit "K" and marked "magnet coils" is in the original Edison form a chalk cylinder which has also been used to some extent, but not so commonly, but broadly the arrangement and design of the patent and of the chart are alike, and they have simply been introduced showing the historical continuity. The relay is in general a device which takes weak incoming oscillations and uses them to initiate new oscillations, derived from a local source so far as the energy is concerned; so that this relay receives a weak incoming current in what amounts to a telephone receiver, and which is represented by electrode magnets at the left of chart "K," and that electrode magnet varies the pressure on the diaphragm which is associated with a chamber containing granular carbon, that being essential to the ordinary telephone transmitter. That varying pressure varies the resistance or conductivity of that carbon, and thereby initiates oscillation in a local circuit which is shown in this exhibit as including a battery and a telephone receiver, and those oscillations will be of amplified form in the ordinary use of the relay, because we have produced them from a totally new source, but in other words we are not using our original signals in the telephone signals, but we have used a new signal produced from a local battery. It will be seen that that is essentially parallel to the vacuum of the tube.

In the vacuum tube such as on Exhibit 8 we have an input circuit consisting of the grid and the filament, which correspond very well to the magnet coils in the magnetic relay, and then we have the output circuit containing the plate and the filament, the filament being common to both circuits in the vacuum tube and there is resistance between the plate and the filament, just as there is resistance in the carbon granules in the mechanical relay, and when we have an incoming current in the vacuum tube relay we vary that resistance just as in the mechanical relay. We also vary that resistance and we get new oscillations in the output circuit due to the local battery, just as in the vacuum tube. We get the oscillations in the output due to the B battery which does not happen to be drawn in Exhibit 8, but which is indicated.

Leaving then the reference to the Edison patent as showing the original introduction of such a mechanical relay, I may refer to the use of such a relay in radio circuits in the same general arrangement as in the Alexanderson patent.

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That is to give geometric selectivity by the successive initiation of new oscillations derived from local sources such as batteries. The arrangement that I am referring to seems to have been first disclosed in British patent No. 10,210 which was filed and accepted in 1910. I have already referred to the fact that the names of the inventors do not appear but are identified by the disclosure being identical in a Canadian patent which gives the inventors as being Schloemilch & Leib. Figure 1 of this British patent shows three mechanical relays. They are of the form indicated in Exhibit "K." in the central figure, where I have for simplicity only shown two. A current or oscillation is supplied to the first relay of the cascade and that initiates new oscillations in the output circuit, and those are supplied to the second relay, and so on as many times as desired. The relay is somewhat specially constructed to give sharp tuning; that is it is made with noticeable inertia and elasticity, and the frictional effect of mechanical resistance is reduced to a minimum. This construction is fully described in the patent, and is illustrated in figures 4 and 5. The moving element is mounted on wires which are stretched and which are tuned mechanically in much the same way that we tune a violin string, so as to give a definite natural period of vibration; that is to make the system highly resonant.

Q. Schloemilch & Leib, you told us yesterday, were Telefunken men?—A. So I understand.

HIS LORDSHIP: Do they refer to this device as relays, in their specification?—A. I think that they do. I will verify their expression. Yes, sir.

MR. SMART: There is no doubt they are relays?

WITNESS: Right in the second paragraph of the patent it states:

"The device according to the present invention is of the type in which the weak impulses act upon a relay whose armatures operate in conjunction with a granular contact."

HIS LORDSHIP: The prior art,—they are put in in book form are they not?

MR. HENDERSON: Yes, a folder. The German patents are translated and I think the French one. They are translated when necessary, and those are the translations which my friend proposes to check.

MR. SMART: Yes. I think your Lordship will benefit more by reference to the patents themselves than to the diagrams.

HIS LORDSHIP: I dislike attempting to read some of these.

MR. HENDERSON: They are hard on one's eyes. I hope they had the good sense to pick out decent ones for the court, so that they would be readable.

HIS LORDSHIP: They appear to be readable. What patent was that to which you referred?—A. No. 10,210, your Lordship, Schloemilch & Leib.

MR. HENDERSON: The English one was issued in the name of Thompson, as your Lordship will see.

HIS LORDSHIP: Does it appear under the name of Thompson?

Mr. Henderson : If your Lordship will allow me, I will have them pick out the one for you. This is the one in the folder.

His Lordship : You might proceed, witness.—A. I think the purpose of the patentee is quite well brought out in the first complete paragraph on page 2, which I will read :

> " In order to get the desired strengthening of the impulses received it is generally necessary to use several strengthening relays with granular contacts arranged in series in such a way that the second strengthening relay is in the local contact circuit of the first strengthening relay, whilst the third relay is in the contact circuit of the second " and so on.

I might interpolate by saying that that is another way of saying " connection in cascade " which is our more usual mode of expression. Continuing :

> " In this way it is possible to strengthen by many thousand fold weak electrical impulses which hitherto were scarcely audible by means of a telephone held close to the ear, so that they will be audible at a distance of several metres away by means of a so-called loud speaking telephone. It is also possible to register or indicate such weak impulses by the use of suitable devices. For this purpose it is essential that the vibrating armature consisting of the various relays should be tuned to one another. In cases where regular impulses are being dealt with, as for instance is usual in wireless telegraphy, all the oscillating armature systems will be preferably tuned to the periodicity of the impulses received."

Now I think that that states not only the idea of Alexanderson, as exemplified in his patent, but it goes further in quite properly emphasizing amplication. The patentees indicate that it is this amplification which they appreciate as being an important element ; but they also bring out the tuning effect for the sake of selectivity. So that they get both amplification and selectivity by the use of these relays.

Mr. Henderson : Emphasize both ?—A. Yes. I would quote again from page 4, beginning at line 44, and I do this particularly to make sure that there will not be any misconception in regard to the way these relays were used. They were not used to strengthen the radio frequency currents in this system illustrated in figure 1, but were used to strengthen the so-called audio frequency currents which had a certain definite pitch as used in the systems of radio telegraphy in use at that time. And this quotation will bring that out :

> " If the first strengthening relay d-1 receives a current the impulse frequency of which is somewhere within the range of vibrations audible to the human ear, which is the case for example in wireless telegraphy when singing sparks are used in the well-known excitation method. The armatures of the strengthening relays are tuned not only to one another but also to the periodicity of the impulses to be strengthened. In this case the working of the apparatus is especially good."

Now, that I think brings out this, that this geometric selectivity and the amplification were used for the spark telegraph system, which at that time constituted the major part of radio. So that of course Schloemilch and Leib

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were directing their attention to the important problems of the day, problems which are not the problems of to-day, where great popular attention is given largely to broadcasting. However, on the other side, Schloemilch and Leib have gone further and have indicated the possibility of using their system for the high frequencies, such frequencies as may occur in the radio waves. And that is indicated in the very next sentence to what I have just quoted.

MR. HENDERSON: Q. What page are you at there?—A. Page 4, and now at line 50:

> "If the current impulses to be strengthened are not regular but are irregular, as in the case, for instance, in transmission of speech by telephone, it is desirable to make the natural periodicity of the armatures higher than the highest periodicity of the speaking impulses to be strengthened."

HIS LORDSHIP: "Speaking current impulses."

MR. HENDERSON: "Speaking current impulses."—A. "Speaking current impulses to be strengthened." That is the inventors realized that the mechanism which they have provided is capable of operation at these higher frequencies, frequencies beyond the audible range, that is frequencies which take us into the radio range. And having that available in that form, of course it could be so applied to give the geometric selectivity of these inventors.

MR. HENDERSON: My lord, it is stipulated between us that Schloemilch and Leib is the same as Schloemilch and Van Brandt,* whose evidence was taken on commission and is before your Lordship. The evidence is put in but your Lordship has not yet read it. He is one of the chief engineers of the Telefunken Company. We will know more about him as the case proceeds.

* *sic ?*

WITNESS: I have here before me the corresponding United States patent, which has the same disclosure, and which gives the names of the inventors. That is patent No. 1,163,180.

Q. You might give the date, while you are at that, Professor.—A. That was filed in 1910, and issued—the patent that I have is a divisional application, and the patent application was filed in 1910.

MR. HENDERSON: And you might note right there, my Lord, that the corresponding Canadian patent is No. 156,452, bearing date the 23rd June, 1914, and granted to Wilhelm Schloemilch and August Leib.

MR. SMART: Yes.

MR. HENDERSON: The application filing date in Canada was August 6th, 1910.

WITNESS: I find that this device of Schloemilch and Leib went into practical use, as indicated in certain publications. For example, in The Electrician, of London, under date of November 24, 1911, I find an article or a section of an article entitled "Sound Intensifier" which goes on as follows:

> "An instrument that has been developed by the Telefunken Company and which adds greatly to the simplicity of receiving with a singing spark is the sound intensifier. It consists practically of three

tuned microphones, and it acts in two ways, firstly, by selecting the sound to which it is tuned, and secondly by magnifying this sound."

That again brings out the two elements of selectivity and sensitivity; and those two elements are again brought out on the following page, 250, the second complete paragraph, as follows:

"As regards selectivity this can be carried very far by decreasing the damping of the tuned armatures, but this is not desirable because the sound emitted by a station may change somewhat and the intensifier is purely for the purpose of amplification or normal selectivity is such that if there is 20 per cent. dissonance from the pitch to which the instrument is tuned the dissonant sound is not effected. Two intensifiers can therefore be worked simultaneously if the notes are dissonant to the extent of 20 per cent."

MR. HENDERSON: I think you can probably explain that after the lunch recess.

Q. I think you can pick up where we left off and continue your discussion of Schloemilch and Leib?—A. I believe that I just read a quotation from the Electrician for November 24th, 1911, relating to the so-called sound intensifier of Schloemilch and Leib. This quotation described the practical condition under which this device was operated which did not require ordinarily a very high degree of selectivity, because it ordinarily would have to distinguish between audible tones that were not likely to be of very nearly the same frequency; and it was also the fact that such audible tones were in practice not very steady, so that sharp tuning might result in occasionally considerable weakening of the signal due to an accidental change in such tone; and therefore it was not the practice to use the high degree of selectivity that the apparatus was capable of giving.

The quotation also emphasizes that the primary purpose of the apparatus was amplification, recognizing that generally speaking in the radio art the advances had been in the nature of increase of sensitivity or amplification, just as I have already described for radio frequency developments. The selectivity of the sound intensifier however, was recognized as being an important element, and that is brought out in another quotation which I will read.

Q. Is that at the top of page 250?—A. The last one, yes sir. Found in a book entitled: "Manual of Wireless Telegraphy for the use of Naval Electricians." Published in 1911.

Q. Published in what country? It is a United States publication is it not?—A. I believe so. I have not the book itself in front of me. On page 136 I find a description of the Schloemilch and Leib system which near the bottom of the page, includes the following statement.

MR. SMART: Is that one of those I had?

MR. HENDERSON: Yes, it is marked "Wireless Manual," in the tab.

A. I quote:—"When used as a resonance relay, the relay diaphragms are mounted so as to have a pronounced mechanical period of vibration and act as wave filters or weeding out circuits responding most efficiently only to wave trains of a frequency the same as their own."

Those expressions "weeding out circuit" or "filter"—both of those expressions were commonly used for the coupled resonant circuits in the Marconi system of geometric tuning, so that it is evident that the idea as applied here to audio frequencies, is the same as the idea as applied to radio frequencies.

The apparatus in question is illustrated in an article in The Jahrbuch for 1911. This is in German and I will not attempt to quote from it but merely call attention to the illustration on page 301, showing the apparatus to be quite elaborate and nicely gotten up; that photograph being similar to one on page 249 in The Electrician article to which I previously referred.

And further in this Jahrbuch, which gives a very full description of the system, there appears a resonance curve. That is on page 310, the last page in that description.

That resonance curve shows the operation of this Schloemilch and Leib mechanical relay as tuned mechanically and is analogous to the resonance curve for an electric circuit such as plaintiff's Exhibit 2, or as in defendant's Exhibits "I" and "J" for cascaded circuits. The resonance curve is very sharp. It is not possible to tell just how sharp because the peak of the curve is not drawn in, but it shows a very large dropping off in response at 20 per cent. in frequency away from the resonant frequency as referred to in my previous quotation from the Electrician.

It also shows a very considerable dropping off when the frequency changes by only 25 cycles per second from the resonant frequency of one thousand. That is a degree of selectivity or sharpness of tuning which is quite comparable with that which would be produced electrically.

I might again mention—as I mentioned yesterday—that such mechanical resonance can in practice be made even sharper than electrical resonance. There are some pieces of apparatus used for holding constant electrical frequency which employ this sharp mechanical resonance. The mechanical resonance reacts on the electric circuit so as to make the electrical circuit also resonant. And when we have that sharp degree of mechanical resonance we have a correspondingly sharp degree of electrical resonance, so that the electrical circuit will behave as if it was a combination of inductance and capacity and be resonant thereby.

Q. Before you leave the Jahrbuch, Professor; you have noted the date at the very end of this article, the 7th November, 1911. In the interest of accuracy, do you know the actual date of publication?—A. I understand from examining this book as a whole that it comes out serially, and it was spread over the years 1911 and 1912, but I have no other information about that date.

Q. You mention that this was in a serial number, and the book as a whole would be after the end of 1911, and early in 1912 somewhat?—A. So I understand.

Q. Your Lordship sees what I mean by that? That it is a serial number.

HIS LORDSHIP: Yes.

MR. HENDERSON: Q. You have completed that have you?—A. I think that is all I can say about the Schloemilch and Leib system.

Q. In these references to mechanical relays, do you find that any of them indicate that from the selectivity standpoint the system is

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comparable with reactively coupled circuits?—A. Yes, I find that such a comparison is made specifically in German patent Number 258,478 of October 6th, 1912.

MR. SMART: That is not the issue date though is it?—A. No. I was about to remark that I give the date as it appears printed on the patent, which I understand is not the issue date.

MR. HENDERSON: That is what Mr. Smart referred to this morning in another connection?—A. Yes. I did not in making any previous reference to these German patents intend to imply that it was the issue date. In that patent, of which I can refer to the English translation, there is a discussion in the first paragraph describing what the patentee—who is Lorenz Incorporated,—considered to be the prior art relative to his invention, and which he follows by discussing his invention.

The system is one for obtaining selectivity at audio frequency; and the prior art which he refers to is that employing reactive coupling between successive tuned circuits; and he states that what he does is to employ relay coupling between successive tuned circuits; and he gives as his reason the increase in sensitivity, or the amplification obtained. The prior art to which he refers may be represented by British Patent Number 18922, filed in 1909 and issued in 1910, to Marconi and his company.

This British Patent, as I shall describe with reference particularly to figure 3, is for audio frequency tuning, and in that figure shows three cascaded circuits each tuned to the same audio frequency. Each of those circuits is tuned by a variable condenser, as represented in figure 3. And the circuits are coupled together reactively by the use of coupled inductances. Thus, for the purpose of identification, one pair of inductances is marked small "i-1" and small "i-3" and the other small "i-2" and small "i-4."

HIS LORDSHIP: Is that figure 3 in the Lorenz patent?—A. No your Honour, it is figure 3 in the British patent Number 18,922.

MR. HENDERSON: I think you will find that right after the Fleming textbook, my Lord, in the binder?—A. We see at the right of figure 3 three separate tuned circuits, and the letters appearing on them are small "c-1, c-2 and c-3." for the three variable condensers, and then the four coils denoted by the letter i, superscribed.

Those circuits are tuned to an audio frequency and a current of that frequency goes directly to the telephone receiver, marked by the letter small *t* at the bottom of figure 3. It is then a system employing the Marconi reactively coupled geometric tuning to audio frequency, and Lorenz takes that system and replaces the reactive coupling by relay coupling. Lorenz seems to have been the first to have recognized that as a step to take away the old form of reactive coupling in tuned circuit and to substitute for it a relay coupling and to describe it from that point of view.

That was the step which, it has been contended, I understand, that Alexanderson took, but Lorenz took that step first.

MR. SMART: I do not think the witness can say that. It will appear in the patent.

THE WITNESS: Leaving then the British patent, and referring once more specifically to the Lorenz patent we find in this figure a relay denoted by the letters small *l* and small *m*, which is the mechanical form of relay such as that of Edison or such as used by Schloemilch & Lieb, but in this case the inventor decides not to tune it mechanically; he decides not to make it sharply resonant by elasticity and inertia, but to make it naturally virtually non-resonant like the ordinary telephone receiver, and then he does the tuning by inductance and capacity, and in the input circuit we have an inductance marked *k* and a capacity marked *i*, and in the output circuit we have an inductance marked *q* and a condenser marked *p*; both condenser and inductance are indicated as being variable for tuning purposes. So that he not only has taken the step of substituting a relay coupling for reactive coupling, but he has left the circuits electrically tuned, just as Alexanderson did. The Lorenz arrangement I have illustrated again in the right hand figure of Exhibit "K," which shows the tuning elements inductance and capacity, and the relay interposed between them. A comparison of Schloemilch and Leib is made evident on this exhibit by arranging them side by side.

Mr. Henderson: That brings us, I think, Professor, to the chapter which I think I can call the vacuum tube chapter. Will you first kindly give his Lordship a general outline of the development of the vacuum tube relay and it use prior to 1913?—A. The vacuum tube relay is illustrated in United States patent 841,387, to De Forest.

Q. You might give his Lordship your chart No. 3?—A. Yes, Chart 3 at the left hand side illustrates the DeForest relay. The patent to which I have just referred was filed in 1906 and issued in 1907.

(OFFERING IN EVIDENCE OF EXHIBIT L.)

His Lordship: What is the number of it?—A. The number is 841,387. There are a number of forms of vacuum tube shown in this patent and I may particularly refer to Fig. 4 which is a relay device for audio or telephone frequency. The structure is not identical with the present ordinary form of vacuum tube in that the element corresponding to the grid is not the form of a grid, but rather has the form of a plate. That is denoted by large B in fig. 4. The filament is denoted by E, and the real plate or anode by D. The operation, however, is just the same in the grid type of vacuum tube relay. A weak oscillation produced in the input circuit F is transferred to the vacuum tube, and in turn initiates a new oscillation in the output circuit, including the battery B and telephone receiver R.

Mr. Henderson: Do you find the grid in any DeForest patent?—A. Yes, the grid type of vacuum tube relay is also due to DeForest and is shown in his United States patent 879,532 filed in 1907, issued in 1908. That is of particular interest, because its two figures show a comparison of the two tubes in identical electrical circuits. Fig. 1 shows the grid type and fig. 2 shows the two-plate type which I have just described. In this later DeForest patent the use of the vacuum tube as a radio detector is shown. Here the device operates simultaneously as an amplifier and as a radio detector, and this is the ordinary method of operation in use to-day. In the ordinary broadcasting receiver we have certain vacuum tubes which are purely relays, and then we have one vacuum tube which is a detector, but which is a relay at the same time, and that latter is what is disclosed in this patent, and that is the particular thing which is illustrated at the left of my chart No. 3, Exhibit "LQ." In this case, the input circuit is tuned to the radio frequency. The output circuit contains the battery known to-day as the B battery and also a telephone receiver.

The incoming signal initiates a new oscillation in the output circuit, but at the same time converts it from a radio frequency to an audio frequency. The energy actually supplied to the telephone receiver does not come in from the wave, but comes from the local B battery, so that we can still call the device a relay, but there has been simultaneously that conversion from radio frequency to audio frequency which we call detection.

Shall I continue with the description of the development of the vacuum tube ?

Q. Yes.—A. The next reference which I will make to the vacuum tube type of relay is to the French patent No. 13,726, as an addition patent. This, I find, was filed in 1911 and issued and allowed also in 1911. There was reference to the filing date in Austria in 1910. I need refer specifically only to Fig. 5 of this French patent, the Von Leiben, Reisz & Strauss.

Q. They are called residents of Austria. I am reading from the French on the front page ?—A. Yes, I find that.

Q. The translation has merely a condensed heading ?—A. Yes.

Q. That would account for the patent originally issuing in Austria ?—A. Yes.

Q. Before you go into that patent I note there that at line 23—I am freely translating the French—it says the Fig. 1 of this design is a scheme of a simple relay—a mode of execution of a simple relay. It uses the word "relais" ?—A. Yes, I find the French word relais. This patent shows a form of relay which is structurally dissimilar from the DeForest type, which has often been called by his name, the Audion. It, however, operates on the same fundamental principles, and I have illustrated it in the same way in the centre figure of Exhibit "L." It has the same three electrodes, an incandescent filament, a grid which here has the form of a grid and an anode which here is quite small at one end of the tube, and is structurally different from the ordinary flat plate, but it connects as a plate to Fig. 5 and shows two of these relays connected in cascades, and that is essentially the purpose of the reference, to show that the cascading of vacuum tubes was known in 1911.

The two vacuum tubes are used here as the tube in the DeForest patent to which I referred as audio frequency tubes. The connection is rather similar to that in the DeForest figure, in that a telephone transmitter initiates an oscillation and that controls a local source to initiate amplified oscillation in the small relay at the left, and that in turn initiates new oscillations again through the larger relay shown at the right of Fig. 5, and these new oscillations actuate a telephone receiver. The two vacuum tubes in Exhibit "L" are shown the same size, but in the patent they are shown as different sizes, because one of them had to take care of the amplified power, and they thought quite reasonably that that might better be made a larger size.

Summing up then this patent on the vacuum tubes so far, we find that they were used either as audio frequency relays or as detectors. The use of these vacuum tubes as radio frequency relays seems to have been first accomplished by Von Bronk. I may refer first to German patent No. 271,059 of September 3rd, 1911, that being again, I understand, the filing date. The single figure of that German patent shows the ordinary DeForest form of vacuum tube, but it is not used here as a detector, but rather as a radio frequency amplifying tube. That is, as a radio frequency relay. There is supplied to its input circuit a radio frequency current, and that initiates a new radio frequency current in its output circuit, that current receiving its energy from a local battery. That new current is then transformed and impressed upon a circuit containing a crystal detector, and that detector changes the radio frequency current to the audio frequency current which is heard in a telephone receiver. That arrangement is shown at the right of Exhibit " L."

Q. This was the same Von Bronk already spoken of referring to Schloemilch and Von Bronk ?—A. I do not remember having referred to these patentees before.

Q. Is it the same Von Bronk whose evidence was taken in Germany last summer ?—A. Yes, so I understand.

Q. And you were present when that evidence was taken ?—A. Yes, all of it.

Q. Will his Lordship find in that evidence Mr. Von Bronk's story of the use of this particular patent ?—A. Yes. I might point out that the German patent does not, I believe, give the name of the inventor, but that is identified by the testimony which has been introduced, and also by the fact that the figure in this German patent is identical with Fig. 1 of the United States patent 1,087,892 to Schloemilch & Von Bronk.

Q. It is given to a German company Gesellschaft fur Drahtlose Telegraphie. That is one German company and the other is the Schloemilch Company ?—A. Yes. The Schloemilch, who is the other patentee with Von Bronk in the United States, is the same Schloemilch who has the joint patent with Leib in connection with the tuned mechanical relay that I have previously described.

Q. His evidence is also before his Lordship ?—A. Yes. The evidence of Schloemilch and Von Bronk was taken over there.

Q. You met the two men personally in Germany this summer ?—A. I did. The Von Bronk patent does not indicate in its diagram a tuning of the output circuit. If it had it would have disclosed geometric selectivity through a relay. It does, however, as I understand it disclose tuning of the input circuit. I think I will not refer to that point in detail as it may come up again. I might refer to it generally, first by reference to chart Exhibit 8. In that chart we have interposed between two vacuum tube relays a transformer, and there is associated with the secondary coil of that transformer a condenser. There is no condenser shown with the primary coil. Nevertheless those two coils are so closely coupled that the tuning of the secondary coil is really a tuning of the two coils as a unit. It is only that tuning that makes it permissible for one to say that the primary coil is in a resonant circuit. It is made resonant by coupling with the circuit.

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That also is indicated in the input side of the first vacuum tube on this chart.

Q. What you have said is only applicable when the coupling is close?—A. Yes, if the coupling were loose it would not be so. If the coupling were very loose the system would function very poorly. The same thing applies to the antenna circuit in this chart, exhibit 8. The antenna circuit contains no condenser except the antenna itself which incidentally is a condenser, but at any rate contains no variable element so that it cannot by itself be tuned. Nevertheless, that antenna circuit is coupled through this transformer 2 to a secondary coil and condenser 8, and that coupling is sufficiently close so that the two circuits act as a unit.

The variation of the condensers in the secondary circuit tunes both the antenna and the secondary circuit itself as a single unit. That same thing applies in this Von Bronk patent as I understand it. In this case, however, in place of the tuning being done in the secondary circuit, it is done in the antenna circuit. The Von Bronk patent has a condenser directly in series with the antenna circuit, and the secondary of the transformer, in place of having the condenser 8, as has Exhibit 8, has no condenser. I understand these coils are sufficiently closely coupled so that the antenna condenser tunes the input circuit as a whole. I say that largely because I know in a scientific way that the system would function very poorly if that were not done.

Q. We have Bronk's evidence that he did do it?—A. I may now refer to another German patent No. 293,300, of February 9th, 1913, again giving the date, as I understand it, from which the patent is operative.

Mr. Smart: Put the issue date down, so that we will have it on the record.

Mr. Henderson: 23rd June, 1919.

The Witness: I find they give here the German word Ausgegeben. I have been informed that the actual filing date in Germany is the day before the date of the patent. I have no knowledge of my own on that but I think that is correct. So that that would make the filing date February 8th, 1913.

Mr. Smart: I think there is some evidence about that.

Mr. Henderson: There is a corresponding French patent 456,788.

Mr. Smart: It would make very little difference. I understand it was sent on the 8th and filed on the 9th. It was sent from the Telefunken office on the 8th and filed on the 9th, but nothing turns on that.

The Witness: I have a French patent No. 456,788, which has three figures, two of which are the same as in the German patent 293,300.

Q. That is a Telefunken patent?—A. And the first figure of which is identical with the single figure of the Von Bronk German patent.

Mr. Smart: May I have the number of the French patent?

Mr. Henderson: No. 456,788.

Witness: This French patent was also issued to the Telefunken Company. There is a corresponding pair of figures.

Q. Perhaps you had better give the dates again. Filed 17th April, 1913, issued 26th June, 1913, published 4th September, 1913, if you will check those dates?—A. Yes. I find these dates on the French patent No. 456,788.

Q. And that these were prior to the Alexanderson United States filing?—A. I have the United States patent to which I have previously referred, No. 1,087,892, to Schloemilch and Von Bronk. This patent has for its figures 3 and 4 the same figures as the later German patent and the French patent to the Telefunken Company, which I have just referred to. I find one difference, that does not seem to be of importance in this issue, that the United States patent has a choke coil in series with the generator, which takes the place of the B-battery. I think I need make no further reference to that.

I think therefore it would be a matter of convenience if I refer to the United States patent rather than to any patents in foreign languages. Of course there is also a corresponding British patent which seems identical with the French patent and which is No. 8,821, filed and issued in 1913; filed on the 15th April and accepted on the 2nd October, 1913.

I have prepared, on chart No. 4, a drawing illustrating the arrangement of figure 3 of the United States patent to Schloemilch and Von Bronk. I have prepared this drawing not only to illustrate the arrangement of the patent, but also the arrangement actually used by Schloemilch and Von Bronk, as indicated in their testimony which has been introduced in evidence.

I have another chart which I may refer to in that connection and discuss a little later, chart No. 4-A, which shows certain differences in arrangement that it will be necessary for me to discuss in some detail.

EXHIBIT M INTRODUCED IN EVIDENCE. CHART COMPARING SCHLOEMILCH AND VON BRONK WITH ALEXANDERSON.

Now, referring to exhibit "M," rather than to the patent or to the testimony, I have represented at the extreme left an antenna circuit including a variable condenser and coupled to the inductance in that antenna circuit is a second inductance associated with a second variable condenser. That circuit leads to the grid and filament of the first vacuum tube relay. The output circuit vacuum tube relay includes the ordinary B-battery and the primary of a transformer or simply another inductance, coupled through another tuned system into a second vacuum tube, which in this case is used as a detector, such as the DeForest detector that I described a little while ago. And that in turn has in its output circuit the telephone receiver and local battery. This sketch and the work which it represents seems to be the first complete embodiment of the arrangement which Alexanderson believed that he invented. This is a radio frequency system having a vacuum tube type of relay and attaining geometric selectivity by having a tuned input circuit and a tuned output circuit. The system may be characterized as the Marconi system with the interposition of a relay, just as the Lorenz patent took a Marconi audio frequency system and interposed a relay. It also may be characterized as the Von Bronk arrangement of exhibit "L" in which tuning has been added to the output circuit. You see therefore a very close inter-relation of all of these developments and the small steps that appear to have been taken, one to the other, and not one big step into a completed whole.

I have drawn at the right of exhibit " M " the arrangement disclosed in the Alexanderson patent in its simple form and a comparison of those two figures on exhibit " M " shows them to be identical in every material respect, and in fact in all but one detail, that detail not being part of the Alexanderson invention ; that detail being the use of a condenser in the grid circuit at the top and towards the right of the left-hand figure.

Q. I am glad you are just now looking at the Plaintiff's exhibit 8. Is there any real difference for our purpose between these two ?—A. No, there is not. Perhaps I can point it out better in exhibit 8. In the detector tube of exhibit 8 there is present in the grid circuit a condenser and a resistance in combination. Now the condenser was originally used in that place without any resistance by DeForest. That is the arrangement that Schloemilch and Von Bronk used, I understand, because they used a DeForest vacuum tube in some of their early work, and presumably they used them in that form, although that is immaterial ; but I have attempted to picture what I understand they did, and I have followed the DeForest idea.

Mr. Smart : You are not proposing yourself to give any evidence yourself, as to what either Mr. Schloemilch or Mr. Von Bronk did ?—A. No, not at all. I am attempting to illustrate what they did as indicated by their testimony. That is, your Lordship, a point which I think is of no importance ; that is, it is not part of the invention ; but I would like to clear it up so that we need not refer to it again.

In a detector vacuum tube there are three things that may be used as elements assisting in detection. One of them is a simple condenser. That was DeForest's original idea. Then there was the condenser shunted by resistance, which is shown in chart Exhibit 8, and in some of the Alexanderson figures. And then there is the use of a battery in that place, which is shown in other of the Alexanderson figures, particularly in the figures that we have been discussing, particularly I should say in figure 1.

I have chosen the use of the battery, but I do not regard that as material in drawing the chart.

Now, with that aside, there is no difference between the arrangement of Schloemilch and Von Bronk as used by them in January, 1913, and the arrangement of the Alexanderson patent.

Mr. Smart : I do not think this witness should say when it is used by them. That is going to be quite a controversial question.

Mr. Henderson : As they say, that is all. We simply want to tie up his evidence, that is all. He is using the date on the patent, or a date that they mention in their evidence. It is simply tying,——

Mr. Smart : The date on the patent is February, 1913, and that may be critical.

Mr. Henderson : My friend and I are quite in accord. It is possible that my friend may give certain evidence which he was doubtful about yesterday, in which these earlier dates will be of importance.

Mr. Smart: I called attention to his statement that the application was January, 1913, whereas the patent is February, 1913.

Mr. Henderson: His Lordship will no doubt find it necessary to clearly consider these dates.

Mr. Smart: I think " January " should be struck off exhibit " M."

His Lordship: Should that be February, witness?—A. No, I understood from the testimony that this particular arrangement was one which was used experimentally in the work of Schloemilch and Von Bronk, and which was modified.

Mr. Smart: I do not want this witness to interpret that testimony, as regards what it shows as to dates. Leave off January.

Mr. Henderson: Your Lordship might draw your pen through " January, 1913," or put an interrogation mark after it, as you wish.

Mr. Smart: Yes, it is very far from proved.

Mr. Henderson: My friend is an optimist.

Witness: I might call attention to the fact that the United States patent to Schloemilch and Von Bronk refers to the tuning of the output circuit in the following way, at page 2, lines 63 to 65:

> " An intermediate circuit *n* syntonized to the oscillations will preferably be provided."

There is no direct reference in the specification, so far as I have found, to the tuning of the input circuit. The drawing, to my mind, clearly and unequivocally illustrates such tuning; but I think in view of the absence of a reference to it, it would be well to refer further to the matter, and I will do that by the use of chart No. 4-A.

Mr. Henderson: I put that in.

EXHIBIT " N ":—Filed by Mr. Henderson, Jan. 13, 1927. Chart showing differences in arrangement.

A. (Cont'd.) The right-hand figure of the chart shows the same input circuit as exhibit " M." The central figure shows the arrangement of figure 3 of the United States patent, showing in dotted lines a capacity which is always naturally present but which is not usually shown graphically except when attention is to be called to it, as here.

Mr. Smart: That was not shown in the patent?—A. I said not. In the left-hand figure is shown another arrangement of the input circuit which was used by Schloemilch and Von Bronk, as I understand their testimony, when they employed the Von Leiben type of vacuum tube relay; that is the type which has been referred to in connection with the French patent.

All of these arrangements, as I understand them, have two successive tunings in the input circuit; the antenna itself is tuned by a variable condenser; and the secondary circuit is tuned either by a variable condenser and a fixed inductance or by a fixed condenser and a variable inductance. Those two alternatives are very well known.

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His Lordship: What do you mean by a variable inductance?—A. I will refer to the centre of the chart in exhibit "N." Your Lordship will notice an arrowhead at the top of the secondary inductance. That arrowhead is used in the art to represent a variation, and when placed against the symbol for an inductance represents a specific variation in the number of turns, or more generally a variation in the value of that inductance. That mode of representation is probably a semi-pictorial one, in that the early forms of inductances used in radio reception were often cylindrical coils with bare wire and in which a sliding metal piece moved along so as to be in contact with one turn after the other; and that was an adjustable feature; and this represents that in a rather pictorial way.

Mr. Henderson: Q. That is what you used to call the slide tuner or the sliding tuner?—A. Yes. Now these different methods of tuning are alternatives to one another, and which is the best or most suitable depends upon the purpose.

As a general thing it is desirable to have the greatest possible inductance and the least possible capacity that are consistent with one another. I believe that I have previously mentioned that in order to tune a circuit, as originally brought out in this Marconi reference, you have to have a certain product of those two properties, inductance and capacity. You may have a high inductance and a low capacity, or a low inductance and a high capacity. In general the high inductance combination is electrically preferable. But there are limitations in the design of apparatus that may not always make that arrangement feasible; and for that reason we use variable condensers, where for other than structural reasons it might be preferable to vary the inductance.

I understand from my knowledge of the art that the purpose of this variable inductance was to tune the circuit in this standard and well-known way, and that that was probably chosen because the patentees considered it electrically the best method.

Referring to the left-hand figure of exhibit "N," we also find an arrow on the secondary coil. This time that arrow is connected to a wire which goes to the filament, and we find there a variable condenser connected to two ends of the inductance. So that we have here an inductance really with three wires going to it, one at the top, one at the bottom and one at an intermediate point, marked "Tap." That arrangement was used whenever such a tuned circuit was associated with some device, either a relay or a crystal detector, that had a relatively low resistance and would otherwise put too much of a load on the system. It was a well known expedient, and is also illustrated in the output circuit n of figure 3 of the Schloemilch and Von Bronk patent. Now that was used when the Von Leiben type of vacuum tube was employed; for the Von Leiben type of tube did have this relatively low resistance, between the grid and the filament. When the De Forest type of tube was employed by Schloemilch and Von Bronk, they did not use that tap.

Mr. Smart: I again object to the way the witness is stating that. The statement he is now making I do not recall any evidence of at all. This witness can not state when either Mr. Schloemilch or Von Bronk did anything, or what they did; and the statement he is now making is one which, although I have read the evidence carefully I have not found in the evidence.

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WITNESS: I was not stating anything about a date; I stated that Schloemilch and Von Bronk made a certain form of connection when they used a DeForest tube; and I believe I can find that statement in the testimony.

MR. SMART: I wish you would at this point, if you will.—A. It may take me a few moments, as I have not been over this recently to mark passages; but I have seen that.

MR. HENDERSON: Look at the bottom of page 33, professor. Is that it?

HIS LORDSHIP: Perhaps we had better get along and let the witness verify it.

MR. SMART: I do not think he can, and I do not think he should give this evidence unless he can find it.

WITNESS: I have the reference which I had in mind, but the reference includes a reference to a photograph, and that I have not here, although I remember at the time what it covered.

MR. HENDERSON: We have the photographs here.

WITNESS: I will read the reference, if I may.

MR. SMART: At what page?—A. Page 33 of the English text:

"Q. I want you to look at figure 6 of the blueprint No. L-898, and tell me what the purpose was of the variable connection to the second coil of the transformer which connected the antenna?—A. The Leiben tube used in figure 6 has considerably lower internal resistance than the cathode tubes used nowadays, consequently if one were to couple the tube in parallel with the entire oscillatory circuit this would likewise result in unsharp tuning, likewise the intensity of the receiving incoming sound would be also impaired. Consequently one is forced to connect the Leiben tube always in parallel only with part of the self-induction."

MR. HENDERSON: Do you want to look at the blueprint?—A. Now that describes exactly what I was attempting to describe in other language, in connection with the left-hand figure of my chart "N."

MR. SMART: Yes, I follow the evidence that far, and I have no criticism to offer on that.—A. The basis of my right-hand figure in chart "N" is in the following question. This begins at the top of page 34:

"Q. Will you tell me whether the same reason applied when you used the type of tube shown in photograph No. 233?—A. No. The tubes shown in this photograph are high internal resistance tubes. At that time we started to use this type of tubes."

So as I understand it, he, when using internal resistance tubes, did not use the intermediate tap which he did use with the Von Leiben tube.

MR. SMART: Yes, but he did not say what he did use in any way?—A. Well there are only two things which anyone can do in a case like that.

MR. SMART: Oh, you may infer and argue about it, but I object to your stating what he did, when he said not a word about using the circuit.

His Lordship: Put it in another way, that you believe he used that.

Mr. Henderson: Will you look at the photograph, Professor?—A. I cannot find the photograph.

Mr. Smart: I do not find any objection to this witness saying he inferred that they used this vacuum tube.

Mr. Henderson: He does not infer. He was there and heard and saw what they did use. He knows what he is talking about.

Mr. Smart: Surely we are not going to have the testimony of a man here when in Berlin they did not say. We are discussing this case in the light of what Mr. Hazeltine says they must have used.

Mr. Henderson: No, that is not it.

His Lordship: There is no dispute about it. It is a very simple matter. I think we had better proceed and let the witness say that he believes these people used this.

Mr. Smart: I think, my Lord, that that form of evidence would be objectionable. I think if your Lordship would instruct the witness that he may say that he would infer that that circuit would be used, that is as far as he can go.

Mr. Henderson: It is much more than an inference.

Witness: I find an identification of the type of tube which would complete that answer which I have just quoted. That is in the answer near the bottom of page 31, where it says:

> "The tube shown in photograph No. 1744 is the so-called Leiben tube, whereas the tubes shown in photograph 233 are the high vacuum cathode tubes."

It is understood of course that the modern type of tube is also of a high vacuum type.

Mr. Henderson: I think your Lordship understands the development of the tube? My recollection is that Mr. Waterman explained that?

His Lordship: Yes.—A. I believe that there are other references to this point which I would like to be able to look up before the next session, to complete that answer, if I may.

Mr. Henderson: Continue then, Professor.—A. Irrespective of this testimony, as a matter of common scientific knowledge, it is desirable, in order to get the best amplifying effect from a high vacuum type of relay, to make the connections of the grid and the filament to the extreme points of the tuned circuit. That of course is shown in the chart Exhibit 8 and it is shown in the second DeForest patent, to which I referred, going back to 1907; and it has generally been the universal practice.

It is only in these rather exceptional conditions where one uses the now obsolete Von Lieben tube that one resorts to a tap. That same special condition occurs when we have a crystal detector, in some cases, and that tap is shown, and for that same reason exactly, in such circuits as circuit n of figure 3 of the Schloemilch and Von Bronk patent. This is what is referred to as a stepping down of voltage. Whereas when we have a system having a very high resistance, to be fed from such a circuit, we do not wish to step down the voltage, we would rather step it up if we were enabled to do so.

Now the reasoning which I have just stated for the use of a tap with the Von Lieben tube does not apply at all with the high vacuum type of tube, and therefore would be foolish if used for that purpose. And that scientific fact is in part my reason for stating what I will state, that the sliding contact in the central figure of Exhibit N is not at all for that purpose of stepping down the voltage; or not at all for the purpose of varying the coupling, as has been sometimes stated. That varying the coupling is an inaccurate way of expressing the idea, the accurate way being to vary the step up or step down of the voltage; but that is not the purpose of that tap, because that would be foolish; you want to get all the voltage that you can, and the only purpose that that tap could possibly have would be for tuning purposes in a case like that. So that I have no doubt in my mind, irrespective of any testimony or any reference in the patents, that that tap was for tuning the input circuit of that vacuum tube relay.

Q. Do you know the position that Schloemilch and Von Bronk occupied at that time in the Telefunken, bearing upon whether or not they were practical men?

MR. SMART: I object to that question being put to this witness. These gentlemen were on the stand as witnesses and were asked with regard to their position.

MR. HENDERSON: His Lordship knows that as a matter of fact.

HIS LORDSHIP: I will assume that they were prominent men in radio work?—A. They are men who have been known for many years as having very high standing in the radio profession.

MR. HENDERSON: And at the head of this particular branch of the Telefunken. Your Lordship will find that Von Bronk was at the head of their Patent Department.

HIS LORDSHIP: That will appear.

MR. HENDERSON: It will appear in the evidence but I thought it was no harm to call your Lordship's attention to it just now, but my friend is getting anxious apparently.

MR. SMART: I am not getting anxious, and I think my objection is a proper one.

HIS LORDSHIP: It is hardly worth objecting to that, Mr. Smart. Proceed.

THE WITNESS: I therefore can sum up the three arrangements shown in Exhibit N by stating that they all had at first a tuned antenna system, and secondly a tuned secondary system, which latter comprised the input circuit of the vacuum tube.

Now I will adopt another point of view, which is not my understanding of either the testimony or the patent of Schloemilch and Von Bronk, but which I think ought to be considered in view of any possible question of interpretation of this difficult point, the significance of that arrowhead on figure 3 of the patent, or in the central figure of Exhibit N.

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If we should adopt the view that that arrowhead might mean a variable ratio, or a variable coupling, which I regard as unreasonable scientifically, we would then employ that circuit in this way: we would closely couple the secondary inductance to the primary inductance, and we would then have in effect just the arrangement of the Von Bronk 1911 patent, which is illustrated in the right hand figure of Exhibit L. Those two would then be directly comparable. We would have a circuit tuned by a variable condenser in the antenna, and closely coupled to a secondary coil. The input circuit of the vacuum tube would still be tuned. It would then be tuned, not as two separate units, which I understand is the actual disclosure, but as a single unit. It would then be tuned in the same sense as the system which we have here in Exhibit 8. We would have an antenna closely coupled to a secondary coil, and the two together would be tuned as a unit by a single condenser, and the two together would constitute the input circuit of the vacuum tube. So that I may sum up all which I have said about this tuning by saying that no matter what interpretation is made of this arrowhead or of the other figures, nevertheless the only sensible scientific conclusion is that the input circuit of the vacuum tube is tuned.

MR. HENDERSON: What do you say as to the importance of tuning the antenna? You remember Alexanderson intimates that it is unimportant?—A. Alexanderson I think was wrong if he intended to give any generality to that idea. It has almost universally been the practice to tune antenna systems. They were tuned by Marconi and by those who followed Marconi, and they are tuned as I have described in connection with this chart, by the present day receivers. Sometimes directly tuned by having a condenser right in the circuit, and sometimes indirectly as in Exhibit 8 or as in the Von Bronk patent.

Dr. Alexanderson seemed to think that sharp tuning—that is reasonably sharp tuning—was not practicable in an antenna. But as a matter of fact, although the tuning is not always quite so sharp as in the other circuits, yet it is sometimes exceedingly sharp, and always sharp enough to be worth while in ordinary practical use.

It is only the exceptional case where we have a really untuned antenna system, which is otherwise called an a-periodic system, that is a system without any tendency to a periodic effect; but that is the exceptional case.

Q. If in the Schloemilch and Von Bronk patent the arrowhead were used as a step up, and down arrangement, what would you have?—A. We would then have a single tuned input circuit including the antenna.

Q. And as to the output circuit?—A. That is always tuned and is so stated in the Schloemilch and Von Bronk patent.

Q. Now Professor, will you without unnecessary repetition, consider the defendant's receiver. We have been referring to Exhibit 8 as a matter of convenience to illustrate the Alexanderson.

Will you now consider the defendant's receiver and compare it with the development of Schloemilch and Von Bronk?—A. The arrangement of the Schloemilch and Von Bronk is essentially that of a vacuum tube relay with a tuned input circuit and a tuned output circuit. The function of that vacuum tube in the Schloemilch and Von Bronk patent is very clearly stated to be amplification. The two inventors quite correctly recognized that the primary function of their system was amplification; sensitivity; getting the strongest possible signal.

Everything that I have just said applies identically to the defendant's receiver. It has a tuned input circuit, a vacuum tube relay, a tuned output circuit, considering only the first vacuum tube. And the same remarks again would apply to the second vacuum tube. And that receiver is designed for the very purpose that Schloemilch and Von Bronk bring out, to give the best possible amplification. It is designed for that reason. Such selectivity as is obtained in that receiver is taken as a matter of course and as a by-product, and that is my understanding of the attitude of Schloemilch and Von Bronk as indicated by their patent, that they take selectivity for granted, and as a by-product; so that I feel that we can say that there is identity between the fundamentals of operation in the Schloemilch and Von Bronk patent and in defendant's receiver.

Q. By the way, Professor, does it make any difference what kind of detector is used?—A. No, not fundamentally. The detector operation is a thing by itself. If you use a different detector you may have to make some corresponding quantitative modification in the system. For example in the thing we have been discussing quite recently, when you use a vacuum tube it is desirable to make connections from the grid and filament to the ends of the tuning system; whereas if you use a crystal detector having a relatively lower resistance you make one connection through a tap. That does not in any way affect the principle but only the details of the design.

Q. Will you be good enough, Professor, to take the diagram called blueprint L-898 of the German evidence and tell his Lordship about it. The figure L-898 appears on it.

MR. SMART: It should now be an exhibit in this case.

MR. HENDERSON: It is. It was put in at my opening.

MR. SMART: But the Exhibits produced on that Commission should now be identified as Exhibits in this case separately.

MR. HENDERSON: If you want them marked separately here, if that is the practice, perhaps I had better put it in then in that way.

I will put in now, my Lord, taking them in the order in which they come, first a photograph marked B, or may I say, this looks like an inverted "S" with the figures 794, attached to the German testimony. We can check that from the evidence. Then the next is the blueprint.

MR. SMART: Would you mind if I check that S-794?

MR. HENDERSON: No. Please check it.

EXHIBIT O:—Filed by Mr. Henderson, 13 Jan., 1927. Photograph of apparatus.

The next is the blueprint L-898.

EXHIBIT P:—Filed by Mr. Henderson, 13 Jan., 1927. Blueprint L-898.

Then "Q" is a photograph numbered 1744.

EXHIBIT Q:—Filed by Mr. Henderson, 13 Jan., 1927. Photograph Number 1744.

"R" is a photograph numbered 233.

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EXHIBIT R:—Filed by Mr. Henderson, 13 Jan., 1927. Photograph Number 233.

If any error has crept in as to " O " it can be checked. I am not going to use it at present.

MR. SMART: I think it is the photograph of the apparatus that was there. If so that explains it.

MR. HENDERSON: Yes, it was agreed that the photograph of the apparatus might be used, instead of bringing over the apparatus itself. That explains it. I had forgotten that for the moment.

Q. Then I am asking you, Professor, to be good enough to explain to his Lordship the blueprint L-898?—A. Figure 6 of this blueprint shows a cascade vacuum tube relay system giving geometric selectivity, as we have been discussing it.

It employs the Von Lieben type of tube and therefore the tap in the input coil somewhat below the letter " A " at the left. It also employs a crystal detector near the letter, " I " at the right, and therefore employs also a tap indicated by the arrowhead at the centre of the secondary coil below the letter " C."

HIS LORDSHIP: Referring to the condenser on the antenna wire, that is on the extreme left; in the actual set where would that appear? The lower part of that line is the ground.

MR. HENDERSON: Would your Lordship like the witness to show you in the set produced?

HIS LORDSHIP: Yes. This explanation need not be taken down.

(Witness explains, referring to the set mentioned.)

MR. HENDERSON: You had not quite finished, I think, when you were interrupted?—A. I believe I referred to the tuned input circuit and the tuned output circuit, and the reason for the use of the tap in each case. The arrangement of the input circuit with that tap is the same as in the left hand figure of Exhibit " N." The output circuit is arranged the same as in Fig. 3 of the Schloemilch and Von Bronk patent, that being stated in the patent to be a tuned circuit. The Fig. 6 of this blue print also indicates elements that are not part of the present discussion, and those elements are denoted by the letters " L " and " B " at the left and by the letter " O " at the right. I do not remember having heard any discussion of that particular portion of the system, nor read any description of it, but I understand it represents something which is not part of our present discussion, known as the reflex arrangement which incidentally is in Fig. 4 of the United States Schloemilch and Von Bronk patent. I think I have already mentioned in answering this question that the vacuum tube is the Von Leiben type of tube.

MR. HENDERSON: I will have a very short examination of the witness in the morning, and the demonstration could be made here at the opening of the Court to-morrow.

HIS LORDSHIP: You want to make some reference to the demonstration in Court?

MR. HENDERSON : Yes, I would expect so, and there is something else that follows afterwards, not necessarily by way of reference to the demonstration.

HIS LORDSHIP : I assume the demonstration is simply to visualise the evidence which has been given.

MR. HENDERSON : Yes.

HIS LORDSHIP : I do not know how you can put it on the record.

MR. HENDERSON : I expect the questions put to the witness and the answers can be placed on record. That has been done in similar cases in the United States.

HIS LORDSHIP : I do not see how you can put the demonstration on the record.

MR. HENDERSON : Because the witness tells us as he is going along what he is doing. He tells us practically simultaneously with his demonstration. I think we will agree that the reporter should be there.

MR. SMART : I cannot say till after I know what is to be demonstrated.

MR. HENDERSON : Professor Hazeltine will give the demonstration, with another witness.

HIS LORDSHIP : I have very grave doubts if there is any proper way of putting that into evidence.

MR. HENDERSON : I have seen it done. I propose to follow the same line as adopted in the States.

MR. SMART : I can say more definitely after I have gone over the proposed experiment to see if it is of a kind to be placed on the record. Have you witnesses enough to occupy to-morrow ?

MR. HENDERSON : I should say we will take up the greater part of to-morrow.

MR. SMART : I would not like to keep my witnesses here over the week-end. Of course, there is my cross-examination.

MR. HENDERSON : I do not think there is any doubt about taking the whole day.

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Q. Professor, will you proceed with your demonstration, fitting it into the evidence which you have given ?—A. I think it might be well to first show your Lordship the individual pieces of apparatus about which we will talk, so that it will not be confusing when having them all together in the completed receiver. I have here some of this apparatus. First I have a variable condenser, which has a rotating element with a number of parallel plates and a stationary element with corresponding parallel plates, and the rotation changes the spacing or the overlapping of the two sets of plates, which has the effect of varying the capacity.

Q. When it is at zero how is it ?—A. The capacity itself is never at zero ; but the zero setting of the condenser, corresponding to a minimum capacity, occurs when the rotating plates are entirely out of the spaces between the stationary plates. Then it may be turned until they are entirely

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within those spaces, which gives the greatest capacity. That is the ordinary method which is more common perhaps than any other.

In the receiver which is being exhibited, it will be seen that there are three such condensers, and they are connected to the dials which the user of the receiver reads and of which he makes record so that he may find the stations over again.

Then the next element which comes in is some form of transformer which has two inductances. This particular one which I have in my hand is sometimes called the ball coupler, because the rotating element is in the form of a ball or a sphere.

MR. SMART: That is not in any of your test apparatus?—A. No. I am showing this because I may need to refer to it in some of the other testimony.

Another form of that transformer is one in which there is no motion between the two inductances as ordinarily used. This is the form which is in the receiver which will be demonstrated, and also which is in the defendant's receiver.

MR. SMART: Are you sure of that last statement, that that is the one which is in the defendant's receiver?—A. It may not have precisely the same values, but it is of the same general form.

Q. Why not, while we are here, keep to the subject matter of the test?

MR. HENDERSON: Will you proceed, professor?—A. This latter form of transformer has two inductances, as usual. Now, each is wound on an insulated cylinder, and one of those cylinders is placed inside the other, to bring the coils into close coupling, when close coupling is desired. If close coupling is not desired, they may be arranged with the coils somewhat separated. There are mounted on each of the cylinders little metal projections, to which the wires are soldered, which go to the batteries and to the vacuum tubes as needed.

Q. *Will you show his Lordship how the connections are made?* How do those connect with the wires?—A. The connections may be seen inside. There is a connection from the metal projections to a wire which is the terminus of the coil itself. This green coil is simply another structural way of making this transformer which avoids certain of the solid material.

Your Lordship asked yesterday about the connection of the antenna and variable condenser, and I think perhaps this whole matter of the connections may be shown at this time.

I have stretched across the room a single wire, and leading from that is a wire which is often called the lead-in. And a tuned antenna circuit may be formed by taking such a wire and connecting it to an inductance which I will take here as the stationary coil of this ball coupler, and then making connection from the other terminal of that inductance through a wire to the terminal of the variable condenser; and then from that variable condenser the other terminal of it we make a connection which goes to a ground connection. That ground in one's house would very often be a radiator.

HIS LORDSHIP: Does this correspond to these coils here?—A. Not precisely in the way I have connected it, but generally. That is, this ball coupler is a transformer and there is a transformer in this set, the first one connecting to the antenna, which is the one at the left-hand end of the set at the back, and then there are two other transformers which are interposed in successive vacuum tubes in the set as we will later on arrange it. Now, they are interposed between successively tuned circuits which are reactively coupled.

The other apparatus which is here it may not be necessary to refer to in particular. We have a vacuum tube, which your Lordship has already seen in the complete form and broken apart.

Here we have two forms of resistance. They both are used in the set, and I may perhaps need to refer to them. Here is a variable resistance, which is called a filament rheostat; that is used for varying the temperature of the filament of the vacuum tubes, and I shall have occasion to adjust one of those.

His Lordship: They vary the temperature?—A. That is when you put the greatest amount of resistance in the circuit with the filament, the filament will have such a little current that it will not be incandescent. Then when you vary the resistance by turning the knob on the rheostat the heat becomes increased and the filament becomes bright.

Then there is another form, known as the grid leak resistance, which is the subject matter of the Langmuir suit.

Now I go directly to the receiving apparatus, and we will explain what we have here. We have this receiver connected to a wire which serves as an antenna, and that in fact receives signals from two local stations. That is they are fictitious broadcasting stations, and one of them is arranged to give a very weak effect, and we have labelled "New York," for convenience; and another is arranged to give a strong effect, which we have labelled "Ottawa"; so that you can easily visualize the interference of the strong station with the weak station which we might wish to hear.

The receiver is arranged to be associated with a loud speaker which will give a more or less musical note—not perhaps a very pleasant one, but it will illustrate what is desired. It is a little more pleasant note when listening to Ottawa than when listening to New York.

We will put on first the Ottawa station alone. I have just lighted the filaments of the tube in this set. These vacuum tubes are not the vacuum tube relays that we have been discussing, as used in the Alexanderson arrangement, but are the succeeding vacuum tubes. That is they are not the radio frequency vacuum tubes but they are first the detector vacuum tube, and then two audio frequency amplifier tubes, which enable us to get a louder response in a loud speaker.

As things are now we hear comparatively little, if any, signal from the loud speaker; and I will attempt to tune in the signal, which will be quite a loud signal. These three tuned circuits are electrically similar to one another so that the readings of the three dials will be nearly alike; and usually a set with that property can pick up a station by moving the three dials one after the other by about an equal amount.

For example, I have all three dials now at 15, and then we will change the dials say up to 20, and we still do not find our signal; then we will go to 25, and we get our signal. It will be noticed that the signal is strongest at some particular setting of each dial, and that is the setting at which

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the circuit is in resonance with the signal being received. That signal was a relatively loud signal. Now we will have the distant signal alone; that is a weaker signal as heard here; I will attempt to tune that in. Now we have the somewhat weaker signal, which is our distant New York signal in effect.

Now I will try to tune that signal in with the other. I have tuned all three condensers now to the distant New York station, and with that on I will start up the local, Ottawa, station, and I will do that with all three stages in use as they have been so far. This is again the New York signal, and we will now have the Ottawa signal. I think your Lordship will observe no change at all, because there is so much selectivity that the distant station comes through without any interference from the local station.

MR. SMART: What is that buzzing noise in the box?—A. The two stations, due to the limitations in the apparatus here, are of different types. What stimulates the New York station is what is known as a buzzer oscillating system. It is electrically somewhat similar to a spark transmitting station; and the other, or Ottawa station, has a continuous wave system, vacuum tube oscillator. If we had had them available we would have used the latter type for both. But that does not affect the demonstration.

MR. HENDERSON: If you have them, Mr. Smart, we will be glad to use them.

WITNESS: Now I will put on the two signals simultaneously with different numbers of stages. We have so far had three stages, and with three stages we hear only the distant station, and the local station causes no interference.

Now, I will uncouple the first stage, so that it can cause no harm, which I do by taking out a coupling condenser, and I transfer the antenna to the second stage; so that now this first stage is entirely out and we have only the two stages. That was a condenser which gives the reactive coupling of the Marconi system.

There is a bayonet joint by which this condenser or vacuum tube can be placed in the socket. It is a condenser which gives us reactive coupling.

Now I will do what I have just stated: connect the antenna to two stages.

We get interference there, and I will show that there is interference by having the local station put on and off, and we will be able to hear that quite clearly, I think on the loud speaker. Now the interfering station is shut down and we do not hear it. Now it is put on again so that we can hear the two notes together. Although the interference is not very severe it is still quite noticeable I think. We will try that again. Now we have only the distant station, and now we have both together.

Now I will transfer the antenna so as to have only a single stage, which will be the system with very little selectivity. That is, it will be the system prior to the Marconi geometrically tuned system that we have previously been demonstrating. Both the stations are now on together and the interference is so strong that we hardly hear the distant station at all.

Now we have the distant station alone. As soon as we put on the local station it quite swamps out the distant station. There we get a tremendous amount of interference.

MR. SMART: May I note that with the fewer number of stages, the louder the signal?—A. Yes. I will demonstrate that directly now. That applies particularly to the interfering signal, because the different stages cut down the strength of the interfering signal. Now we will put on only the distant signal that we wish to hear and show that the loudness is not so very greatly affected. I will connect this in the same order in which we have been listening to it before. First with all three stages. I will verify that it is in tune. Now I will go to two stages. That is evidently slightly but not very greatly louder I should say. Then I will go to one stage. That also is somewhat louder but not very greatly louder. If your Lordship will vary this or that dial you will notice the effect. Moving each dial out of tune weakens the signal. There is just one setting that brings it in the strongest.

HIS LORDSHIP: The idea is to get it the strongest?—A. Yes.

MR. SMART: How closely can the ear detect the difference between two signals?—A. I have no personal knowledge of that. The ear is not at all sensitive to changes in intensity as compared for example with the eye. The eye can notice on a curve a difference that is very slight. If plotted to a large scale the difference can be noticed to a fraction of one per cent. The ear cannot do anything like that. The figure that the ear can barely notice, if I remember correctly from what I have heard is of the order of ten per cent; but the effect that is of appreciable importance is considerably larger than ten per cent.

MR HENDERSON: I suppose in practice it is the ear that counts?—A. Oh, yes, and in the use of the receiver it is not wholly the loudness of the signal, but the loudness of the signal compared with a background of noise. If for instance people are talking in a quiet room, they modulate their voices to very low tones; and in a noisy room they talk much louder.

Q. And if someone plays the piano they let go still more loudly?—A. Yes. If the background noise is less, it is not necessary to have so loud a signal, so that in spite of the difference we notice here, it seems quite slight; in favour so far as intensity alone is concerned, of the single stage, and yet for convenience and ability to read the signal for the telegraph operator, or to enjoy it as a broadcast listener, the greater number of stages is preferable to the smaller number. Now I think that that finishes the particular part of the demonstration when we were using these coupling condensers.

I will take them out of their sockets and replace them with vacuum tubes.

The sockets have been arranged, as I think I mentioned so that we can substitute an ordinary small variable condenser for the vacuum tube which would normally be used in the same place. And that variable condenser in each case, there being two of them, gave the reactive coupling which was characteristic of the Marconi system.

Now that we have put in vacuum tubes,—which also have natural capacity, and which therefore really are themselves little condensers,—I can perhaps refer to this broken apart vacuum tube. Here we have the plate so called, or anode. And close to that, in its normal position on both sides we have the grid made up of a fine wire. Now those two elements the plate and the grid, are metal conductors insulated from one another, and that is exactly what a condenser is. A condenser has two insulated metal conductors; that is they are separated by insulation, so that the vacuum tube is a little condenser, and that condenser is of considerable importance in the actual operation of the system.

Now the vacuum tubes which I have put in place are not lighted, so that they have no other operation than as condensers.

I will quickly run through the same set of experiments that we had before. We will first pick up the distant station and I will re-tune to that. Now we have our distant station received with the two vacuum tubes which have just been inserted unlighted, and we get an intensity of signal not very different as far as I can judge, from what we have just had with the coupling condensers.

Now I will go through the same experiments a little more rapidly to show the selectivity. I now put on the interfering local station. I think that we do not hear it at all. I do not hear it, when we have three tuned circuits in use, when we get the geometric selectivity in that way in three steps.

Now I will shift the antenna to the second of the three tuned circuits so that we will have just two tuned circuits. We will then have still geometric selectivity but in a less degree. Now we will put the interfering station on. The interference seems to be rather slight but I can make it out. Now it is turned off and we will go to the single circuit which has no geometric selectivity, but has just a single tuned circuit, and we will find that the interference is very bad. There is a bad interference. And now we will shut down the station and we get the distant signal again quite clearly. That shows a very marked gain in selectivity by going to the two circuits and having the geometric selectivity and a still further gain, not quite so marked, when we go to the three circuit arrangement.

Mr. Smart: Will you make an entire change in the signals?—A. I will indicate, without making other changes, simply the change in signal strength as we go from three to two and two to one circuit. There are three tuned circuits. Now there are two tuned circuits with some increase. And here is one tuned circuit with some further increase, but the difference is not certainly very great. It is noticeable but I would not call it a very large difference.

Q. Will you try the one and the three?—A. Here is the one. And here is the three. I should mention in making that comparison that an ear of course will notice the difference much more markedly if you hear one note shortly after another; but if you are listening on one evening and then listening on another evening, you might not be able to tell from memory which of the two was the strongest.

Now we will light the filaments of the tubes that have been inserted, and thereby transform the system into the Alexanderson system. I will leave first the three stages in circuit. Now I will vary this rheostat so as to light these filaments. This seems on this side to be lighted. It is lighted rather dimly. You can see a little orange colour around the base there to show that it is lighted. Now we notice that when we turn it on too far we get a very scratchy sound that is not characteristic of the note that we want to hear. That is when the system goes into oscillation as I will show more clearly in a moment. We will have to avoid that effect in order to get the operation as it should be. so I will not light the filaments so brightly as that. Now I turn the rheostat, and we get our signal not very different from what it was before. I will turn it over quickly to make the comparison. Now there is the system with the Marconi reactively coupled arrangement, and now when we get Alexanderson you will notice there is not much increase. But there is some before we get to the oscillation condition. Now I turn this over and there is the Alexanderson, and it has the same amplification, almost as much as we can get without going into oscillation.

I will demonstrate selectivity once more. Both stations are heard. We have both the distant station and the local station, and I think we can now hear only the distant station. We will now come to two stations. At present there is only the distant station. Now we will have both. The interference is there as much as it was before. Now we will go to the other and we have only the distant station which we can hear clearly. Now we will put in the local station and it will drown it out. I think it is plain that that drowns it out.

The results that have just been obtained, so far as my ear can judge, are essentially the same with the Marconi reactive coupling as with the Alexanderson arrangement, so far as ability to keep out interference is concerned. As far as one can judge they appear to be on a par in regard to selectivity. The Alexanderson arrangement, however, enables one to get a certain amount of amplification, although with the arrangement that we have here, which we have used in attempting to follow the Alexanderson patent, we find that amplification that we can obtain in that way is relatively slight.

I want to refer a little more to the subject of oscillation, because we found we got a scratchy note when we had the filaments bright.

MR. SMART: Q. Will you just note that you lost the signal from stage to stage in this arrangement—the signal weakened from stage to stage. —A. Yes, as I demonstrated, this Alexanderson system was the weaker signal, the larger the number of stages, which was the same condition that we had with Marconi.

Now that that has been brought out, it might be desirable to demonstrate it the other way. Let us try out the distant oscillator. I have adjusted the filament in the vacuum tubes so that there is a certain amount of amplification, and we will run through the comparison again as to selectivity. Let us have both stations. Now turn off the interference. (Illustrates.) I do not think that I heard any interference in that case any more than we had previously when we had three stages.

Now, we will have two stages. Both signals were so loud and so rough, due to the tendency to oscillate that I am not sure that my ear would tell me how good the selectivity was on two stages. We can, however, go directly to the single stage, where there is no geometric selectivity.

There is the distant station alone, and there it is with the interference. I do not think my previous remarks about the selectivity are any different now from what I stated before. We have some amplification by having the filaments brighter. We have still selectivity as we had it before. In fact, I think it is correct to say, from what we have just observed, that the effect of these vacuum tubes has been to give us amplification, that they have in no way contributed towards selectivity. We had the selectivity without the vacuum tubes. We put them in and still have the same selectivity as far as we can tell.

MR. HENDERSON: What about the one-way device?—A. I want to show that oscillation before we leave this point that I am referring to, I want to show the effect of the vacuum tube in being a one-way device. The vacuum tube, if it did not have this capacity I refer to, would not have allowed any signal to go through it before we lighted this filament. We did find a signal going through before we lighted the filament.

We will now put on the local station, which is a continuous wave station as we have it here, because that most nearly similates the ordinary broadcasting station so that we can get similar results. This is the local station that we have here and it is a little too loud not to overload, as we say. I have the filament turned down so far. We have weakened the station so that we do not get the loud signal. Now I will turn the filament on. Now you notice we get a sudden quick or momentary roar. That is an indication that oscillation is starting. I do not know whether your Lordship is familiar with that squeal or not in the use of the radio. That is a characteristic effect of oscillation.

HIS LORDSHIP: What is the reason of that?—A. The brightness of the filament in this case. That is not true in the better forms of radio receivers. For instance, in the defendant's receiver there is a special arrangement, which is the subject of my patent, for preventing such oscillation, and it is not necessary with such a receiver to dim the filaments, but in this receiver, where no other means are provided for the purpose, this method must be resorted to. There is a squeal with the filaments fairly bright and when they are dimmed it disappears, and of course most of the signal does too. Now I put it back again and there is a very much weaker squeal. As soon as I attempt to get amplification it squeals again, and that effect, of course, is not only annoying to the user of the set, but as I mentioned yesterday it causes interference to the neighbours by reradiating the oscillation. The oscillation occurs.

Now I have a third experiment to give you. We will take the receiver and turn it this way, and having the receiver through it then we adjust it——

MR. SMART: I would ask you to illustrate that to Doctor Roberts. Will you state how it has been adjusted? (Doctor adjusts receiver.) A. Dr. Roberts has adjusted the set so that it does not appear to be oscillating and gives us considerable amplification. I find out, however, on varying the tuning dials that although it did not appear to be oscillating as it was tuned, yet it was actually oscillating. It was oscillating under a condition that was known in the art as zero beat. That is a condition which will give rather loud signals, but which is a very dangerous condition, because it is not steady, and is liable to cause considerable distorting, and of course it is re-radiating energy from the antenna. That is a condition we consider very bad form in broadcasting reception. The oscillation is there and the squeal is produced, although if we are careful we can get right in between two squeals if I may express it that way. The circuit is not now out of tune.

I will approach the tuning zone and we get a squeal. Now I put it quiet again, and if I go beyond that point it immediately squeals. I am doing all that without changing the filament temperature from the adjustment made by Dr. Roberts, so that it was oscillating all the time and is oscillating, but the squeal now has a pitch beyond what the ear can hear. We do not hear it, but there is a natural oscillation which does produce a squeal, but the frequency is not so high.

Q. You will agree that the signal heard with Dr. Roberts' adjustment was much louder when the filament coils were on than when they were not?—A. Yes, it was louder, but I am not sure that it was not distorting. We have here no means of judging the quality of reproduction, and under ordinary conditions with such adjustment the quality of reproduction is very poor.

Mr. Henderson: Can an ordinary user get what Dr. Roberts got in ordinary practice?—A. I do not think so. It is a critical adjustment and one which a novice could not get to his own satisfaction, and while he was getting it he would be a great nuisance to his neighbours.

Mr. Smart: Dr. Roberts might get another one without producing the critical adjustment which you have mentioned. (Dr. Roberts experiments with radio.)

Mr. Smart: It went on and off without squealing.

Mr. Henderson: What have you got to say about it? Is that an adjustment his Lordship or I could make?

His Lordship: It is a matter of argument.

Mr. Smart: It is adjusted to amplify without oscillation—as close to amplification as possible.

The Witness: Do you want me to make any comment upon it?

Mr. Henderson: If you wish.

The Witness: I observe that when the filaments were lighted there was a certain amount of amplification, but a relatively small amount of amplification before oscillation set in.

Q. What is the condition now?—A. Suppose Dr. Roberts turned the filaments off again so that it would not amplify, it would be merely transmitting signals.

Q. Does it disprove what you said?—A. I think what he did was just the same as I did.

Mr. Smart: It was intended to be. We are not quarrelling with it.

MR. HENDERSON: Q. Is there anything else in the way of demonstration?—A. Yes, we have to reverse the set to show the two-way coupling. To make this second demonstration we will have to use a second vacuum tube detector, an amplifying system, because the one we have been using has been permanently attached to what is normally the output end of the receiver, and now we will put such a system on what is normally the input end.

Q. What is that thing I am pointing to?—A. That is another condenser which is not being used. We have tried out certain things for our own information which we are not intending to demonstrate. This device is a detector vacuum tube connected to the amplifier vacuum tubes to take the place of the correspondingly attached permanent tubes I have been using so far. We will start off with the filaments lighted in the two radio frequency relay tubes that we have been using so far.

Now we have turned the set around and we have put our input system where previously we had our output, and our output system going to the loud speaker, and so forth, where we previously had our input, and it will be seen that our signal goes through there very readily from stage to stage. As the relay vacuum tubes are not one-way devices, they do not allow signals through only one way, as Alexanderson seemed to think in his patent, but they allow it to go through very well in the reverse direction, if we make connections in that direction.

MR. SMART: These are special coils which you rigged up?—A. Yes. We rigged these up with proportions as fairly as we could do to follow the disclosures of Alexanderson's patent. We think the defendant's receiver is much better than the receiver of the Alexanderson patent. I know of no receiver that is being made regularly or that has been made regularly in accordance with the disclosure of the Alexanderson patent, so that it was necessary to make up such a receiver, following as far as I could the disclosure of that patent.

Q. What are the white coils?—A. The white coils are the primary coils of the radio frequency transformers.

Q. Will you describe them?—A. The white coils are wound on a cylinder made a little smaller in diameter than the green coils which are the secondary coils, and they are placed at one end with a little axial spacing so as to get relatively loose coupling. This was done so as to follow my understanding of the Alexanderson disclosure to give a certain degree of looseness of coupling. I have particularly in mind Fig. 1 of the Alexanderson patent which shows specifically a loose coupling. I was not able to tell how loose Alexanderson intended it to be, because he was reticent on that point, and I have chosen a moderate degree of looseness.

MR. HENDERSON: There is no significance in the colour white?—A. No. The green coils appear to be coils of a commercial receiver because they were suitable for it. These coils were made up for the Alexanderson patent, and we had white insulated wire available. We have wound two interleaved or bi-filar coils in the same space. One of those coils is not in use and has not been in use in this demonstration.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 11. Louis Alan Hazeltine. Examination —*continued.*

MR. SMART: You have not the details of the number of coils?—A. I can get it.

Q. You might leave the apparatus in case you require it.

MR. HENDERSON: I am told it is 19 or 20. (Demonstration completed.)

Q. Will you please refer to the super-heterodyne receiver, about which Mr. Waterman testified, as embodied in Alexanderson, and compare it if you will with any of the references to the prior art which you have got?—A. In the super-heterodyne receiver, as Mr. Waterman has explained, there is a detector, and in the input of the receiver in the succession through which the signal passes and that detector changes the wave frequency to a lower frequency and amplification, this occurs at that lower frequency. The tuning in cascade is in that lower frequency portion of the receiver, and I understand Mr. Waterman to have said that it is that tuning at that lower frequency in cascade that embodies the Alexanderson arrangement.

MR. SMART: It seems to me not relevant to this action to compare this with the prior art. The witness has already compared the patent in suit with the prior art, giving his view in regard to it. It seems to me to be apart from this suit whether certain things in this super-heterodyne may or may not be prior art.

HIS LORDSHIP: What is the purpose of this?

MR. HENDERSON: The purpose is to discover whether or not Mr. Waterman is right in saying that he finds Alexanderson in the super-heterodyne.

MR. SMART: Assuming he is wrong, it would be not relevant. It is for Professor Hazeltine to say whether or not he thinks he is right or wrong, obviously.

MR. HENDERSON: That is for his Lordship to decide.

MR. SMART: I mean that the answer to the question either way is not material. If we are to compare each of these 28,—there are a number of radiolas,—with the prior art, if it were the same as the prior art, it would not help.

HIS LORDSHIP: Is there any other way to put your question to get the answer you want?

MR. HENDERSON: My learned friend I presume, deliberately has introduced the use of Alexanderson, as he puts it in common ——

HIS LORDSHIP: I want you to be allowed to get the answer, if you want it.

MR. HENDERSON: You will remember that on cross-examination I asked for the chart, so that I could lay the ground for this. Mr. Waterman gave evidence I presume for the purpose of indicating the commercial utility, which is an element to be taken into consideration always, of the Alexanderson patent. And he gave evidence that he found the Alexanderson system in these several different makes.

HIS LORDSHIP: Ask the witness what he has to say about it.

MR. HENDERSON: That is what I have asked him.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 11. Louis Alan Hazeltine. Examination —*continued.*

Mr. Smart: My objection does not go to that, but it does go to the witness comparing it with the prior art.

His Lordship: There is some force to the objection, but you may ask what he has to say about it.

Mr. Henderson: My friend's objection is not to my question, but he is objecting to the way the witness answers in the way he does.

Q. Go on, please.—A. The Schloemilch and Leib arrangement is represented first in the British patent.

Mr. Smart: The witness is still going on to discuss something which is not pertinent to the question as defined by your Lordship.

Mr. Henderson: I want the witness to explain to your Lordship whether or not Mr. Waterman is right in saying that he finds Alexanderson in these sets.

His Lordship: In what?

Mr. Henderson: In the Radio Corporation sets. The witness is going to demonstrate to your Lordship that it is not Alexanderson which is there, but that it is this other.

His Lordship: Witness, this is not intended to be a discussion as to prior art in respect to this particular thing any more than in the nature of a reply to what Mr. Waterman says. You understand that.

Witness: If I understood Mr. Henderson's question, it had to do essentially with a comparison of Alexanderson with the prior art, which is the comparison that I have been making in my previous testimony.

Mr. Henderson: I will put the question again, professor, so that you will understand it. Will you refer to the super-heterodyne receiver, about which Mr. Waterman has testified as embodying Alexanderson, and compare it, if you will, with any of the references to the prior art which you have discussed, that is tie up the prior art to the super-heterodyne.

Mr. Smart: That is what I say is irrelevant. That question emphasizes the point.

Mr. Henderson: Surely not. It is perfectly proper for me to give the evidence for the purpose which I have indicated.

Mr. Smart: That is for his Lordship to decide.

His Lordship: I must say that if I could recall what Mr. Waterman said clearly it might help. You understand that the purpose of Mr. Smart's objection is to restrict you to the particular matters in question, and he does not want you to give evidence as to other elements in the radio.

Mr. Henderson: I do not understand any basis in principle on which Mr. Smart's objection can lie. I do not understand his objection at all.

Mr. Smart: Then may I make a statement as to my objection?

Mr. Henderson: Pardon me. My friend apparently is under the impression that I am giving evidence in reply. I am not.

Mr. Smart: I am not under any misapprehension on any point. As I understand the matter, Mr. Waterman under cross-examination by my learned friend, stated that certain super-heterodyne radiolas embodied the

Alexanderson system. My learned friend is now proposing to ask this witness not merely whether the super-heterodyne embodies the Alexanderson system, as he would no doubt be entitled to have the opinion of this witness, but he is proposing to ask this witness to compare this super-heterodyne, which are very complicated systems in themselves, with the prior art.

MR. HENDERSON : No.

MR. SMART : To compare these heterodyne circuits with the prior art. Now, however interesting that comparison may be it is quite irrelevant to the issues here, because whichever way the witness answered it, it would still be irrelevant to the question of whether the Alexanderson system is a good one or whether it is infringed ; and the witness has already given his evidence as to whether the prior art is or is not the same as the Alexanderson.

MR. HENDERSON : At last I understand my friend's objection. If he had waited he would have seen he had no cause for alarm. I am asking this witness to refer to the super-heterodyne receiver, which Mr. Waterman has testified as embodying the Alexanderson. I agree that the super-heterodyne receiver as a whole is a very tremendously complicated piece of mechanism. I am dealing with the portion of the super-heterodyne circuits which Mr. Waterman has referred to as embodying Alexanderson ; and that is all. And the witness does not intend to go over the super-heterodyne as a whole.

HIS LORDSHIP : I will allow the question. It does not involve a discussion of the heterodyne itself ?

MR. HENDERSON : Not at all, merely that portion of the super-heterodyne circuit which Mr. Waterman says embodies Alexanderson.

MR. SMART : My objection still stands that any portion of it should not be compared with the prior art.

HIS LORDSHIP : I will allow the question, subject to your objection, Mr. Smart.

WITNESS : The simple form of selectivity of Alexanderson involved the cascading of relays and the tuning of them to the frequency of the radio wave. In the super-heterodyne that is not the case ; the frequency of the radio wave is changed to a lower frequency, and the selectivity is obtained at that lower frequency. That form of selectivity obtainable or obtained after a change in frequency is the form of selectivity specifically shown in the Schloemilch and Leib arrangement which I have discussed ; particularly, for example, in figure 1 of British patent No. 10,210, of 1910. In that figure there is a detector denoted by the letter c associated with the antenna. That is very close to the input end of the arrangement ; and that detector changes the frequency of the signal from the frequency of the wave to a lower frequency ; and the selectivity is then accomplished by successive tuning to that lower frequency.

MR. HENDERSON : Q. Then will you refer to the chart showing the radiola 10, I think Mr. Waterman called it sometimes the Radiola X, and he said the regenoflex is the same, and make a similar statement as to these.

Mr. Smart: I am satisfied you should lead him and ask whether it was the same in all of these.

Mr. Henderson: Mr. Waterman classified them as super-heterodyne and he said the radiola X was not a super-heterodyne, but that these two were related. Exhibit " C," I think, you want to refer to. I am just taking the two types?—A. In exhibit " C," I find two sheets marked C-5 and C-7 which are also marked Radiola X. These receivers have tuning in the input circuit and in the output circuit of a vacuum tube relay, which I understand Mr. Waterman believes is an embodiment of Alexanderson. I find that the tuned input circuit includes an antenna system tuned by a variable condenser associated with it by what is called direct coupling; and I find a secondary inductance coupled with this antenna system, which is adjustable as indicated by a conventional method of drawing two coils at right angles. I find that this is specifically indicated as adjustable, because on the chart C-7 one of these right angle coils is marked " rotor," indicating that it is capable of rotation. This arrangement is, so far as I have described it, substantially identical with the arrangement that I have discussed at length yesterday, as shown in Fig. 3 of United States patent 1,087,892 to Schloemilch and Von Bronk. That arrangement of Schloemilch and Von Bronk has also an antenna system tuned by a variable condenser, and that system is coupled also inductively to a secondary system having a variable inductance. So that the parallel is exceedingly close, amounting to substantial identity.

Q. What do you say as to the other figures of the Schloemilch and Von Bronk patent in respect to tuning of the input circuit?—A. The figure which I have just referred to.

Q. You referred to Fig. 3?—A. Fig. 3 is the only one of the figures which shows a variable secondary self inductance in the input circuit, but all of the figures have a tuned input circuit. All of the figures have in series with the antenna a variable condenser. That was the arrangement which I showed to your Lordship before the demonstrations this morning; and that antenna circuit is coupled to the secondary circuit magnetically in such a way that the two circuits act as a unit and constitute together the input circuit of the vacuum tube relay. The input circuit is therefore tuned by that variable condenser in the antenna circuit. This is exactly the arrangement of the earlier Von Bronk German patent No. 271,059, patented from the 3rd September, 1911, as printed on it, which I discussed yesterday.

Q. Now then will you be good enough, professor, to look at exhibit " B," that is the sketch drawn by Mr. Waterman at my request, and compare it with the blueprint marked on the taking of the German evidence and now marked exhibit " P." You have your own copy of it, have you not? I was going to hand this to your Lordship, so that you could follow the witness' evidence. Have you got the simplified sketch, you know, this?—A. Yes. The sketch of exhibit " B " shows a single vacuum tube relay having a tuned input circuit and a tuned output circuit. The tuned output circuit includes a transformer whose secondary is associated with a tuning condenser, and which is connected to a crystal detector and a telephone receiver. The tuned input circuit includes first an antenna which is coupled to a secondary coil, and the tuning condenser is connected across the latter.

This description of the sketch of Mr. Waterman, exhibit "B," applies identically to Fig. 6 of exhibit "P."

In exhibit "P" we see the input circuit marked below the letter "A," and that has an antenna inductively coupled to a secondary circuit having a tuning condenser. Then we have certain special apparatus denoted by D, L, which need not be discussed as it is no essential feature with regard to selectivity.

Then we have the vacuum tube, which is an output circuit containing the transformer "C." The secondary of that transformer has a tuning condenser below the letter K; and at the extreme right there is a crystal detector near the letter P, and a telephone receiver below that, shunted by a condenser, just as in exhibit "B."

HIS LORDSHIP: What does the round circle mean immediately below? —A. The Von Leiben tube had a form of a somewhat elongated bulb in which the lower portion is expanded in a rather spherical form. It is mechanically a different structure. There are amongst the exhibits some photographs of that tube, if your Lordship wishes to see it.

HIS LORDSHIP: I think I understand that.

MR. HENDERSON: It is attached to the evidence.

Q. Then we have used the expression "a plurality of resonant circuits connected one to the other by means of a relay"—do you find that in Schloemilch and Leib?—A. Yes, I have found that in all of these references that I have been discussing with relation to selectivity.

Q. I meant to say Schloemilch and Von Bronk, of course?—A. Yes. In the figures which I have just described, the figure of the blueprint, and the figure exhibit "B," we have two tuned circuits coupled through a relay; and I understand that a plurality includes that case of two tuned circuits.

Q. And that is the practice in the use of that word?—A. Oh, yes. Plurality, as I understand it, refers to any number greater than 1.

Q. I am not sure that this is not repetition, but I think it brings out something additional. Does a vacuum tube,—you have said something about it in the demonstration, I think,—in itself act as a filter, that is is a tube selective?—A. Oh, not in the slightest degree. The selectivity is of course in the tuned circuit.

Q. Just explain that.

HIS LORDSHIP: How and where?—A. Selectivity is obtained entirely by successive tuning, whether or not a vacuum tube or other relay is present. We get the selectivity by having one tuned circuit coupled to a second tuned circuit, and if we desire that may be coupled to a third tuned circuit, and so on.

HIS LORDSHIP: The only element entering into that is the condenser? —A. The condenser and inductance. The two together. The vacuum tube is simply one form of coupling means. A coupling means may be reactive or it may be by a vacuum tube. The coupling means does not give the selectivity. The selectivity is all in the inductance and the condenser.

MR. HENDERSON: And you may use any form of relay you prefer? —A. Yes, any form of relay that is suited to the frequency and other conditions that confront one.

His Lordship: The relaying is actually done by the tubes?—A. Yes, your Lordship.

Mr. Henderson: Can you say that a vacuum tube is a reactive coupling?—A. The vacuum tube is a reactive coupling, as we illustrated it this morning.

Q. If you use it as such?—A. Yes. It is incidentally one may say, a reactive coupling. The vacuum tube is intended primarily to be a relay coupling, and it is incidentally a reactive coupling unless one takes the trouble of neutralizing it.

Q. Because, as you explained this morning, it has the necessary qualities?—A. Yes, as we showed it this morning it did constitute a reactive coupling. It was always a reactive coupling whether lighted or not. When the filament was lighted, it in addition became a relay coupling, so that we had two couplings used simultaneously.

His Lordship: When the filament is not lighted you say it also acts as a condenser?—A. Wholly as a condenser. The reactive coupling is due to the condenser action. Perhaps I might at that point refer to the usage of words.

"Reactive" is a word that applies to three different things so far as coupling is concerned. We have magnetic or inductive coupling, or perhaps we had better call it mutually inductive coupling, when we have the two coils of a transformer. That is the kind of coupling for example shown here in the chart, Exhibit 8. We have a primary coil, and a secondary coil, and they are placed close together, and that gives us magnetic or mutually inductive coupling.

Now we have another kind of coupling that is very similar in its effect, although it does not look quite the same in the apparatus or on the diagram of connections; and that is known as Direct coupling. With direct coupling, we have some coil which is common to the two circuits; that direct connection, the direct association being the reason for its name.

Then we have a third form of coupling, which is due to a condenser. We used the form of coupling that we used this morning, not because it had any peculiar virtues, but because we wished to show the Alexanderson arrangement, which had that inherently; and therefore, rather than complicate the experiment by using different forms of coupling in different parts, we used the same form of coupling throughout.

Now those three forms of coupling—Inductive, Direct, and Capacity couplings,—behave electrically in essentially the same sort of way, and they are all grouped under the proper term "Reactive Coupling." They all behave quite differently from relay coupling in their mathematical detail. They may behave quite the same, so far as the result is concerned, in certain cases.

Mr. Henderson: But in their mathematical result they behave differently?—A. Yes.

Q. You have finished with that, have you?—A. Yes.

Q. Now I think it would be useful in closing if you could just concisely summarize the situation as you have put it.—A. I have first discussed the reactive coupling systems of Marconi which gave geometric selectivity, and which did so without any great loss in sensitivity. These were widely used systems of very great practical utility.

I next discussed relays. First the mechanical relay, which was the old form. And then the vacuum tube relay, which was the new form. The function of both forms of relay was to take a weak incoming oscillation and use it to initiate new oscillations. When such a relay was used as a coupling means in place of the reactive coupling, which preceded it in radio circuits, then we kept the same old degree of selectivity. We did not gain; we did not lose appreciably in selectivity; but we secured the possibility of amplification, and that amplification is really the only excuse for the use of a relay. It is the reason that the relay, the vacuum tube relay, is used to-day. And it is the reason for the use of the relay in all of these systems which I discussed.

In Schloemilch and Leib a relay was used and it was tuned.

And in Lorenz a relay was used and also tuned. The tuning was not for the purpose of giving selectivity, but was for the purpose of retaining the selectivity which was already available in the art prior to those inventors. They put a relay in to give amplification, and they tuned it to retain the same old selectivity. The same applies since the vacuum tube relay came into use. It was used to give amplification. If at the same time selectivity was desired, then the circuits were tuned just as they were in the prior art.

The Von Bronk patent illustrated the first use in radio frequencies of such a relay; the vacuum tube. In that patent he did not seem to care particularly about the highest degree of selectivity, and he tuned only one circuit. But when the tube was to be used for a greater degree of selectivity, so that the advantage which the prior Marconi system had would still be retained, then the circuits were tuned at both the input and the output.

Mr. Smart: You are referring now to Schloemilch and Von Bronk?—A. Yes. Schloemilch and Von Bronk showed first the tuning of both the input and output circuits.

Mr. Henderson: Do not overlook the fact that the vacuum tube of to-day is not the vacuum tube of 1913?—A. Yes. Just to refer to that particular point. The early vacuum tube was not as good a piece of apparatus, either as a detector or as an amplifier, as it is to-day. And when it came to detector action, it was often inferior to the crystal; which is the reason that Von Bronk gives in his patent, and also Schloemilch and Von Bronk together, for the use of a separate crystal detector in place of a second vacuum tube. So that their combination was a vacuum tube relay plus a crystal detector. Whereas to-day the ordinary receiver would have vacuum tube relay plus a vacuum tube detector. That of course has nothing directly bearing on the question of selectivity, but explains the differences that we notice as we examine the arrangements in the various patents.

Well then, summing up some of these patents,—the ones I have just mentioned; we have in Schloemilch and Leib a relay system, which gives amplification primarily, but retains the old selectivity, and it does that by employing a relay whose input and output circuits are tuned.

Then we have Lorenz who does exactly the same thing, but he does his tuning by an inductance and a capacity. He has also a mechanical relay

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No. 11. Louis Alan Hazeltine. Examination —*continued.*

and he has an inductance and capacity in the input circuit, and the corresponding pair in the output circuit, and he gets his amplification and his selectivity in that way. And he clearly brings out in his patent that his selectivity is not a new selectivity; that is he was not the one to get this geometric selectivity but rather he was the one who substituted a relay for the old reactive coupling, and thereby got amplification without losing the selectivity.

And then finally we have Schloemilch and Von Bronk doing every single step that is shown in the Alexanderson patent. They had the geometric selectivity, by tuning more than one circuit. They coupled those circuits through a relay. And they used for that relay the ordinary three electrode vacuum tubes, just as Alexanderson did. So they have every single step of the Alexanderson arrangement.

HIS LORDSHIP: Is that all from this witness, Mr. Henderson?

MR. HENDERSON: Yes, that is all, my Lord. My friend and I had hoped that I would complete my examination by about one o'clock, so that Mr. Smart would not have to commence cross-examining until the afternoon session.

HIS LORDSHIP: I am afraid that if he does not begin, you may come back after lunch with a number of fresh questions. I think we will let Mr. Smart begin.

MR. HENDERSON: Your Lordship has foreclosed me, and I will not return with fresh questions.

HIS LORDSHIP: Oh well, I think we had better go on until one o'clock.

MR. SMART: I was going to say that there are some matters that I should like to consider. I can of course go on presently, but I think I can shorten it considerably if we adjourn now.

HIS LORDSHIP: Very well. We will adjourn until 2.15.

MR. HENDERSON: I stated that I was through. Certain diagrams were used in the demonstration this morning, and I think they should be marked.

EXHIBIT "T":—Filed by Mr. Henderson, Jan. 14th, 1927. Diagram used in demonstration by Professor Hazeltine.

EXHIBIT "U":—Filed by Mr. Henderson, Jan. 14th, 1927. Diagram used in demonstration by Professor Hazeltine.

MR. SMART: I have carefully considered the evidence of Professor Hazeltine, who has, I think, stated the case for the defendant in this matter, and he is in the same interest with them, and has stated his case as clearly as it can be stated. I fully understand his position which he has stated with clarity and emphasis. In so far as a great part of his evidence is concerned I do not disagree. In so far as he has expressed an opinion contrary to that of Mr. Waterman, and contrary to that which we believe is the correct opinion, I propose to offer evidence to controvert.

I do not see that any useful purpose will be served in cross-examining him on his evidence already given, but I do not wish my failure to cross-examine to be taken as an admission of the correctness of any opinion expressed by him.

MR. HENDERSON: My learned friend is not overlooking the rule laid down in Brown vs Dunn. I think my learned friend can hardly take that position.

MR. SMART: I think I can with respect to expert evidence.

HIS LORDSHIP: I forget the rule. With reference to cross-examining experts as a rule I do not know that anything is to be gained by it. Of course, personally, I am glad to save a lot of time.

MR. HENDERSON: It is for my learned friend to say. I am prepared to go on. I call Mr. Binns.

[*This witness was recalled, see p.* 192.]

No. 12.

Evidence of John R. Binns.

JOHN R. BINNS, Sworn, Examined by MR. HENDERSON:

Q. Where were you born?—A. I was born in Brigg, England.

Q. And your age now?—A. I am 42.

Q. Have you had experience as a telegraph or radio operator?—A. Yes, sir.

Q. Will you be good enough to recite your experience, and in doing so state it with some reasonable fullness so as to cover your qualifications as an expert on the subject of radio?—A. I first became a telegraph operator in the year 1901. At that time I was employed in the telegraph department of the Great Eastern Railway. My duties were those of an operator and I was also in charge of a relay section of the Transcontinental Telegraph wire running between London and the continent of Europe. Among these wires was one between London and Teheran, Persia. My duties in that connection consisted in testing these wires every day for resistance continually, and so on, making necessary loops whenever conditions warranted it. I remained with that company as an operator until 1904 and then entered the British Post Office Telegraph Department as a special operator at Newmarket, for the racing season. Early in 1905 I entered the service of the Marconi International Mercantile Marine Communication Company of London.

After passing through their school at Liverpool I was put with a number of others through a competitive test and chosen to be transferred to the Marconi Company as an operator on German ships.

Q. What was the necessity for that?—A. The reason for that was that the German steamship companies up to that time had been equipped with a Slaby Arco system of wireless telegraphy which was a competing system. Certain conditions had arisen whereby the Belgium Marconi

Company was enabled to get an entry to the British ships, and it was impressed on me that it was very necessary to have operators able to communicate at a very rapid rate compared to the German system of the Marconi Company that you have referred to.

Q. The Marconi Company at the time you have referred to took steps to get expert operators ?—A. Yes. I was assigned to the steamer Kaiser Wilhelm.

Q. That was a very large ship ?—A. Yes, and in April, 1905, I passed from one German ship to another, until July, 1908, at which time the German Reichstag passed a law prohibiting the use of any but German Nationals as wireless operators on German ships.

I was re-transferred to the Marconi National Marine Communication Company and assigned to the land station at Crookhaven in county Cork, Ireland. I stayed there until 1908, and was then recalled to Liverpool, and placed in charge of the apparatus on board the steamship Republic. I remained on that ship until she was sunk in collision in January, 1909.

Q. That collision was with what ship ?—A. With the steamship Florida.

Q. In Mr. Fleming's book already referred to I see a reference to that as a case in which there was complete loss of the ship, was there not ?—A. Yes.

Q. But not of the people on board ?—A. There were six people killed outright by the collision but no losses after that.

Q. And that is regarded historically as practically the first occasion in which an S.O.S. was effective in saving the lives of a whole shipload ?—A. Yes.

Q. And you are the man who sent the message ?—A. Yes. After vacation I was then attached to the Head Office of the Marconi National Mercantile Marine for a period, during which I was given the duty of revising the rules and regulations covering the operation of wireless apparatus on board ship.

After that I again went to sea and was on the steamship Adriatic from the latter part of 1910 until the latter part of 1911.

Q. The Adriatic of the White Star Line ?—A. Yes. Then I was transferred to the steamship Minnewaska of the Atlantic Transport Line until February, 1912. I then resigned from the Marconi Company and went to the United States to take up residence, and entered the newspaper business.

In June, 1917, I enlisted——

Q. Between 1912 and 1917 you speak of entering the newspaper business ?—A. Yes.

Q. In what connection ?—A. I was on the Editorial Staff of the New York American.

Q. Doing what class of work ?—A. Reporting.

Q. General work ?—A. General work.

Q. What happened then ?—A. I enlisted in the Royal Flying Corps and came to Toronto, Canada. After military training I was Chief Mounted Commission officer in charge of the construction of wireless telegraphy at the school of Aeronautics in the University of Toronto. My duties there were teaching flying cadets the use of radio apparatus on aircraft in

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No. 12. John R. Binns. Examination —*continued.*

connection with gunnery and patrol work and various other things necessary to co-operate aircraft with forces on land through the medium of communication. I remained there until October, 1918, when I was sent over to England for a commission.

Q. You had been a non-commissioned officer ?—A. Yes, with the rank of sergeant up to that time. I was assigned to the Advance School of Wireless Telegraphy at Farnborough, England, and remained there until I was demobilized.

Q. Going back from the time of your connection with the Belgium Marconi Company, which I think you said was in April, 1905, I gather you were engaged at sea until 1907, in the month of December ?—A. I was engaged at sea continuously from April, 1905, until July, 1908.

Q. And in that connection have you told us sufficiently the types of duties you performed ?—A. Yes, I was wireless operator.

Q. And what did that include ?—A. There was this addition : after my transfer to the English Marconi Company, and in January, 1910, with one or two others I was given the rank of travelling inspector. The duties involved in that were additional to the duties of wireless operator at sea in this respect ; it was necessary in a foreign port to go round to certain other ships that were under your jurisdiction, to see that they were complying with the laws that had been passed by various countries as a result of the Berlin Convention, and also in some cases as a result of the Republic Gazette.

Q. In 1907, I think you took a vacation ?—A. Yes.

Q. For how long ?—A. I had been engaged in the Belgium Marconi Company very steadily from April, 1905, until December, 1907. The number of ships that were being equipped with radio was growing rapidly, and there was some difficulty in getting operators. The result was that I hadn't had any vacation. In 1907 I obtained the first vacation.

Q. For how long ?—A. Since 1905.

Q. How long did your vacation last ?—A. I was recalled, and the reason for my recall was to join the steamship " President Grant."

Q. How long was that ?—A. Three weeks.

Q. Three weeks vacation ?—A. Yes.

Q. You were continuously at work up to then ?—A. Yes.

Q. And you were recalled to join steamship " President Grant " ?—A. Yes.

Q. Under what circumstances ?—A. The steamship " President Grant " was a new steamship, and she was making one of her first voyages, and she had on board Secretary of War Taft, of the United States, who was returning from a round the world trip which he had been making.

Q. That is the present Chief Justice Taft ?—A. Yes. There were also on board a large number of American newspaper correspondents. The order recalling me stated that it was expected that there would be quite a large amount of traffic as a result of the presence of Secretary Taft on board and also because of his prominence as a possible candidate for the presidency that year.

Q. Then when you use the word " traffic," you mean wireless telegraphy ?—A. Yes.

Q. And did that prove to be the fact ?—A. Yes, sir.

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No. 12. John R. Binns. Examination —*continued.*

Q. They were there ?—A. Yes.

Q. And there was this heavy demand upon the Marconi system ?—A. Yes, sir.

Q. Now, just incidentally what happened out of the ordinary on that voyage ?—A. Why it was a very stormy passage and it took the ship three weeks to go from Boulogne to New York.

Q. Instead of the usual time ?—A. Ten or twelve days. As a result of that situation at that time, a ship's transmitter was not able to reach out very far, we were out of communication with either shore for approximately two weeks of that period, and that brought about a great deal of anxiety regarding the safety of those on board, and resulted in what was unquestionably an increased amount of traffic. There were a number of enquiries and replies.

Q. Again you are speaking of traffic, referring to the work on the wireless system ?—A. Yes.

Q. Now, what equipment did you have on the President Grant ? You have heard Professor Hazeltine's evidence here, have you not ?—A. Yes.

Q. Have you heard his mention of the Marconi Franklin multiple tuning ?—A. Yes, sir.

Q. Are you familiar with that receiver ?—A. Yes, sir.

Q. And what did you have as equipment on the President Grant ?—A. The President Grant had a transmitting and receiving equipment. It was a new ship, and it was equipped with the latest apparatus available at that time. There were quite some improvements in the transmitting apparatus, including the receiving equipment, which was the Marconi Franklin multiple tuning, made by the Marconi Wireless Telegraph Company. I think it was made in the Chelmsford works.

Q. And what was your experience with the use of that transmitter under these rather difficult circumstances that you have described ?—A. That was my first experience with the Marconi multiple tuner.

Q. It is the receiving end that we are concerned with, of course. You had it as a receiver ?—A. Yes.

Q. Well, would you describe the practical operation of that receiver, as you experienced it ?—A. That particular voyage was my first experience with the Marconi multiple tuner. Of course the Marconi Company at different times issued circulars to its operators, notifying them of different apparatus which had been devised, with instructions how to operate ; and in the course of events I had received these instructions, but had not seen the apparatus until I joined the President Grant. On leaving Boulogne I checked over the apparatus with the instructions which came with it, and very quickly learned how to manipulate it. The apparatus was so arranged that it was possible to listen in with one circuit only, and then throw over into the tuned position. The object there was to listen in for stations, and then select the one which we wanted afterwards.

I found that it was possible with this receiver to receive weak signals even in the vicinity of strong local stations from greater distances than I had ever been able to do before, because of this tuning device, after throwing over the switch into the tuned position from the stand-by position.

Q. By the way, Mr. Binns, were you here when Mr. Waterman gave his evidence ?—A. Yes, sir.

Q. You heard what he said about the difficulties approaching the seaboard ?—A. Yes.

Q. He was quite right ?—A. Oh yes. The conditions around the shore at that time were exceptionally bad, especially on congested sailing days, such as Saturdays or Tuesdays. Around New York, in the English Channel, and such places where ships come together to approach the ports, there was a considerable amount of interference, or as we called it at that time jamming. I have had occasions where it was necessary to spend two hours trying to get one single message through, because of that interference.

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No. 12. John R. Binns. Examination —*continued.*

Q. Was that before or after the use of the Marconi Franklin tuner ?—A. Before. The advent of the Marconi multiple tuner practically did away with that situation and made it possible to get into communication and maintain communication with ships and transmit and receive traffic with an ease which had been impossible before.

Q. For instance, approaching New York harbour, what was your experience on that trip ?—A. The first experience that I had in getting into communication with a shore station on that particular voyage was near Cape Race. There had been handed to me a considerable amount of traffic for transmission to shore, especially news despatches from the correspondents on board, and also from other passengers.

As we approached Cape Race, I had been calling for some considerable time, trying to establish communication, and I finally got him very weakly. There were near us at that time the steamship Kaiserine Augusta Victoria, of the same steamship line that owned the President Grant ; and there were a number of other ships around there communicating with each other, and very close to me ; and I found I was able to tune them out and bring in the Cape Race station and carry on with my traffic. Under a similar situation previously it had been impossible until two or three hours later.

That experience is a very close description of the situation that existed near the other ports, especially around New York; and as a matter of fact entering New York the situation was far worse, because there was a large number of ships equipped with competing systems that were not well tuned at all in their transmitters.

Q. Your destination was New York ?—A. Yes, sir.

Q. And approaching New York with even greater difficulties you succeeded ?—A. Oh yes, I was able in and around New York, at that time there were three coast stations, one at Seasconsett, on Nantucket Island, another at Sagponack, Long Island, and a third at Seagate, Coney Island, that is just outside New York harbour.

Q. As to the distances that you could communicate ?—A. That depended entirely on the power used.

Q. I mean with the Franklin, as compared with your previous experience ?—A. I would say that in what we call the jamming areas, that is in areas where there was great interference, we could receive over greater distances with the Marconi multiple tuner than we had ever been able to communicate before ; and that was due to the fact that we were able to tune out a great deal of the interference that existed.

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No. 12. John R. Binns. Examination —*continued.*

Q. Then, as far as you have spoken of, they are rather difficult to pronounce, Seasconsett and Sagaponack, could you communicate with them with the Franklin ?—A. Yes, I found, for instance, in our previous experience it had been impossible after passing Fire Island to maintain communication with Seasconsett, which is further to the East on Nantucket Island, but with the Franklin tuner, I was able to hold him until after we had passed Fire Island, a thing we had never been able to do previously; and the same with Sagaponack, we could hold him until we had passed into the harbour.

Q. Was there any appreciable diminution of signals ?—A. It did not seem so; in fact it seemed that there was an increase wherever there was any interference, without the tuning you could not hear the signal at all.

Q. I suppose that is like the illustration that we have heard of here, in a quiet room as compared with a room in which there is conversation ?—A. Yes.

Q. But it appeared to you that it was stronger ?—A. Yes.

Q. Then what experience did you have with the Franklin tuner, you called it the Marconi multiple, following on after that trip ?—A. My next experience with it was on the Kaiserine Augusta Victoria ship that I went on some time later; and again after I had been transferred to the English company on the steamship Adriatic and the Minniwaska.

Q. How long did that extend ?—A. That was until January, 1912.

Q. How did your experience continue with it ?—A. Exactly the same, except that its value became more pronounced since there were more ships and more stations in communication as time went by.

Q. That is it is commercially valuable ?—A. It has operating value.

Q. I suppose the other ships had improved methods as the years went by, more ships were using the Franklin ?—A. That was my experience as an inspector, yes.

Q. What do you say then as the result of your practical experience as to the ability of this type of receiver to receive weak distance signals, as against powerful nearby stations, transmitting at a different frequency ?—A. It was possible to do that, and practically impossible to do it without it, with the apparatus which existed prior to that time.

Q. What was your experience as to utilizing it to build up, by resonance the signal you desired to receive while discriminating against the others ?—A. That was a question of tuning. After throwing over into the tuned position we gradually built up the signal strength by tuning the two intermediate circuits until the best position or the resonant position was obtained.

Q. Now I understand, Mr. Binns, you are at present associated with the Hazeltine Corporation ?—A. Yes, sir.

Q. What is your position in the Hazeltine Corporation ?—A. I am the Assistant Treasurer.

Q. Your place of business being where ?—A. 15 Exchange Place, Jersey City, New Jersey.

Q. In the United States of America ?—A. Yes, sir.

Q. And what is the business of this corporation ?—A. The Hazeltine Corporation is a patent holding company, owning radio patents and engaged in the development of radio apparatus.

Q. Doing experimental work at the laboratory, that Professor Hazeltine has told us about ?—A. Doing research and experimental work there, yes.

Q. And you know, I have explained to his Lordship, and will you tell me if I am right, that it has issued an exclusive license to the Independent Radio Manufacturers Incorporated ?—A. Yes.

Q. Which in turn issue sub-licenses to a number of different manufacturers ?—A. Yes sir, fourteen.

Q. The parent company of the Canada Fada, is it one of these ?—A. It is one of these sub-licensees.

Q. Now I want to ask you as to the character of the business done under the Hazeltine patents in which you have engaged with the Hazeltine Corporation.

MR. SMART : I do not see any relevancy in that, my Lord.

HIS LORDSHIP : What is the purpose of it ?

MR. HENDERSON : It is a well understood principle of law, my Lord, that commercial success is what one of the judges calls so very strongly persuasive of invention. There is a well known line of cases on that, that where something takes hold readily commercially and is commercially successful, and particularly when you come to combination inventions, of course——

HIS LORDSHIP : Yes, but the Hazeltine patent is not in question here.

MR. HENDERSON : Yes, my Lord, the Defendant is operating under the Hazeltine patent.

HIS LORDSHIP : But you are not trying to sustain that patent ?

MR. HENDERSON : That is what the litigation is ; that is the effect of it, and it has been so treated in the other suit,—it is only in a very indirect way.

HIS LORDSHIP : No, not even in an indirect way. Supposing the plaintiff's action is dismissed, it does not follow that the court is upholding the patent ?

MR. HENDERSON : No, my Lord.

HIS LORDSHIP : Your defence is that the Alexanderson patent is invalid and therefore you do not infringe.

MR. HENDERSON : That is our defence, but that is not necessarily the form of it.

HIS LORDSHIP : There is no way that I can see by which I can be asked to decide whether the patent you operate is valid. You do not have to go into that.

MR. HENDERSON : We do not have to go into it, but——

HIS LORDSHIP : You want to show that the Hazeltine Company do a very large business. Supposing they do. I know that that class of evidence is given on behalf of the patent that is attached. Some courts attach some importance to it, and some do not.

MR. HENDERSON : What I am going to lead up to is that we say,—perhaps I had better tell your Lordship because probably my friend knows

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No. 12. John R. Binns. Examination —*continued.*

it very plainly now,—this Alexanderson patent was a mere paper patent. It has been so held as to the others in the Twentieth Century case, and Mr. Justice Inch said it rested quietly in the archives until the Hazeltine became a very great success, and was then dug out so as to meet the Hazeltine.

MR. SMART: There is nothing of that kind said in this case.

MR. HENDERSON: I am saying it now in this case in this Court.

HIS LORDSHIP: The Hazeltine patents are not in question here.

MR. HENDERSON: I think your Lordship will understand it as the matter develops, and I am going to very, very seriously contend that this was what was called in the cases a mere paper patent.

HIS LORDSHIP: I do not know what you mean by a paper patent.

MR. HENDERSON: It is a well understood line of cases in the United States and in England, a patent which is not put into commercial use until after something else succeeds, and is then brought out from the archives of a large corporation and is sought to be used.

HIS LORDSHIP: Supposing that is so, what is the harm? A man may invent and secure a patent, and he may fail to have it accepted by the public, and at a later date it may be accepted by the public. That could all happen under a valid patent. It might not be valid, of course.

MR. HENDERSON: Yes, but there is a long line of decisions, and it works in several ways. I do not know precisely what argument my friend is going to advance.

HIS LORDSHIP: You need not argue that point now that the Alexanderson is a paper patent, that is that it is an alleged invention of years back and remained dormant for a long while. That is a matter of argument. Supposing that were all true, the point here involved in your question has to do with whether the Hazeltine patent is a valid patent.

MR. HENDERSON: Oh no, not at all.

MR. SMART: My friend said the reverse a moment ago.

MR. HENDERSON: No, I did not intend to do so. What I am pointing out is that even on the question of the interpretation of the claims in the patent, which my friend will doubtless seek to broaden——

MR. SMART: I do not need to broaden them.

MR. HENDERSON: The facts are important, because in a certain class of cases the court will construe the claims one way or the other way; the case may depend upon the facts. I am inclined to think that this is a particular branch of patent law which has not yet received any very serious attention in Canada, but has received a very great deal of consideration in the higher courts of the United States, and a vast amount of consideration in the lower courts of the United States.

HIS LORDSHIP: Will you please tell me the kind of law that is, so that I will be sure.

MR. HENDERSON: First I get what I call a paper patent. You have to get at that by getting at the facts of the case and establishing the kind of case which I speak about, a patent which lies dormant for a greater or less

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time and is brought out to meet a new situation which has arisen because of another patent coming into play.

HIS LORDSHIP: Then the question is whether the so-called dormant patent is a patent, and then there is the question whether the new one is a patent.

MR. HENDERSON: No, not necessarily. The validity of the new one does not affect the situation at all.

HIS LORDSHIP: Except that if it is a valid patent, it is an answer to every infringement.

MR. HENDERSON: Which reads directly upon it.

HIS LORDSHIP: Reading directly upon it is not very mysterious. It is like every other contract, you have got to read them in a sensible way.

MR. HENDERSON: I entirely agree with your Lordship in that. One of the principles which has guided——

HIS LORDSHIP: Stick to your point. Perhaps I have diverted you. In this class of case, in the United States do they hold that a valid patent becomes invalid by reason of the fact that it has not been acceptable to the public in a commercial sense?

MR. HENDERSON: They hold that the principal claims of what I call a paper patent will not be construed narrowly to save that patent from invalidity in view of the prior art. Whereas, on the other hand, if a patent has been actively operative from the very beginning, there will be a tendency——

HIS LORDSHIP: To interpret generously the invention which has come to the public and been commercially accepted by the public.

MR. HENDERSON: Bearing in mind after all that there is underlying it the giving of something to the public in exchange for a monopoly.

HIS LORDSHIP: There may be something in that. It is not new law.

MR. HENDERSON: It is discussed in the English cases as well as in the American cases.

HIS LORDSHIP: I suppose it is the same idea that it is a fair deduction that if a patent has been accepted by the public and heavy investments have been made there should be a generous interpretation.

MR. HENDERSON: May I say something right there, and if your Lordship thinks it should not be said, you can direct it to be struck off at once. I am leading up to the evidence that there has been some eighty-eight millions of dollars worth of radio sets manufactured and sold.

HIS LORDSHIP: By whom?

MR. HENDERSON: By the Hazeltine licensees, and that the Hazeltine Incorporation in the year 1920 had an income which averaged about $50,000 a month from royalties. So that your Lordship sees what an enormous business there is.

HIS LORDSHIP: I am very glad to hear that; I like to see everyone getting along well, but I do not know that that has much to do with this case. I have to deal with the legal effect of it, and after that, Mr. Henderson, this is a matter of argument.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 12. John R. Binns. Examination —*continued.*

MR. SMART: May I put it in this way: this particular defendant who is sued here has or has not a substantial interest. If some other defendant has a large business it cannot be relevant to this case. It may go to show that the invention is a useful one because it has been so widely used. There is not any serious question of that here on the question of infringement.

I am willing to admit that the Hazeltine Corporation has a very substantial business in the United States.

MR. HENDERSON: And in Canada?

MR. SMART: And in Canada, yes.

MR. HENDERSON: I am prepared to separate the Canadian business here.

HIS LORDSHIP: Then we can deal with Mr. Henderson's argument which is purely one of law, when we come to the argument.

MR. SMART: Yes. I will admit that it has an incorporation in the United States and in Canada, and a very substantial business.

MR. HENDERSON: I do not ask my friend to accept my exact figures.

MR. SMART: Nothing turns on the exact figures.

HIS LORDSHIP: No, that is just as good as if you had the figures in dollars and cents.

MR. HENDERSON: Then I will not press it for the moment, my Lord.

HIS LORDSHIP: Does the Hazeltine Incorporation do business in Canada in its own name or through its licensed subsidiaries?

MR. HENDERSON: The Canadian business is done through licensed subsidiaries.

HIS LORDSHIP: However, you have got the admission in form.

MR. HENDERSON: Then he is your witness.

Cross-examination.

CROSS-EXAMINED BY MR. SMART:

Q. You have described to my learned friend this so called Marconi Franklin multiple tuner. I wish you would compare it with the previous tuner that was used.

MR. HENDERSON: May I say this before leaving the previous point. When I spoke of him as an expert, I meant as a practical operating expert and not as an expert in the usual sense.

MR. SMART: If you qualify it, you qualify it.

MR. HENDERSON: That is in fairness to the witness. He does not pose as an expert witness in the usual sense. He is a practical operator.—A. The previous apparatus that we had for receiving consisted of a "receiving jigger." That was the name given to it at that time. It consisted of a transformer, fixed in value. And our tuning arrangement was done by means of variable condensers, one in the antenna circuit, and one in the secondary circuit, to which the magnetic detector was connected.

Q. That was the old, was it?—A. Yes.

Q. Now then what advance over that was the Marconi Franklin multiple tuner?—A. The Marconi multiple tuner consisted of an arrangement with three tuned circuits arranged in cascade—one after the other—and also had a means of providing the coupling inside between the coils.

HIS LORDSHIP : That is what we had this morning with the tubes out.

MR. HENDERSON : I think so, my Lord. But the witness can answer that question.

MR. SMART : No, he is not an expert.

MR. HENDERSON : He knows that part of it.

MR. SMART : There is no doubt about what the Marconi circuit was. We have the patents here.

HIS LORDSHIP : I asked if what we were shown this morning by Professor Hazeltine was not the Marconi system ?

MR. HENDERSON : Oh yes.

HIS LORDSHIP : That is with the tubes out ?

MR. HENDERSON : Precisely. Reactively coupled.

MR. SMART : *Was the detector the same in each of these ?*—A. Immediately preceding, yes ; we had the magnetic detector for approximately—well, from my experience—from 1905.

Q. What I am getting at is this : you have compared first what you had before the Marconi Franklin multiple tuner and then that tuner ?—A. Yes.

Q. Was there a different detector ?—A. No, the same.

Q. They worked on the same detector ?—A. The same detector, yes.

Q. And am I correct in understanding that all the ship sending sets were on the same wave length ?—A. No, we had in fact three different waves.

Q. What were they ?—A. Tune A, tune B, and plain aerial.

Q. What wave length would tune A be ?—A. We did not have very accurate apparatus at that time, but I imagine it was in the neighbourhood of 180 metres.

Q. And tune B ?—A. About 360.

Q. And what was the other one ?—A. The other one was whatever the antenna length was. It was direct transmission of the antenna ; putting the spark directly on the antenna.

MR. SMART : That is all.

MR. HENDERSON : Might I ask my friend if he knows yet about calling Dr. Langmuir and Dr. Alexanderson ?

MR. SMART : I would like my learned friend to finish his case.

MR. HENDERSON : My friend has heard Professor Hazeltine's evidence. I may say that I do not like technicalities as to the admissibility of evidence, and differences of opinion between Counsel on this subject. There were certain stipulations entered into here, we never doubting that these gentlemen would be called. My friend may intend to use the evidence that was stipulated, and I will have to object to it unless they are called, because there are certain documents that were to be used in the course of their examination as I understood. It would be very unfortunate if we had any unpleasantness regarding that.

HIS LORDSHIP: I cannot compel the other side to tell you what witnesses they will call. What stipulations do you refer to? Was that to produce documents?

MR. HENDERSON: I may be quite frank about it. My friend, or my friend's friends on the other side of the line, in the Splitdorf case used certain correspondence, and we have agreed to the use of a certain letter instead of producing the party who received the letter. We have agreed by stipulation with Mr. Smart, as to that, and we have agreed that photostat copies of certain other communications and things may be used, and it was of course in connection with the evidence of these gentlemen, and I want to cross-examine on that information. I do not want to have to take those documents and call attention to certain things in them, as it were setting up a straw man, if they are going to be here. It would be a sheer waste of time.

HIS LORDSHIP: I do not know what I can do to assist you, Mr. Henderson.

MR. HENDERSON: I would think my friend would tell me.

HIS LORDSHIP: There is no way of compelling the other side to tell you what they intend to do. Have you any other witness you can call to-day?

MR. HENDERSON: We have not, my Lord. Another thing, I had asked my friend and he had undertaken to learn for us, in order to save the necessity of examination for discovery, the date when the Alexanderson application was sent to Canada from Schenectady. My friend told us only the other day that he was unable to ascertain that date. I ask my learned friend if he will permit me to put in a photostat copy of the record in his Schenectady office, showing the date when it was sent to Canada, to England, to Germany and to France.

MR. SMART: Yes.

MR. HENDERSON: Then I will put this in my Lord. This was sent on the 14th day of the 11th month in the year 1913. It is stated: "11-14-13," and there is a letter or memorandum signed N.M.D., to consolidate the contents of this docket, and these read together show that this reached Canada on that date.

EXHIBIT "V":—Filed by Mr. Henderson, 14 Jan., 1927. Photostat of correspondence from the General Electric Company as to date when Alexanderson sent to Canada.

I am really absolutely at sea at the moment, my Lord, as to proceeding, because the evidence is being fed to me day by day, and I had asked particularly not to be given more than one day's work at a time. I regret the situation, but I do not want to put in evidence without knowing what the witness is going to say. I frankly confess that in this case it is as much as I can do to understand one witness at a time, because I have tried to have a real understanding.

HIS LORDSHIP: If you have no other witness that you can call this afternoon, the only thing to be done is to adjourn until Monday.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 12. John R. Binns. Cross-examination —*continued.*

MR. HENDERSON: In view of the expression of opinion on the commercial end, it is possible that the balance of our evidence will be very short.

HIS LORDSHIP: At the conclusion of the trial of this case, we will take up the Langmuir case and complete it, so that the two cases, this one and the Langmuir case, can be disposed of together in argument. I understand from both of you that the same point arises in each case?

MR. SMART: Not exactly. I think it would be just as convenient to argue this case and then put the short Langmuir case in and argue it.

MR. HENDERSON: Argue this case first and then discuss the Langmuir.

HIS LORDSHIP: Counsel will know better than I do about that. We will adjourn now until Monday.

THE REGISTRAR: The Court is adjourned until eleven o'clock on Monday the 17th.

No. 13.

Discussion.

No. 13. Discussion, 17th Jan., 1927.

17th January, 1927.

MR. HENDERSON: Now, my Lord, I wish to put in the record file of the Canadian Alexanderson application which resulted in the issue of patent No. 208,583. In doing so as a matter of convenience I would draw your Lordship's attention to the fact that the application is called throughout one for selective tuning systems. And the petition so calls it. The main point, however, that I want to point out to your Lordship is the oath which the statute requires and which reads in this way, at the end: "I further say that the same has not been patented to me or to others with my knowledge or consent in any country."

MR. SMART: There is an error there; no doubt about that.

EXHIBIT "W":—Filed by Mr. Henderson, Jan. 17th, 1927. Record file of Canadian Alexanderson application, patent No. 208,583.

MR. HENDERSON: Then I desire to put in the German patent to Alexanderson, No. 299,301, bearing date the 30th October, 1914, but issued 5th July, 1917. The way they go is that the German patents have a line "Patented in Germany on the 30th October, 1914" and then "Issued 5th July, 1917." Their patent dates back to the date of the application. I think that is what it means, and that that is the way they put it.

EXHIBIT X:—Filed by Mr Henderson, 17 Jan., 1927. Alexanderson's German patent Number 299,301. Dated 30th October, 1914.

Then I think there was the Hoxie patent referred to in evidence, but it does not appear to have been marked. That is United States patent 1,382,914. The application was filed 10th May, 1920, and the patent issued 28th June, 1921.

MR. SMART: I renew my objection to this patent of Hoxie's being received. The witness gave an expression of opinion which is already in evidence. The patent itself can have no materiality in this action.

MR. HENDERSON: The patent will speak for itself.

HIS LORDSHIP: I will receive it and note the objection.

EXHIBIT Y:—Filed by Mr. Henderson, 17 Jan., 1927. Hoxie U.S. patent Number 1,382,914. 28th June, 1921.

MR. HENDERSON: I think the Langmuir Canadian patent is in.

HIS LORDSHIP: There is to be no evidence here about the date of conception. I think I saw something about that in the American case.

MR. HENDERSON: Yes, my Lord, I am going into that now. First I will verify the Langmuir patent.

THE REGISTRAR: Exhibit F. is the Langmuir patent.

MR. HENDERSON: No, this is the Langmuir reissue. I want to put in the original Langmuir patent, my Lord. It is Number 196,390 and is dated the 20th January, 1920, the application having been filed on the 6th October, 1919.

EXHIBIT Z:—Filed by Mr. Henderson. 17 Jan., 1927. Langmuir patent Number 196,390, 20 Jan., 1920.

HIS LORDSHIP: What has that to do in this case?

MR. HENDERSON: A question of argument, my Lord. A question of law that is coming up. I am quite content to intimate it to your Lordship now. We call it "the Langmuir patent" and we call it "the Alexanderson patent," but as a matter of fact each patent is granted to the Canadian General Electric Company as assignee, and there will be a very interesting question as to the legal effect.
Then I recall Professor Hazeltine.

MR. SMART: I thought we were through with the Professor.

MR. HENDERSON: I am recalling Professor Hazeltine.

MR. SMART: I do not think my learned friend is entitled to recall Professor Hazeltine.

MR. HENDERSON: Yes, I intimated the other day that I would, unless my learned friend made a statement which he did not make. However, I am recalling the Professor.

HIS LORDSHIP: For what purpose?

MR. HENDERSON: The question to which your Lordship referred. The question of conception. I have a perfect right to recall a witness if I choose.

MR. SMART: Not after he has been on the stand and his examination concluded.

HIS LORDSHIP: Not ordinarily, Mr. Henderson.

MR. HENDERSON: I have a right to recall a witness on a separate branch, my Lord.

HIS LORDSHIP: I know, but it is a very inconvenient way of doing things, and irregular.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 13. Discussion, 17th Jan., 1927 —*continued.*

MR. HENDERSON: At the time, I asked my friend to deal with this, and my friend told me he would stand on his rights. I am standing on mine, that is all.

HIS LORDSHIP: What is your objection, Mr. Smart?

MR. SMART: The normal course is to examine a witness, cross-examine him, re-examine and finish with him. And unless there is a matter of surprise, he should not be put in the box again to give new evidence. The evidence which Mr. Hazeltine could have given was no doubt in his mind quite as well when he was on the stand. Now, having seen my position with respect to his evidence, having not been cross-examined, my learned friend now wants to put him back in the box. It seems to me that the court should say that he is concluded.

HIS LORDSHIP: You do not want to re-examine upon any matter already dealt with?

MR. HENDERSON: Absolutely not.

HIS LORDSHIP: I think it is irregular, and bad practice, to have Professor Hazeltine's evidence broken in the record. However, it is discretionary, and I would not like to take the responsibility of refusing the evidence.

MR. HENDERSON: Does your Lordship think it is irregular?

HIS LORDSHIP: Yes, I think so. Is not that your experience?

MR. HENDERSON: No. I have again and again done it.

HIS LORDSHIP: You can recall a witness to explain something that has come up, something omitted.

MR. HENDERSON: But, my Lord, when you take your case in its usual order, this is a case which divides itself into separate parts, and I am now going to take up a totally new branch of this case, and the logical thing to do is to call Professor Hazeltine as my first witness on this branch.

HIS LORDSHIP: That would not work out well in the actual operations of a court if counsel made a practice of that. The business would not be done in an orderly way. However, I am allowing you to do it.

MR. HENDERSON: I want to defer to your Lordship, and I want your Lordship to understand me, that with great deference, my Lord, I do not see anything out of the ordinary, in fact I think it is the logical way of proceeding. Your Lordship anticipated the thought as to what was the actual date of invention. I asked my learned friend the other day, your Lordship will remember, about that.

HIS LORDSHIP: But, Mr. Henderson, the only reason I asked about the evidence on conception was that I hoped there would not be any. I happened to look at the American case referred to in the beginning, on Saturday, and I saw that the court there dealt with it. I was very happy that it had not been referred to here, because, as you know, I do not place a great deal of reliance upon evidence about conception; I do not agree with the principle generally adopted—although of course I am not prejudging it—by the American courts. They receive a lot of evidence about conception. It is undesirable as we think here, or at least I do.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 13. Discussion, 17th Jan., 1927 —*continued.*

MR. HENDERSON : I know your Lordship's views. Will your Lordship pardon me a moment if I confer with my friends who are with me.

HIS LORDSHIP : It is not important in view of the ruling I am making, but when you are attacking a patent alleged to be infringed, if it is part of your defence to show anticipation, and that anticipation is to be established by some evidence about conception, clearly it is a part of your case, I think, to have done that in the main defence. However, we will not waste time in discussing it ; the case is very important from the side of both parties, and I am going to allow you to recall the witness.

MR. HENDERSON : I am still at my defence.

HIS LORDSHIP : That makes it worse. You cannot be putting witnesses in and out of the box all the time. However, I am going to allow you to do it so there is no reason for discussing it.

MR. HENDERSON : Then I will recall Professor Hazeltine.

No. 14. Louis Alan Hazeltine (recalled). Examination

No. 14.

Further evidence of Louis Alan Hazeltine.

L. A. HAZELTINE, Recalled. Examined by MR. HENDERSON.

Q. You are already sworn, Professor Hazeltine. Now will my friend be good enough to produce what we call the Vivian notes. My friend knows what I mean.

MR. SMART : Before these are put in I would like to ask my learned friend whether he is filing these as an Exhibit or not ?

MR. HENDERSON : Yes, I propose to use them.

MR. SMART : If my learned friend will state what he wishes, perhaps I will agree to it.

MR. HENDERSON : This is already a matter of consent.

MR. SMART : I quite agree that we have a consent covering these things, but I want to have it definitely on the record what my learned friend is offering so that I may know on what terms we are consenting.

MR. HENDERSON : I want portions of the Vivian notebook as covered by the consent already filed.

MR. SMART : I quite agree, but I wish it stated before the Exhibit is filed, that it is offered as an Exhibit and so on.

HIS LORDSHIP : For the purpose of offering it as an Exhibit then, Mr. Henderson.

MR. HENDERSON : It is for the purpose of marking it as an Exhibit. Then will my friend be good enough to produce it ?

MR. SMART : We have photostat copies which we have agreed to use.

Mr. Henderson : They could be used if the originals were not forthcoming. I am now asking for the original. If the original is not forthcoming I must use the photostats.

Mr. Smart : I have the originals here now.

Mr. Henderson : Q. Then you have a photostat copy of the Vivian notes before you, have you not, Professor ?—A. I have notes marked with the letter " V " on each page, which I understand are the Vivian notes to which you refer.

Mr. Smart ; Now, will my learned friend state what these notes are ?

Mr. Henderson : I am going to show them to you. I am asking if these are what were covered.

Mr. Smart : I am not objecting in any sense to my learned friend's method of offering them.

Mr. Henderson : This is what I propose to put in. I did not make this consent myself, but I am told by Mr. Herridge who did, that this is the photostat referred to.

Mr. Smart : Let me state this : I am quite prepared to agree that this Exhibit Z 1, is a document containing certain notes made by Mr. Vivian, a gentleman in the employ of the General Electric Company, during the last two or three months of the year 1912.

Mr. Henderson : Then it is marked as Exhibit Z 1.

EXHIBIT Z 1 :—Filed by Mr. Henderson, 17 Jan., 1927. The Vivian notes.

Q. Have you carefully considered the Vivian notes, as we call them, now marked Exhibit Z 1 ?—A. Yes, I have looked these over carefully and have studied them.

Q. And will you tell his Lordship first of all what they contain ?—A. These notes contain a general discussion of geometric selectivity with relays interposed. They include an algebraic development, and numerical calculations, in addition to the verbal discussion.

Q. Do you find in them any connection diagram ?—A. I find a single elementary diagram of connections.

Q. That is at the last page but one ?—A. Yes.

Q. And that is the only diagram connection you find ?—A. That is true.

Q. And what is the nature of that connection diagram ?—A. That connection diagram shows three stages each including an inductance and a capacity in series. Across each capacity are two connections, and there is running through those connections a dotted line marked with the word " relay."

Q. A dotted line marked wth the word " relay." If that word relay were not there would anyone ordinarily skilled in the art know what the dotted line meant ?—A. No.

Q. Is the dotted line in any way explanatory of any type of relay ?—A. No, not at all. It is not at all evident how a relay should be introduced in such a circuit.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 14. Louis Alan Hazeltine (recalled). Examination —*continued.*

Q. And is there any indication as to how the relay or relays should be connected in a circuit ?—A. No, not at all.

Q. Do you find through the mathematical discussion any information as to that, or the general discussion ?—A. I find only two references to the relay, which I think perhaps I had better read. On page marked V-4 I find at the bottom this statement :

> " The above result can be secured by relaying the impulses from one circuit to another with the relay, which does not consume any power in doing the transfer. There is a relay now built which will give the above result."

Q. Is there anything on these notes to show the date ?—A. I have not found any dates on these notes.

Q. The other reference to relay that you found, is where ?—A. That is on page V-21, and is similar. That is a statement in parenthesis, as follows :

> " There is a relay now built by the use of which this relation can be secured."

These are the only two references that I find to relay, and they give me no indication as to what form of relay was in mind nor how that relay could be associated in the circuit to which I have referred.

MR. HENDERSON : May I ask my learned friend to make an admission as to the date or the approximate date of these notes ?

MR. SMART : I have already stated—and I think my learned friend accepted my statement—that these notes were made during the last three months of 1912.

MR. HENDERSON : That is a pretty broad statement.

MR. SMART : Well, it was calculations involving work extending over that period.

MR. HENDERSON : That is my learned friend's statement and we have nothing to show the contrary.

MR. SMART : Yes, they speak for themselves, and that is why I thought they should be put in.

HIS LORDSHIP : Who is Mr. Vivian ?

MR. HENDERSON : As I understand it, Mr. Alexanderson, having an idea, instructed one of his assistants, Mr. Vivian, to work on it ; he did so for some time and made these notes. Then Mr. Alexanderson instructed another assistant, Mr. Thomas, to carry on, and we have some reference to Mr. Thomas' notes.

MR. SMART : I accept my learned friend's statement that these notes were made by Mr. Vivian on Dr. Alexanderson's instructions during the last three months of the year 1912.

MR. HENDERSON : I am trying to ascertain from these notes what Dr. Alexanderson himself said, as the correspondence is going in—how much he knew about it during that period of time.

Q. Then there is a diagram of some kind, I think, on the last page. What is that ?—A. I have looked at the diagram on the last page and understand, I think, that it is intended to represent the building up of oscillations in tuned circuits, but I do not clearly understand it.

Q. To what, at the most, could these diagrams apply?

Mr. Smart: I think the question is framed a little too widely?

His Lordship: I do not understand it.

Mr. Smart: Maybe he has a narrow answer in mind.

Mr. Henderson: What is the diagram on the third page from the end, if it is a diagram?—A. There are two diagrams on the third page from the end. The upper diagram is a resonance curve, and has an indication on it that the circuit which the writer had in mind was a circuit having inductance and capacity in series, which is the same as the diagram of connections to which I have previously referred. Below that is the Vector diagram, such as commonly used in mathematical treatments of alternating current systems, and this also indicates that the circuit in the mind of the person who drew the diagram is the circuit having inductance and capacity in series as in the sketch of the circuit connections.

Q. I want you to explain the significance of that system. What ways are there of tuning an electric circuit?—A. In general there are two ways of tuning an electric circuit. One is to connect inductance and capacity in series and the other is to connect inductance and capacity in parallel.

Mr. Henderson: Your Lordship is familiar with that?

His Lordship: What do you mean by parallel?

Mr. Henderson: Q. Better explain that to his Lordship and you can do it just by reference to Exhibit 8 which is very frequently used.—A. Exhibit 8 which is here shows several instances of parallel connection; the first one is at the left hand where there is a condenser 8 connected in parallel with an inductance. That parallel connection means that the different elements are connected with one terminal on each together at one end, and then with the other terminals of each together at another point. The series connection is not illustrated on this chart.

Q. Not on Exhibit 8?—A. Not on Exhibit 8. I think your Lordship will remember having asked me about such a connection. When we have an antenna system, which is a condenser connected in conjunction with an inductance, so that we have an electric circuit going first through one and then through the other, beginning at the antenna and ending at the ground, that would be a series connection.

His Lordship: Where the condenser is below that antenna, where that would be an indication of it being a series?—A. Yes, my Lord.

Q. Is there such a thing as tuning by either inductance or by capacity?—A. Yes.

Q. Usually both in practice?—A. It is quite likely that both may be employed in certain receivers. It happens that in the defendant's receiver only the parallel arrangement is employed. In fact, in a radio receiver the normal operation would not call for the series connection, except possibly in the antenna circuit, and that is not used in the defendant's receiver.

Now to continue with my answer, the two arrangements differ rather radically, both in operation and in their use, although both may be employed for tuning purposes. The series arrangement is suitable in the output circuit of a relay which has very low internal resistance. In that case the relay would be capable of giving rather large currents, but at rather low voltages.

On the other hand, when we have a relay which has a relatively high internal resistance, then the parallel tuning arrangement is suitable. In that case, the relay is capable of giving only relatively small current, but at relatively high voltages.

Now the vacuum tube is the relay of this last class, and it is the universal practice for that reason to connect the inductance and capacity in the output circuit of the vacuum tube in parallel and not in series. In the chart, Exhibit 8, the inductance and capacity in parallel do not happen to be directly in the output circuit. That is, they are not directly in the circuit of the plate, but they are inductively related to the circuit of the plate, and that is a well known equivalent of having them in parallel directly in the plate circuit.

That is something that is well understood by everyone familiar with the art. So that we have here a direct connection of inductance and capacity in parallel. The same is true of every one of the figures in the Alexanderson patent. They all have output circuit in which the inductance and capacity are in parallel, which is quite different from the sketch in the Vivian note, and quite different from all of the mathematical developments of all of the diagrams that I have referred to in these notes. All of these show the series connection. Further than that I know of no relay that can be used in the way indicated in the Vivian diagram and the way indicated in the quotations which I made. These show the two things; first, the series connection of inductance and capacity, and second that the input circuit of the relay is connected across a condenser and is intended to consume no power. I do not know to-day of any relay that would fulfil those requirements.

Q. Now pass to the Thomas report. As a matter of form you have not introduced the original Thomas report.

Mr. Smart: No.

Mr. Henderson: Will you take the Thomas notes?

Mr. Smart: Will you state what you understand those notes to be?

Mr. Henderson: I understand these to be notes made by Mr. Thomas, an employee of the General Electric Company, Schenectady, who was working under Dr. Alexanderson's direction in considering and reporting to Dr. Alexanderson, on what I, for my purpose, am calling his conception, and my learned friend tells me that these notes were made during the month of January, 1913. That date is sufficient for my purpose.

Mr. Smart: I am content that the notes be put in for that purpose.

Mr. Henderson: I do not understand that there is any intrinsic evidence on the face of the notes as to their date. There is a rather interesting note that the word conception is given at the opening in giving a mathematical description of the above conditions.

His Lordship: What is the meaning of that?

Mr. Henderson: The phrase is quite applicable.

His Lordship: How does that help you? I can understand that the notes show his activities, but they changed the whole thing since the date of the Vivian note and before making his application, did they not?

Mr. Henderson : I am going to show out of their own mouths as it were that there is no invention at this period of time, and I am using this now to avoid any conflict with my learned friend as to the admissibility of the evidence and as to my right in regard to it.

His Lordship : There is no evidence that Alexanderson made his invention before the date of his application in the United States ?

Mr. Henderson : No, but my learned friend asked us to make certain admissions which we have made in good faith, as to the use of these photostat copies. Now in view of the fact that I could not get him to say what his intentions were, I am not taking chances. I am using them myself—using his own material.

Q. Now will you be good enough to explain to his Lordship the nature of the Thomas notes ?—A. The Thomas notes are comparatively brief, but relate to essentially the same subject as the Vivian notes. There is a general discussion of geometric selectivity with relay including a certain algebraic and numerical work.

Q. Are there any diagrams of connections ?—A. No, there are no diagrams of connections and no disclosure of any operative means for carrying the ideas into effect.

Q. In the description distinguishing between the inductance and capacity in series and in parallel to which do the Thomas' notes refer ?—A. The Thomas notes are like the Vivian notes in that they refer only to inductance and capacity in series, not in parallel, as I pointed out is the case in the output circuits of vacuum tubes.

His Lordship : In results, what is the distinction between the resonance in series and resonance in parallel,—in results is there any difference ?—A. The results would not be different in such cases, as the different systems would be applicable. The point is that the series arrangement is not applicable to the ordinary vacuum tube. Its electrical properties are of a different order of magnitude from those which would call for the series connection. So that if one actually did use a series connection with a vacuum tube it would be quite impossible to obtain any considerable degree of tuning or selectivity.

Mr. Henderson : Is that susceptible of a simple explanation ? Sometimes, your Lordship, Professor Hazeltine tells me that there is no use in attempting to explain certain things, that they would be too deep for me. I do not know the fact.

His Lordship : Do they get a greater current when they are in parallel or a lower voltage ?—A. The parallel arrangement is suitable when the system supplying the tuned circuit is a system which gives a high voltage and a low current, relatively speaking. The series arrangement is capable when we have the high current supplied at the low voltage. I think perhaps I can continue on that point just a little bit further. Supposing instead of complicating our discussion we imagine the condenser to be in the plate circuit of one of the vacuum tubes, such a connection, for example, is actually illustrated in Fig. 4 of the Alexanderson patent. Now we have in this plate circuit a relatively small current. When we have this condenser in parallel with the coil 12, the current in each of them will be much larger than the current as supplied from the plate. That seems unnatural. It is always a thing that students are surprised at, because it seems contrary to the axiom that the whole is greater than its part, while here the whole is perhaps only one per cent. of its part. The point is that there is built up in here a resonant flow of current, and the current flowing in the inductance and that flowing in the condenser are at any instant of time nearly equal to one another, but in opposite directions; so that just a little current supplied produces quite a large current in each of those branches, and that is directed to the point which your Lordship mentioned, concerning the magnitude of the current. We have only a small current supplied, but we get a large current in the apparatus.

An analogy would be a weight hanging at the end of a string. If you give a little motion to the support at just the right frequency, that swing will be quite violent.

HIS LORDSHIP: The magnetic field would be between the primary and the condenser?—A. The magnetic field would be in the condenser. If we left the secondary there and simply transferred the condenser we would have a magnetic field produced by the relatively large current in the primary, and that would enter the secondary and the system would function perfectly. The reason we do not use that system in practice is wholly a matter of convenience. The ordinary condensers, which your Lordship has seen here, are of a convenient size to use; the physical dimensions are reasonably small. If we put the condenser in the primary and attempted to carry through an equivalent design, the condenser would have to be so large that it would be too large; we would have to use a condenser with mica. The actual effect would be quite the same, but it would be more expensive and less convenient to operate.

Now if I may continue in this matter. I have just indicated that with the parallel arrangement we get an increase of current in our tuned apparatus; we get no increase in voltage. The voltage of the coil and of the condenser, after we have transferred it to the plate circuit, are exactly the voltage delivered by the plate. You get no increase in voltage, but the vacuum tube being actually capable of delivering a relatively high voltage, we do not need any increase in voltage. We do need the increase in current.

If you take a series circuit, on the other hand, then the current that will flow through the inductance and the capacity is exactly the current that is supplied to it. There is no building up of current in that case, but there is a building up of voltage. We may have a voltage across the inductance, or across the condenser a hundred times as great as the voltage supplied. We get the resonant building up of voltage, but no building up of current. So that evidently one system is suitable where we have a device capable of giving high voltages, and the other where we have a device capable of giving high currents.

And the thing which makes the vacuum tube incapable of giving high currents is its high internal resistance. It has an internal resistance of the order of ten thousand ohms, which is a resistance of quite a high value, for instance, very much higher than the resistance of an incandescent lamp, which is a resistance device. And that property of the vacuum tube makes this parallel arrangement essential.

I will just indicate why the series arrangement would not work there, and why we would get very little selectivity, which your Lordship asked about.

Mr. Waterman showed some two resonance curves, which I believe were exhibit 2.

MR. SMART: Surely we are not going to have Professor Hazeltine go over evidence which he has already discussed once. My friend said this was to be confined to these notes.

MR. HENDERSON: Yes.

HIS LORDSHIP: This was because of my question.

WITNESS: I used that illustration because your Lordship had already seen it. One of those resonance curves showed a high degree of selectivity which went up to a sharp peak. The other one applied to a circuit with ten times the resistance, and it only went up to a very low peak. If we should undertake to use series tuning in the vacuum tube circuit, we would have a condition that would be even much worse than indicated in the flat curve of exhibit 2. We would have so very much resistance in the vacuum tube that the series inductance and capacity would be quite swamped out in their tuning effect, and we would get very slight selectivity, if any appreciable selectivity at all.

MR. HENDERSON: Q. That finishes what you have to say about the Thomas notes?—A. Yes.

MR. HENDERSON: May I mention to your Lordship that the Thomas notes, as we are putting them in, are in the handwriting not of the most readily legible character; but it happens, fortunately, that they are in typewriting form incorporated in another report which I am going to put in a little later. I will mention it when I put it in, that this is substantially the Thomas notes,—I will call attention to that.

HIS LORDSHIP: See that it is attached to the exhibit.

MR. HENDERSON: It will go in as another exhibit. I have to deal with this chronologically.

Will my friend produce a letter written by Mr. Alexanderson to Mr. A. G. Davis of the Patent Department, under date, Schenectady, February 4th, 1913?

This is a letter as to which there is an especial stipulation. We are agreed, and my friend attaches considerable importance to this letter, and I want to mention it particularly.

We are agreed that this letter was written by Doctor Alexanderson, under date 4th February, 1913, to Mr. Albert G. Davis, in Schenectady, New York, who received it on the 5th February, 1913; and that copies of the said letter were simultaneously delivered to Dr. Langmuir, Mr. Hawkins, Mr. Whitney, and Mr. Day; those all being employees or co-workers.

MR. SMART: In the Research Branch of the General Electric Company.

MR. HENDERSON: Have you the letter before you?—A. I have.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 14. Louis Alan Hazeltine (recalled). Examination —*continued.*

EXHIBIT "Z-3":—Filed by Mr. Henderson, Jan. 17, 1927. Photostat copy of letter dated Feb. 4, 1913, from E. F. Alexanderson to A. G. Davis.

MR. HENDERSON: I think I should read this letter to your Lordship:

"The most important improvements that are to be expected in the art of Wireless Telegraphy is to provide means for undisturbed communication by use of highly selective systems. This is the reason why high frequency alternators are expected to be of so an importance."

I may say, my Lord, that there are three or four obvious clerical errors, which may be the result of the scientist being superior to the typewriter.

"A continuous train of wave in itself allows a considerable greater decrease of tuning than the oscillating charges, even when ordinary methods are used. However, I believe that not only the sending apparatus, but also the receiving apparatus must be considerably improved in order to protect the receiving station from forced impulses of considerable magnitude.

"In order to describe the new system of tuning which I have devised I will give a short theory of the phenomena of tuning. The method of suppressing interference by means of tuning consists in using an electric circuit which has a very low admittance to single impulses of voltage, whereas a continuous set of waves will act upon the circuit accumulatively so that each successive impulse adds its energy to the previous impulses. In order to reach a high degree of tuning it is necessary that the swings of the local circuit should be in phase with the incoming waves for a greater number of cycles. In the following I will refer to this characteristic as the tuning factor, that is a tuning factor of 100 means that the impulses are effectively in phase for 100 cycles, in other words only frequencies that are within 1% of the natural frequency of the receiving circuit will have full effect upon the same. If the incoming frequency is 5% different the impulses will be in phase only for 20 cycles instead of 100 cycles and consequently, the accumulative effect will be 1/5 as great.

"It is apparent from the consideration that, although the ordinary method of tuning can be made to give a fair degree of selectivity, it cannot be expected to protect the receiving station from very strong disturbing impulses. For instance, if it is attempted to establish communication to a far distant point, the regular impulses must be very weak and a sending station in close neighbourhood may easily give electric waves of 1000 times the intensity of those that are to be received. In such a case the tuning factor should be more than 1000, in other words the local circuit should be kept in phase with the incoming waves for more than 1000 cycles. This would require an accuracy of adjustments in both sending and receiving and which would scarcely be expected, due to the described characteristics of ordinary tuning circuit where the tuning factor is proportional to the number of waves which are in phase. I wish to call the characteristics of this system-tuning by arithmetical progression whereas I have attempted to devise a system by geometrical progression where the tuning factor will increase in geometric series when the number of waves which are kept in phase increase in arithmetical progression. The device necessary to accomplish this is some form of high frequency relay which enables one high frequency current to control another high frequency circuit without the first circuit being influenced by the phenomena in the second circuit. Such a relay is the incandescent rectifier where the flow of current in the local circuit is controlled by a potential introduced in the path of the radiating energy.

"A receiving apparatus with a tuning factor of 1000 might be designed as follows with the use of the new method; the primary impulses are taken through a circuit with a tuning factor of 10, in other words, the effect of each individual impulse is suppressed to 1/10 whereas full effect is obtained if the local circuit is in phase with the incoming waves for 10 cycles. Therefore, in this primary circuit the disturbing influence has been decreased to 1/10, whereas the waves of desired frequency pass through undiminished. The current passing through this primary circuit is relayed by an incandescent rectifier or some other form of relay in a secondary circuit which also has a tuning factor of 10. In this secondary circuit the remaining part of the disturbed impulse is suppressed to 1/10, in other words the original impulse is suppressed .01, whereas the waves of proper phase yet pass through undiminished. Similarly in the third circuit which may be introduced by another relay in which disturbing impulse is suppressed to .001.

"This whole process as described is completed in 30 cycles instead of 1000 cycles which would be necessary to reach the same degree of tuning with ordinary methods.

"Yours very truly,

"(Signed) E. F. ALEXANDERSON."

I regret to say that the copy I have has been underlined in certain places. If my friend has a clean copy, we will put it in.

HIS LORDSHIP: To whom was that letter addressed?—A. To Mr. Davis, who I understand to have been at least chief legal advisor of the Patent Department.

MR. SMART: He is now Vice-President of the General Electric.

MR. HENDERSON: And he was then the head of the Patent Department.

Q. Will you now take the first paragraph of that letter, please, and tell me what it relates to? I want to analyze the letter. I want to go over that letter from the point of view of the man in the art.

MR. SMART: I do not think the witness can tell what it relates to; but he can tell what he understands.

MR. HENDERSON: I want to ask what it means to the man in the art, and that is all I am asking him.

WITNESS: As I read it, the first paragraph is essentially introductory and relates to the expectation of Dr. Alexanderson that an improvement in the selectivity of radio receiving apparatus is necessary.

Q. Then the second paragraph?—A. The statement in the second paragraph which is of most significance to me is that in the second sentence,

" The method of suppressing interference by means of tuning, consists in using an electric circuit which has a very low admittance to single impulses of voltage." That introduces a highly technical word " admittance " which prevents it from being readily understood by one not thoroughly trained in alternating current circuit work.

Q. What is the meaning of that word ?—A. That word itself means the ease with which current flows through a circuit. It is the reciprocal of impedance, which is an even more common word, and which means the difficulty experienced by an alternating current.

Now this particular statement means that in the electrical circuit which Dr. Alexanderson had in mind there was a very low admittance to interference. That is it did not readily permit an interfering current to flow. It did readily, therefore, permit the desired current to flow.

Now that is the property of the series tuned circuit that I have previously discussed. In a series tuned circuit, which has the large current readily produced out of tuning frequency, out of resonant frequency and other frequencies, it is difficult for currents to flow. That would not apply at all to parallel tuned circuits such as the output circuit of a vacuum tube. There the interfering current is allowed to flow easily ; in other words, you try to get rid of it by giving it a good passage and not allowing it to build up in voltage ; whereas the current which you wish to have at the resonant frequency experiences more difficulty in flowing in the output system of the vacuum tube, and in experiencing that difficulty it builds up a voltage, and that voltage is passed on to the following vacuum tube or to whatever we may have, such as a crystal detector. And it is that voltage which makes the following apparatus work.

His Lordship : When you refer to the output circuit, that always means in the circuit through or below the valve ?—A. Yes, your Lordship.

Mr. Henderson : The vacuum tube.

A. (Cont'd) So that this indicates the sketch in the Vivian notes, that is the series inductance and capacity, but is not applicable to the vacuum tube system, such as the parallel inductance and capacity in its output or plate circuit.

Q. Then you note there the explanation which Dr. Alexanderson gives relative to the building up of the signal, and his use of the expression " tuning factor." Will you be good enough to comment on those ?—A. I have studied that and have not been able to completely understand it, particularly in the matter of terminology. I have not been able to quite make out what is meant by " tuning factor," but it is evident to me that it does not mean the same in this letter as it means in the Alexanderson patent, where I find it used on line 3 of page 3 apparently definitely to mean amplification, which is not what it means here. He has, however, a sufficient description to indicate an idea of geometric selectivity, even though the steps I am not able to follow out completely, and the language is not the language that is familiar to the radio engineer.

Q. Now take the next paragraph of the letter. I understand you agree with his conclusion in that paragraph that with the single tuned circuit an impracticable accuracy in frequency adjustment would be required to give selectivity, with one tuned circuit ?—A. Yes, but I will need to explain that his contrast is what he considers the ordinary method, as distinguished from the proposed method. Of course, as I have explained previously, that distinction is not a proper one, as the ordinary method did not involve a single tuned circuit at that date. But if we understand that he is referring simply to a single turned circuit, then I would agree that it would hardly be practicable to get the high degree of selectivity desired with a single tuned circuit.

Q. Then he speaks of tuning by arithmetical progression. What significance do you find in that phrase as he uses it ?—A. I am quite unable to understand any significance in the use of that phrase " arithmetical progression." I have not found it anywhere else nor in the patents specifically, and it simply does not enable me to picture anything definite.

Q. But what do you say to that portion of that letter or what do you say of the letter as a whole, as bearing upon Alexanderson's familiarity with the prior art which you have already discussed in evidence and which I do not want to open up again ?—A. From what I have stated in the previous answer relating to his phrase " ordinary method " I would understand that he was not familiar with the general practice at that time in radio reception.

Q. Then you will notice that after he has stated his purpose in the two parts, he says he reaches the desirability of a relay and says " Such a relay is the incandescent rectifier "——

Mr. Smart : Why not deal with the previous sentence,—you omitted a sentence there.

Mr. Henderson : First of all we have the purpose stated and he says " I have attempted to devise a system by geometrical progression where the tuning factor will increase in geometric series when the number of waves which are kept in phase increase in arithmetical progression." Then occurs what Mr. Smart refers to : " The device necessary to accomplish this is some form of high frequency relay which enables one high frequency current to control another high frequency circuit without the first circuit being influenced by the phenomena in the second circuit."

Mr. Smart : Yes.

Mr. Henderson : I have read that.

Mr. Smart : What I meant was that we are obtaining Mr. Hazeltine's discussion of this letter, and then there is a sentence intervening.

Mr. Henderson : I was not intending to leave out anything. " Such a relay is the incandescent rectifier where the flow of current in the local circuit is controlled by a potential introduced in the path of the radiating energy." Now, take the words " incandescent rectifier " in the last quotation, and what is your comment on that ?—A. Here I should understand, perhaps, because I am familiar with the subsequent correspondence and the patent, that the device in Dr. Alexanderson's mind was a vacuum tube, possibly of the audion type ; but the phraseology is not correct, because the vacuum tube when used as a relay is not acting as a rectifier. It is acting as a rectifier only when it is used as a detector.

Q. So, is his language appropriate ? It is a fair assumption that he

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is there referring to the type of audion which DeForest invented, and which he expected Langmuir to improve. I think that is a fair statement.

Mr. Smart : Does the stenographer note the nod of the witness ?

Mr. Henderson : No. I say you are assuming that ?—A. Yes, that is my understanding.

Q. My learned friend is quite right that a nod does not go down. But you are assuming that a vacuum tube when used as a relay does not act as a rectifier ?—A. No.

Q. It does not act as a rectifier when used as a high frequency relay, and he says that the device used is some form of high frequency relay. Now do you find any specification or anything to show you that he proposes to connect the relay in circuit ?—A. No, I do not. I find only one further reference on the last page to the relay, which, is that " the current passing through this primary circuit is relayed by an incandescent rectifier or some other form of relay."

Q. Or some other form of relay. Now he does not tell Mr. Davis anything about the DeForest or proposed Langmuir relay.—A. No, there is no indication at all about the properties of the relay or the circuits of the relay except the one I have already mentioned, and that was an indication that it was not the ordinary DeForest audion.

His Lordship : Where does that relay commence in actual operation, Mr. Hazeltine ?—A. The relay, your Lordship, is simply the vacuum tube itself, that is the real relay.

Q. It commences there and ends there ?—A. That is the way I would use the word, your Lordship.

Mr. Henderson : Do I understand your Lordship to ask when does the process of relaying commence ?

His Lordship : Where it is carried out. It begins and ends in the tube.

Mr. Smart : It must have an associated circuit in order to operate the tube.

His Lordship : Oh, yes, the tube without the circuit would be no good.—A. I did not mean to imply that the process was confined to the tube necessarily, I meant that when I was relaying or someone was relaying I would think of the tube by itself, and of course I would understand that the tube would be useless if it were not associated with the circuit.

Mr. Smart : And the circuits determine how the tube will function.

Mr. Henderson : Surely.—A. Yes.

Q. Then the next thing I think, in order, that we have, as a matter of history in this correspondence, is a letter from Dr. Alexanderson to Dr. Steinmetz, dated the 8th March, 1913, and the report accompanying that letter, which I will ask my learned friend for.

Mr. Smart : No, I haven't that.

Mr. Smart : Q. You have a copy there, Professor ?—A. Yes.

His Lordship : What is the purpose of Alexanderson's letter to Davis ? Was it to make publication, disclosure ?

MR. HENDERSON : I take it, my Lord, that each one of these gentlemen as a matter of duty has to report.

Apropos of that, has my friend a copy of the contract between Dr. Alexanderson and the General Electric Company ? We have asked for it for some time, and I understood it was to be here.

MR. SMART : No. Your Lordship asked as to the purpose of the letter. The purpose is generally this : when an invention has been made and completed in such form as is proper to be published to others associated in the department in the research organization, it is the practice to write such a letter and circulate it among a number of the officials, and those to whom this letter is given are named on the copy as your Lordship will see.

MR. HENDERSON : That seems to be a logical process, when you realize that these men are all parts of what I may—not offensively—call a large machine ; an operating machine. But this document has not got the report attached to it.—A. This is it.

Q. This is a rather poor copy. Perhaps I could have a better one ?

MR. SMART : It is as clear as any we have.

MR. HENDERSON : Then I put in, my Lord, a copy of a letter bearing date the 8th March, 1913, from Dr. Alexanderson to Dr. Steinmetz of the General Electric Company, of whom your Lordship has doubtless heard.

> " I am sending you report on investigations which have been made on the characteristics of tuning circuits. It appears that the method of tuning in geometric progression is much superior to the ordinary method of tuning for wireless purposes. In order to make use of this system it is necessary to have a relay for high frequency currents, and it is probable that such a relay can be made on the principle of the incandescent rectifier which is already used under the name of Audeum."

He spells it A-u-d-e-u-m. He had not the right name, there is no such word.

> " In the wireless art, although in its present form it is too sluggish for relaying when high frequency current or another current of more frequency is used. However, with the improvements that the research laboratory expects to make, in the construction of the Audeum, this difficulty is expected to be overcome.
>
> " Yours very truly,
>
> " E. F. ALEXANDERSON."

And the report accompanying it, to which I attach it is a typewritten report which your Lordship will see to be the promised report. Z 4 will be the letter and Z 5 the report with the letter, the Thomas Report.

EXHIBIT Z 4 :—Filed by Mr. Henderson, 17 Jan., 1927. Letter 8th March, 1913, Alexanderson to Steinmetz.

EXHIBIT Z 5 :—Filed by Mr. Henderson, 17 Jan., 1927. The Thomas Report, attached to Z 4.

HIS LORDSHIP : Steinmetz, I suppose, was the chief of the Research Department ?

MR. HENDERSON : If he was not chief, he certainly was not at the bottom of the ladder. Do you know how far up Dr. Steinmetz was in that year? I think he was in a consulting position at that time.

MR. SMART: Dr. Steinmetz was in a different research laboratory, and a consulting engineer, chief consultant, probably, on general matters at that time.

MR. HENDERSON: Then the first paragraph in the letter to Dr. Steinmetz I think is similar to one of the opening statements of the Alexanderson patent. Did you notice that, Professor Hazeltine?—A. Yes, in that paragraph he makes a comparison of geometrical tuning, with what he considers the ordinary method. And he undoubtedly means by the ordinary method, a single tuned circuit, which was his idea—although mistaken—of the prior art.

Q. And you will note, he speaks of geometrical progression, as being something entirely new with him?—A. Yes, which is also of course a mistake.

Q. Again you will note his use of the word "audeum."

MR. SMART: I do not think my learned friend should attempt to suggest to or assist this witness. He is telling him just what he thinks the report is.

HIS LORDSHIP: The objection is that you are leading.

MR. HENDERSON: No, I am not leading. I merely say, you will notice the word "audeum." Was there any such word known in the art at that time as "audeum"?—A. Not that word. I understood him to mean "audion."

Q. "Audion" was what DeForest called his tube?—A. Yes.

Q. And that was well known? But "audeum" did you ever see it anywhere except in this letter?—A. No.

Q. Then the sluggishness which Dr. Alexanderson speaks of.

MR. SMART: May I see the copy of that letter which has been filed? The copy that was filed and which is I think attached to our consent had the word corrected in pencil to "audion."

MR. HENDERSON: I put this in in good faith. Was it not "audeum" in the original?

MR. SMART: I don't think so.

MR. HENDERSON: If so, that is a rather foolish error to have crept in. Why not have the original? Why isn't it here?

MR. SMART: I have Exhibit B, which we agreed should go in as the original, and which has the correction initialled by us, and which has it correctly spelled "audion."

MR. HENDERSON: Someone has called attention that when he spoke of "audeum" he meant "audion." And it is not corrected. Show his Lordship what I mean.

MR. SMART: If my learned friend will allow me to state my position. We have a consent here, my Lord, with respect to the letter, and I am going to read the terms of the consent so as to show your Lordship exactly how the matter stands.

"A letter of which a copy is hereto attached, marked Exhibit B, was sent by said Ernst E. Alexanderson to Dr. C. P. Steinmetz, and a copy was simultaneously sent to the said Whitney Hawkins, Day and Davis."

This, which I now produce and request to be substituted for the Exhibit. Exhibit Z 4 is a copy which both of us initialled, and which under our consent is the only authentic copy of the letter.

MR. HENDERSON: I quite agree. I asked my friend for it, and I was just using what I had, and what my friend is calling attention to now, may I show your Lordship?

HIS LORDSHIP: Is this important, Mr. Henderson?

MR. HENDERSON: I don't think it is, but in this particular copy the letters "ion" have been written over the letters "eum." But the letters "eum" are not crossed out and there is nothing to show whether or not that was done at the time of the writing of the letter, but my understanding is that it was not.

MR. SMART: My point is that we have an Exhibit in which it is corrected and which we have agreed should be the copy of the letter.

MR. HENDERSON: My point is that we have an Exhibit which is not corrected and I simply say, Here it is.

MR. SMART: My learned friend has consented that it is correct.

MR. HENDERSON: I did not say correct; I said corrected.

HIS LORDSHIP: There is no reason for taking time over it. That document becomes Exhibit Z 4.

MR. HENDERSON: Yes, if that is the number, instead of this unfortunately uncorrected one, which I had put in.

Q. What do you say as to the sluggishness of the audion referred to in that letter?—A. The sluggishness referred to in that letter, in the statement that "in its present form it is too sluggish for relaying one high frequency current to another current of the same frequency."

I understand this to refer to a property that is quite common in vacuum tubes having a considerable amount of gas. The action is far from instantaneous, and not rapid enough to give proper response at the exceedingly high rate of radio signal frequencies. I understand that Dr. Alexanderson had this in mind and that he had the expectation that the research laboratory of his company would be able to overcome this difficulty. He was of course familiar with the reputation of Dr. Langmuir, who had made a special study of the phenomena in high vacua, particularly in connection with incandescent filaments in a vacuum, and that his work as a matter of fact has been universally recognised as of the highest scientific order both experimentally and theoretically, and I understand that Dr. Alexanderson had in mind that Dr. Langmuir would be able to make some type of vacuum tube that would be likely to work in such a system that he imagined.

Q. I think that can be argued from the reading of the document itself. Then referring to the report which accompanied the letter and which is now Exhibit Z 5, the first three pages I might indicate to his Lordship—

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I gather that the first three pages are I think word for word the letter to Mr. Davis.—A. I have looked them over and I find that to be the case.

Q. The first three pages of the report is the letter to Mr. Davis. Then comes the Thomas report with the balance of it.—A. Yes.

Q. Do you find in that report any diagrams of connections or connection diagrams?—A. No, there is no diagram of connections, and no description that would enable one to make up a diagram of connections.

Q. What is the practice of electrical engineers as to that, and what was it at that time, if a man had something new?

MR. SMART: I submit this is objectionable. This witness cannot say what the practice was of every electrical engineer. The practice of this electrical engineer, Dr. Alexanderson, is indicated by these documents.

MR. HENDERSON: The practice of electrical engineers generally. I think we all know, my Lord,—to our great regret sometimes,—the readiness with which they will dash off a diagram is so great that it is hard to follow them. They think in terms of diagrams.

MR. SMART: Some do and some do not.

HIS LORDSHIP: Do they when they discover anything new?

MR. HENDERSON: When they talk about anything at all, if they have anything to talk about, they illustrate it at once with a diagram.

HIS LORDSHIP: I will accept that as being the practice of engineers.

MR. SMART: Some engineers make diagrams and some do not. Surely the witness cannot say that the universal practice is to make diagrams.

MR. HENDERSON: I did not use the word universal.

HIS LORDSHIP: I can understand two engineers being together and not opening their mouths at all, but using pencil and paper and algebraic terms. It might be like the conversation of the dumb.

MR. SMART: In that way they understand each other.

HIS LORDSHIP: Yes.

MR. HENDERSON: As one who understands the ways of electrical engineers, can you conceive at all an electrical engineer who had something tangible to talk about, not using a diagram?

MR. SMART: That is objectionable.

HIS LORDSHIP: I do not think it is important, but I do not reject it. Ask the witness his own experience.

MR. SMART: He usually uses diagrams, I suppose.

MR. HENDERSON: What is your experience, not merely in your own practice, but in the practice of electrical engineers when they have to discuss something?—A. My experience is—and this includes my own practice as well as the practice of a great many with whom I have talked and discussed new subjects—that a diagram of connections is practically the first thing to be drawn, unless either the subject is an exceedingly familiar one to both parties, or unless the idea is too intangible to permit a diagram to be drawn.

HIS LORDSHIP: There is none here?

MR. HENDERSON : No, there is none here.

Q. Then the next letter we have in chronological sequence, is one of the 14th May, 1913, to Mr. M. W. Sage, of the General Electric Patent Department. Has my friend that? It will be Exhibit Z 6.

MR. SMART : I have not the original. I have the one we initialled.

EXHIBIT Z 6 :—Filed by Mr. Henderson, 17 Jan., 1927. Letter, 14th May, 1913, to M. W. Sage.

MR. HENDERSON : Then let me put in the one we initialled and not get into any more trouble. You have this letter before you, but perhaps I had better read it, as it is not very long, and it is a very poor copy. It is dated May 14th, 1913, and is addressed to "Mr. M. W. Sage, Patent Department."

> "In the patent granted to me October 22, 1912, the method is claimed of using a vacuum tube for relaying high frequency current for wireless telephone. In that patent the principle is illustrated by a vacuum tube of the mercury arc type in which it was assumed that the flow of current could be stopped and started by an exciting anode, the potential of which is controlled by the telephone current. Dr. Langmuir demonstrated today to Mr. Hawkins and myself a vacuum tube relay of the incandescent type, which proved to be sensitive enough to respond as a relay for alternating currents up to 100,000 cycles, and probably much higher if such frequencies had been available. The incandescent vacuum relay which was demonstrated would be well adapted for sending apparatus of a wireless station if it is developed on a larger scale. The electrical connection that may be used for this purpose may be varied to a considerable extent and I will, therefore, confine myself to illustrating its use by describing one or two possible arrangements.
>
> "With the present development of the incandescent vacuum relay, as perfected by Dr. Langmuir, it seems that its capacity for handling considerable amounts of energy can be easier increased by employing high voltages than by attempting to handle large currents. For this reason it would probably not be feasible to connect the vacuum tube directly in series with the antenna in order to control the flow of current as shown in my original patent. The connection must, therefore, take place through the intermediary of some kind of transformer which translates the energy flow in the antenna into a higher voltage and lower current. One way by which this can be accomplished is to connect the alternator directly in series with the antenna and connect the primary of a high tension transformer, either in shunt with the alternator, or in series with the antenna. The secondary of this transformer having its circuit closed through the vacuum tube relay. If the current that is allowed to flow through the vacuum relay is varied by a suitable potential applied to the exciting anode, the flow of power in the low tension primary circuit is changed correspondingly and the fluctuation transmitted to the sending antenna. In order to make use of this arrangement the telephone transmitter may carry either alternating current derived from the same alternator, or direct current in the ordinary way.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 14. Louis Alan Hazeltine (recalled). Examination —*continued.*

"How the flow of current in the tube may be controlled by alternating current is made sufficiently clear in my first patent; whereas the action of a direct current telephone for this purpose might need some explanation. It has been found in the work done on incandescent vacuum relay that the greatest sensitiveness is reached if a definite negative potential is applied to the exciting anode, a slight variation in this negative potential will change the flow of current from the incandescent wire from maximum to zero. The best relay action is obtained by super-imposing the exciting current of this negative potential which is regulated so as to bring the combined potential to the point of greatest sensitiveness. If it is desired to relay high frequency current, this can be done by applying a high frequency alternator current to the exciting anode in addition to the negative potential and thus control the flow of a direct current from the incandescent terminal. If on the other hand a high frequency alternating current is applied to the incandescent terminal, the intensity of the flow can be regulated by change in the negative potential of the exciting anode. Thus, it would be seen that if the potential of an ordinary direct current microphone is applied to the exciting anode and a negative potential suitably adjusted, fluctations in the potential due to the telephone will control the intensity of the flow of the high frequency current from the incandescent terminal.

"Inasmuch as an incandescent vacum relay in its simplest form can carry current only in one direction, it may be found of advantage to use two of these relays connected in opposition, as shown in my original patent, in order to control the flow of the high frequency current on both the positive and the negative half wave."

"Yours very truly,

"E. F. ALEXANDERSON."

MR. HENDERSON: Do I understand that this rough diagram was connected to it?

MR. SMART: Yes.

MR. HENDERSON: Take that up, Prof. Hazeltine.

MR. SMART: I am not sure that there is any reason why this witness should go into this subject matter. It is not relevant. It describes quite an intricate form of device, a further invention of Alexanderson.

HIS LORDSHIP: I did not know just what Mr. Henderson was going to put in. These reports or letters should have been put in by you. Mr. Henderson should have waited till you put them in. He is anticipating things perhaps to his own advantage. They should have been put in or Mr. Henderson should have waited till they were put in, when he could have called this witness. He is entitled to some leniency when he is taking the risk of going ahead now.

MR. HENDERSON: I am taking the risk of going ahead. That is a simple proposition and I wish to avoid any discussion as to my learned friend's right to put them in without calling his witness, but your Lordship will see what I mean by that.

His Lordship : It is clearer now to me than when you made the application.

Mr. Henderson : I am taking chances of putting in my learned friend's evidence.

His Lordship : It was part of the stipulation that it should go in.

Mr. Henderson : It was part of the stipulation these letters should go in, but they were intended to eliminate the evidence given by this witness. That is not guarded in the stipulation and because that was not guarded in the stipulation, and because there may be some question with regard to my right to comment on them later on without special permission, I am putting them in myself.

His Lordship : I understand the situation.

Mr. Henderson : The first reference to the Alexanderson patent is the reference to the mercury arc type.—A. Yes.

Q. Is it quite different ?—A. It is alike in some respects, and quite different in other respects. It has rectifying properties which are the same, but it is very sharply distinguished in the way that is brought out in this letter in that it is a low resistance device, therefore suitable for use with a series circuit which I have previously discussed, whereas the vacuum tube arrangement, which is the main subject matter of this letter is a high resistance device and suitable for use with a parallel circuit, as I have discussed somewhat at length. This distinction is most clearly brought out in the sentence near the top of the second page :—

> " With the present development of the incandescent vacuum relay, as perfected by Dr. Langmuir, it seems that its capacity for handling considerable amounts of energy can be easier increased by employing high voltages than by attempting to handle large currents."

That is the thing that I have already discussed in answer to his Lordship's question that the vacuum tube is this high voltage device suitable for parallel tuning whereas the mercury arc was the high current device for series tuning, and this indicates that at this time, May 14th, 1913, Dr. Alexanderson had been informed as to these characteristics of the relay which differ from those which he indicated to be in his mind in all of the previous development and correspondence.

Q. What bearing has it to one familiar with the art on the disclosure of Dr. Alexanderson's understanding as to the resistance of the output circuit and the consequent effect ?—A. That is what I have just generally outlined. I perhaps can add no more, except to point out that it is illustrated in the diagram which he includes with his letter, and that diagram may be compared with his patent diagram showing the distinction between the series arrangement in the patent with the mercury arc, and the parallel arrangement in this letter both by the explanation and also by the diagram which he includes with his letter.

Q. As far as we have gone down to May 14th, 1914, as far as this correspondence discloses knowledge by Dr. Alexanderson, will you say whether or not he could have applied a vacuum tube relay as an operating thing for carrying out his idea of geometric selectivity ?—A. He could not have done so.

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Defendant's Evidence.

No. 14. Louis Alan Hazeltine (recalled). Examination —*continued.*

Mr. Smart: There are several letters in that series which my learned friend has not put in.

Mr. Henderson: If my learned friend has any letters he wants to produce, I think I will put them all in. I am down to this stage. I have not intentionally omitted anything.

Mr. Smart: There is a letter from John Hays Hammond.

Mr. Henderson: I had thought that this was merely worrying the Court.

Q. You remember the letter from John Hays Hammond to Dr. Alexanderson?—A. Yes.

Q. It says that he is having Prof. Pierce construct a vacuum bulb suitable for use as a rectifier for detecting high frequency electric oscillation. He is glad to hear good news about alternators and his laboratory will be ready for them next week. Then apparently I have not put this in. On 4th February Dr. Alexanderson sends to Mr. Hawkins, his co-laboratory worker, a sample of the incandescent detector which he had received from Mr. Hammond; so that apparently he had received this. You are familiar with that?—A. Yes. I have seen those letters and studied them carefully.

Mr. Henderson: I do not want to burden the record with these. I will put them in if my learned friend wishes.

His Lordship: I do not see their relevancy. Notwithstanding the stipulation to put these in, I reserve the right to determine whether they are proper evidence. I want to hear Counsel on that.

Mr. Henderson: We cannot perpetrate evidence on your Lordship by stipulation.

Mr. Smart: That is a letter Dr. Alexanderson wrote.

Mr. Henderson: My policy in this case is to hold back nothing from my learned friend—to take no chances on a thing of that kind. I find the more we go into it the more nebulous Alexanderson's idea appears to be.

His Lordship: The weakness of that is this—and it shows the weakness of this kind of evidence to establish validity of patents—Alexanderson may come and say, "I wrote this letter hurriedly one afternoon in Schenectady; I was careless and did not state all I had in mind," and what can you say? He might say he had an incompetent stenographer and audio frequencies were not right and the stenographer didn't get the right word.

Mr. Henderson: I have reason to expect that if Dr. Alexanderson or Dr. Langmuir takes the box they will not differ one word from Prof. Hazeltine. I am prepared to take chances on that.

His Lordship: This is not the place to gamble. We cannot deal with that.

Mr. Henderson: Does your Lordship think they should go in?

His Lordship: I think they should go in.

EXHIBIT "Z-7":—Filed by Mr. Henderson, Jan, 17, 1927. Letter from Dr. Alexanderson to Mr. Hammond.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 14. Louis Alan Hazeltine (recalled). Examination —*continued.*

EXHIBIT " Z-8 ":—Filed by Mr. Henderson, Jan. 17, 1927. Letter from Dr. Alexanderson to Mr. Hawkins.

Q. My last question was substantially this, Professor: With the knowledge that Dr. Alexanderson had at the time, as disclosed by the letters and reports which you have read down to this time, could he have applied a vacuum tube relay as an operative means for carrying out his idea of geometric selectivity with a tuned relay circuit?

MR. SMART: I object to that question. Obviously this witness can not say what Dr. Alexanderson could have done.

MR. HENDERSON: I mean now as a matter of practical application.

HIS LORDSHIP: Using the knowledge disclosed in the letters and reports.

MR. HENDERSON: Could he have applied a vacuum tube?

HIS LORDSHIP: I am assuming that if this had gone on in another way, and Mr. Smart had put these letters in, as he evidently would, Mr. Henderson would have been allowed a very wide range of cross-examination. I do not see that the question can be objected to.

MR. SMART: The witness can not speak as to anything but whether he would himself.

MR. HENDERSON: Could anyone skilled in the art have done so,—probably that is a better way of putting it, not limiting it to Dr. Alexanderson.

HIS LORDSHIP: Yes.

MR. HENDERSON: Could anyone skilled in the art?—A. No, not prior to the knowledge which Dr. Alexanderson indicates that he had received on the 14th May.

Q. What is the particular significance of the knowledge received on that date.

HIS LORDSHIP: This witness has already said that on the patent, and it really does not matter much now.

MR. HENDERSON: May I make this plain to your Lordship, as I do not know whether your Lordship has the significance of these dates?

HIS LORDSHIP: No.

MR. HENDERSON: My friend has in another case claimed the 4th February as his invention, dated it back to the 4th February as the date of conception.

HIS LORDSHIP: I want to hear what the witness says.

MR. HENDERSON: Your Lordship will remember that the Schloemilch and Von Bronk patent was filed in Germany on the 9th February, and their evidence is, which your Lordship has not yet read, I imagine, that some ten to fourteen days had been consumed in preparing the patent application.

MR. SMART: That is not their evidence, my Lord.

HIS LORDSHIP: Let Mr. Henderson state it. It will be more or less a matter for argument, I presume.

MR. HENDERSON: It will be for argument, and this is but to direct

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Defendant's Evidence.

No. 14. Louis Alan Hazeltine (recalled). Examination *—continued.*

your Lordship's mind. Your Lordship will see that on these dates things were running pretty closely together. Schloemilch and Von Bronk were working along very much at the same dates ; and that is the reason I am emphasizing the dates and the stages.

Q. Will you indicate just what you mean, without going all over it again, as to the new knowledge mentioned in that letter ?—A. It is mentioned in that letter that on the 14th, Dr. Langmuir had made a demonstration to Dr. Alexanderson concerning the vacuum tube relay ; and then Dr. Alexanderson continues referring to this work of Dr. Langmuir and indicates that it has shown that the relay is of the high resistance type, which would require parallel tuning in place of the series tuning which he indicated in all of the previous letters and correspondence and in the notes of his assistants. And it was not until his ideas were corrected in that way that he would be able to apply the proper circuits, as I understand, to carry his object into effect.

MR. HENDERSON : Now then, will my friend be good enough to produce Dr. Langmuir's notebook ?

MR. SMART : I haven't it.

MR. HENDERSON : I certainly understood we were to have it here.

MR. SMART : I am quite content that my learned friend should produce the photostat copies of it.

MR. HENDERSON : Why not have it here ? We were asking to see it, and it should have been here several days in advance of the trial. It was referred to in the stipulation that photostat copies of the original notebook of Irving W. Langmuir, pages 214, 216 and 217, notebook No. 458, pages 100, 101, 111, 112 and pages 130 to 133, may be used instead of the original provided that communication of the original notebooks is given to counsel for the defence at least ten days in advance of the trial. We understood we were to have an opportunity of perusing the original notebook.

HIS LORDSHIP : And you have not had that opportunity ?

MR. HENDERSON : We have not.

MR. SMART : I am not going to offer the pages of the notebook in evidence, and consequently I did not need to give communication of it to my learned friend. It is in Wilmington.

HIS LORDSHIP : The book is not here ?

MR. SMART : No.

HIS LORDSHIP : Then you will have to be satisfied with the copies.

MR. HENDERSON : It is very unfortunate. We want to see the notebook as a whole, so far as it relates to this particular subject, and we should have had the opportunity of looking over it.

HIS LORDSHIP : The stipulation seems almost to require that.

MR. SMART : The stipulation requires that if I am going to use the pages of the notebook I must allow my learned friend to inspect it. I have no copies except of the relative pages.

Mr. Henderson: The stipulations were mutually understood, and we desire to use the notebook. We will have to go on with what we have got; but it is very unfortunate that we could not have the information which from day to day we have been expecting to have. Have you the photostat copies of the Langmuir notebook, first notebook 413?—A. I have the two pages numbered 285 and 286, which I understand are photostat copies of those pages in the Langmuir notebook No. 413.

Mr. Henderson: *Will my learned friend let me have unmarked copies?*

Mr. Smart: We have not got the notebook, but I have copies here without marks.

His Lordship: On what ground are these relevant? I suppose I should direct these questions to you, Mr. Smart, rather than to Mr. Henderson.

Mr. Smart: I do not intend to use them. I did not see that they were relevant to the issues defined.

His Lordship: I want to understand the question of their being evidence or not.

Mr. Smart: My learned friend proposes to offer them.

Mr. Henderson: I am giving this, as well as all this evidence, my Lord, to show in an affirmative way how much these co-workers knew.

His Lordship: Why make use of Dr. Langmuir's statement?

Mr. Henderson: Because they were working together and were communicating back and forwards. We propose to show that at that time——

His Lordship: I do not see how that helps you; but, however, I am not objecting.

Mr. Henderson: This shows how far Dr. Langmuir had reached with the tube at this stage.

His Lordship: On the theory that a man must put into writing everything that he knows.

Mr. Henderson: No, my Lord.

His Lordship: If he had not written the letter at all?

Mr. Henderson: Then we would not have been in a position to show affirmatively, as we now can, how little he knew. It was all experimental at that stage, you see, and we are leading up to a later date when we show from this written record that for the first time then they said that the thing will work. Up to that time it was all experimental. They were working on it and conjecturing what might be; and they finally reach a stage at a later date when they think it works; and we are coming to that. May I proceed, my Lord?

His Lordship: Yes.

Mr Henderson: This will be exhibit "Z-9," pages 285 and 286 of the Langmuir notebook. I did not ask for the earlier pages which are here.

His Lordship: When did Alexanderson file his application in the United States?

MR. HENDERSON: October 29th. May I detach the earlier pages? Have you any objection to these?

MR. SMART: No.

EXHIBIT "Z-9":—Filed by Mr. Henderson, Jan. 17, 1927. Photostat of Langmuir notebook 431, pages 285 and 286.

Q. That begins as an explanation "use of two audions in series," and I think there is a diagram shown there is there not?—A. Yes, sir.

Q. What is that a diagram of?—A. Just below the heading which you quoted "use of two audions in series" there was the statement of the diagram as follows: "DeForest says nothing is to be gained this way. I should say that the sensitiveness would be greatly increased by following arrangement."

Q. And then comes the diagram?—A. Yes. I should explain that the word "series" in that place is equivalent to what we have been calling cascade. And the diagram shows one relay vacuum tube associated with a following detector vacuum tube; so that as far as that is concerned it would correspond to the arrangements of some of the figures in the Alexanderson patent.

Q. Is that a high frequency relay?—A. This is a high frequency relay, yes. However, this diagram shown here is not that of a selective system. It is a diagram not showing tuning and instead showing what is shown as a resistance coupling. I would understand from what I have read that this was a proposal or something which had not yet been tried. That refers to the date on which the note was made. This particular page is not dated; but at the beginning of the next entry, which is on page 286, there is a date of February 17, 1913, thus indicating that this arrangement had not been tried out up to that time. There is no reference in that connection to the Alexanderson arrangement.

Q. What follows after that?—A. What follows after that is a sketch of the structure of a different form of vacuum tube, which was referred to as "deflection detector." There is a very brief statement, which is "This morning I drew up a sketch of the first deflection detector, to operate in a manner described on pages 246 and 7." I have not had available those pages, so that I cannot comment on them. But it is a form of vacuum tube quite different in its structure from the audion, although it employs an incandescent cathode, and has control members, as has the audion.

Q. On those pages is there any reference to a proposal of Dr. Alexanderson?—A. No, not on either of the pages.

Q. Then will my friend let me have notebook 458?

MR. SMART: The same thing applies to that.

MR. HENDERSON: Have you photostat copies of Dr. Langmuir's notebook, No. 458, pages?

MR. SMART: What pages?

Q. It is pages 101, 102, 111, 112, and then 130, 131, 132, and 133. These are the ones covered.

HIS LORDSHIP: Were Alexanderson and Langmuir working together on this thing?

MR. HENDERSON: In this sense, my Lord, my learned friend will correct me if I am astray, and I am putting it in a very broadly layman sense. Alexanderson says, I have geometric selectivity of a type which can be used successfully if Dr. Langmuir can make a relay tube which will operate in a certain way. He communicated that idea to Dr. Langmuir, and Dr. Langmuir was working on the tube, and we are going to show your Lordship that on a day later on again, they say we have that, and the Alexanderson arrangement will now work.

MR. SMART: I do not agree with that statement.

MR. HENDERSON: I am not asking my learned friend to agree to it.

MR. SMART: But my learned friend asked me to correct him.

MR. HENDERSON: I asked my learned friend to follow me, that is all.

MR. SMART: I wish to say that our position is that Dr. Alexanderson disclosed his invention fully to Dr. Langmuir who understood it at a date which is given.

HIS LORDSHIP: I am interested in knowing what Mr. Henderson's view is, so that I can follow him, and I have no doubt you will disagree with him.

MR. HENDERSON: Let me put it in this way; or my friend puts it that Dr. Alexanderson disclosed to Dr. Langmuir something which would become operative if Dr. Langmuir could do something. Another way of putting the same thing.

MR. SMART: It would become operative with any of the then known tubes in the art apart from anything Dr. Langmuir would do.

MR. HENDERSON: That is a matter of argument.

Q. Starting at page 100 now of this notebook, the date is what?—A. It is dated May 9th, 1913.

Q. Will you read the reference to what happened on that morning?—A. The page begins under the head "Audions." As follows:—

> "This morning Alexanderson and Day came over and I showed them several audions that White has made up."

Q. Stop there. Do you know who Mr. Day was?—A. No, I do not think that I do.

Q. Do you know who Mr. White was?—A. Yes, White was an assistant of Dr. Langmuir's in the research laboratory of the General Electric Company.

Q. I do not think the personality of Mr. Day is of any moment to us, but I am quite content to take a statement from my friend as to it. Was he another General Electric man?

MR. SMART: Oh yes.

MR. HENDERSON: I presume so, but nothing turns on that.

Q. Then it shows that that morning Dr. Alexanderson had shown to Dr. Langmuir and Mr. Day some audions that Mr. White had made up. What does he go on to say?—A. He goes on to say:—

> "It was arranged that White and I should test them out with Alexanderson's alternator, to see if there is any sluggishness; i.e.,

whether they will give a frequency in the relayed current equal to that in the primary, and of *increased* energy."

The word " increased " is underscored. Then going on in a new paragraph he says :—

" I expect that up to a few million cycles we should have no trouble from sluggishness provided we have very high vacuum and anodes, free from gas."

" We will determine the greatest possible increase in energy which we can obtain in a relayed current, and this at various frequencies from 20,000 up to 100,000."

That is the complete page.

Q. Now page 101. Is it dated ?—A. Page 101 is dated at the top May 12th, 1913.

Q. That is three days later than the page previous to it.—A. Yes.

Q. And what do you find on that page ?—A. This is also headed by the word " Audions." And the first paragraph reads :—

" To-day White and I tested out one of his new audions with high frequency currents."

Then in parenthesis a word that I cannot make out, and then " 75,000 cycles."

Q. May I show that word to his Lordship ? What do you take that to mean, Mr. Smart ? We might interpret it as we go along. Perhaps you might ask some gentleman who knows.

MR. SMART : It is an abbreviation for circa.

MR. HENDERSON : " Circ." An abbreviation for the Latin " circa."

Q. What follows ?—A. Then follows another short paragraph :—

" The results were exactly as I had expected, and help to prove the correctness of my theories as to the action of these relays. The connections were as follows : "

And then there is a diagram of connections showing a testing arrangement of a single vacuum tube relay. It is not a tuned system for it was not used in that way.

Q. Is there anything else significant on page 101 ?—A. No, the rest of the page simply gives some explanation as to the elements in the diagram of connections.

Q. Then the next page is 111, is it not ?—A. I have before me page 102, but I do not think that adds anything important to 101 ; so that the next page that is available to me is page 111.

Q. Do you find any date on that page ?—A. There appears to have been no date originally on that page, but the photostat indicates what appears to be a pencil date on the original sheet of May 12th, 1913.

Q. And what is the first important statement ?—A. The first paragraph I think I need not read, because it does not seem to apply to this and I cannot make it all out anyhow on account of the poor photostat ; but the second paragraph is as follows :

" I asked White to rig up to-morrow morning another audion so as to relay his *potential* "—underscored—" from the generator through a very high resistance to a coil, and thence to our new wave detector or receiver."

I am not quite certain of that last word; it is not very clear, but I think it is "receiver."

"In this way we will show conclusively that the circuit from the plate of an audion has besides a D.C. component an A.C. component of the same frequency as the wave that stimulates the grid and of greater energy."

Q. What does D.C. mean?—A. D.C. is the standard abbreviation for "Direct Current."

Q. And A.C.?—A. And A.C. for "Alternating Current."

Q. What does that quotation indicate?—A. That quotation indicated that it had not yet been determined experimentally whether the vacuum tube would operate in this way as a high frequency relay; and that Mr. White was being instructed to make an experiment and to determine this.

Q. And what is the next reference on that page?—A. The next reference at the bottom of that page is merely a specific one that I do not think has any general bearing. And that is continued in the first two lines of the next page 112.

Q. Is there anything important on that?—A. Page 112 shows the diagram of connections to be employed, and this is the first diagram that I find in the notes available to me, showing a vacuum tube relay with a tuned input circuit and a tuned output circuit.

Q. For the first time?—A. Yes, this is the first one that I find.

Q. And what significance do you attach to that diagram? Is it dated?—A. Page 112 is not dated. The following page which I have available is 130.

Q. We will not go to that yet. What significance do you attach to that diagram on page 112?—A. The diagram is the one that White was instructed to employ in his tests as I understand it. And these were to be the first tests to determine whether the audion type of vacuum tube could be used as a high frequency relay.

Q. Do you find a condenser "L" in that diagram?—A. Yes, there is such a condenser connected in parallel with the primary inductance of the output transformer. That is a connection such as I was explaining to your Lordship this morning in connection with Exhibit 8.

Q. That is page 112, my Lord, the diagram shown has the condenser "L" in it. There will be some significance as to that appearing a little later.

Will you repeat what you said there? That that is such a condenser as you showed his Lordship this morning? Where in Exhibit 8?—A. I was at that time describing that the condenser 15 in parallel with the secondary inductance might be transferred to the primary inductance which is directly in series with the plate circuit. In this sketch both condensers are shown.

Q. Now will you pass to page 130. What is the date of that page?—A. Page 130 is dated at the top May 18th, 1913.

Q. And what do you find stated on it?—A. Beginning at the bottom of the page, under the head "Relays" I find:—

> " Day before yesterday and yesterday White and I made tests with improved audions to determine if the system of two audions in series, each with its resonance system (i.e., Alexanderson's tuning in geometrical progression), would actually work as predicted. We obtained the most striking results."

It then goes on to describe some of these results.

> " We varied the frequency of the A.C. current from 20,000 to 100,000, and measured how far apart the coils C and D page 112, must be placed in order to obtain a constant deflection of the detecting instrument ' K '."

Q. That refers back to the diagram on page 112 ?—A. Yes, that is the diagram I have just described, and the two coils referred to are coils which can be moved for the purpose of adjusting the input. In other words, it will be equivalent in a broadcasting system to changing the strength of the received signals.

Q. Read on then.—A. The next sentence states :—

> " The system used was exactly as shown diagrammatically on page 112, except that the condenser ' L ' was omitted."

That is the point just raised. I do not attach any weight to the inclusion or omission of that condenser. It would not change, as I understand it, the functioning of the system in any essential way. There follows at the bottom of the page an introductory statement :—

> " This experiment shows experimentally the following points "

and there are three listed.

Q. You are passing now to page 131, are you not ?—A. Beginning at the bottom of page 130 and going on in page 131 :—the first point Number 1 is :—

> " A hot cathode relay like that we have made responds perfectly to frequencies as high as 105,000 cycles. No sluggishness noticeable. Verifies theoretically predictions, see page "—blank. The page number

has not been filled in.

> " And makes it probable that we can work up to very much higher frequencies, probably quite easily up to 10 million cycles."

I think that the next point, which is written out at some length on pages 131 and 132, is not particularly pertinent ; but the third point on page 132, under the number three, is striking :—

> " Tuning by geometrical progression, according to Alexanderson's scheme, is an accomplished fact."

There then follows some detailed consideration of resonance curves.

Mr. Smart : You might read the next sentence there for the sake of the record.

Mr. Henderson : Read the next sentence. Mr. Smart asked that it be read.—A. The next sentence is :—

> " All this means that we can secure any desired degree of immunity from disturbance by using several audions—(resonant circuits) in series ; by using sufficient damping in each circuit it will be possible to obtain a broad enough range of sensitiveness thus."

And there follows the resonance curves to which I have referred.

Q. Now prior to that note of May 18th, 1913, do you find anywhere a reference to the actual use experimental or otherwise, of a tuned vacuum tube relay circuit ?—A. No, I do not.

Q. Is there anything in all this to indicate that they tried more than one high frequency relay ?—A. No there is not. The circuits to which I have been referring had only a single high frequency relay, and there is no reference to the actual use of more than one.

Mr. Smart: The sentence just read says several relays; audions in series.

Mr. Henderson: In theory they might be used. You do not quarrel with that ?—A. As I read it, I understood that to be a proposal but not anything that had been done practically.

Q. Now will my friend produce the White notes and report of 24th May, 1913 ? May I just for the moment check to see if I have the same. This will be Z11. They go together, the report and data sheet.

EXHIBIT Z11:—Filed by Mr. Henderson, 17 Jan., 1927. White report and data sheet of May 24, 1913.

Q. What is the purpose of that report as expressed in the opening paragraph ?—A. This report of Mr. White dated May 24th, 1913, has the following opening paragraph :—

> "The two main objects in making these tests were, first, to determine if the improved audions would relay high frequency currents satisfactorily. And second, to get a working demonstration of geometrical tuning for wireless telegraphy as proposed by Mr. Alexanderson."

Q. And you have certain connectional diagrams ?—A. Yes, a diagram of connections carefully drawn appears with this report, and correspondence both, and a rough sketch diagram, dated May 17th, 1913, in the White notebook, and also corresponds in its general features with the sketch on page 112 of the Langmuir notebook, which I have just been referring to. The condenser "L" is omitted, according to the instructions of Dr. Langmuir to Mr. White, which I have read.

Q. So that that is confirmatory of what you have said concerning Dr. Langmuir ?—A. Yes. And it not only confirms that as to facts but also confirms as to dates, for the notebook shows that these tests were made with the tuned input and output arrangement on May 17th, 1913, which corresponds to Langmuir's reference on May 18th, to "yesterday."

His Lordship: Mr. Henderson, perhaps you have already told me, but what patents are used in seeking to show the antedating of Alexanderson ?

Mr. Henderson: I am dealing now more specifically with Schloemilch and Von Bronk.

His Lordship: That was February, 1914 ?

Mr. Henderson: 1913. Schloemilch and Von Bronk were filed in Germany on the 9th February 1913, and as I have indicated to your Lordship, my friend differs from me.

His Lordship: Is that in the United States ?

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 14. Louis Alan Hazeltine (recalled). Examination —*continued.*

MR. HENDERSON: No, the Schloemilch and Von Bronk German patent. Their United States patent was March 13th, 1913.

HIS LORDSHIP: That is the date of application?

MR. HENDERSON: Yes my Lord. And the date of their patent issue in the United States.

HIS LORDSHIP: February, 1913.

MR. HENDERSON: We have put in the German patent, my Lord. The Schloemilch and Von Bronk. It was not issued until 1919. Of course everything over there was held up by the war, but we have their evidence as to what they did.

HIS LORDSHIP: What is the number of that Exhibit, the German?

MR. HENDERSON: 293,300. The 9th February, 1913. "Ausgegeken" 23rd June, 1919.

HIS LORDSHIP: The German patent 293,300?

MR. HENDERSON: Yes my Lord.

HIS LORDSHIP: It is in the name of the Telefunken Company?

MR. HENDERSON: It is in the name of the "Gesellschaft fur Drahtlose." That is the technical name of what they call the Telefunken Company. Then the French patent.

HIS LORDSHIP: I have got that.

MR. HENDERSON: Then that is all I have to ask the witness at the moment, unless your Lordship wants something further?

HIS LORDSHIP: No.

CROSS-EXAMINED BY MR. SMART:

Cross-examination.

Q. Professor Hazeltine, I understood you to state to his Lordship this morning that a resonant circuit might include only an inductance or only a capacity. Is that correct?—A. I do not think I stated it to be limited. Inductance and capacity are the essential elements of a resonant circuit; but all practical circuits naturally have also resistance.

Q. The point I was at was, Must not a resonant circuit include both inductance and capacity?—A. A circuit which is made resonant by electrical means must include both inductance and capacity.

Q. Perhaps you will sketch a typical resonant circuit for me?

MR. HENDERSON: One moment, if I may interrupt.

My learned friend has a technical right to examine the witness on anything now, although he did not cross-examine him before, but I would have the right to re-examine as to any of the old matters my learned friend goes into?

HIS LORDSHIP: Yes, I suppose so.

MR. SMART: I am confining myself to this morning's examination. —A. I have made two diagrams, one marked "A" series tuning and one marked "B" parallel tuning, but I have shown in each case inductance and capacity, and I have also represented resistance in series with the inductances. That resistance is usually not a separate piece of apparatus, but is inherent in the inductance. It is not always drawn in making a diagram of connections, but is most commonly understood, except when it is a separate piece of apparatus.

HIS LORDSHIP: How do you separate?—A. Your Lordship will remember that I showed you two forms of resistance; one was the filament resistance, for controlling the temperature of the filament and another was the grid leak. They are simple resistances.

Q. I observe in the sketch " A " the circuit is not completed?—A. No. In both sketches I show merely the resonant part of the circuit. I have not shown any source of power in either case.

Q. Will you, in place of that sketch, make me a sketch which shows what I ask for, which was a complete and typical resonant circuit? As far as you have drawn——

MR. HENDERSON: Let him finish.

MR. SMART: He is not answering my question.

MR. HENDERSON: You cannot tell till he is finished.

MR. SMART: I see what he is drawing.

HIS LORDSHIP: Better let him finish.

MR. SMART: He is not drawing what I asked for. If he is not answering my question I feel free to interrupt him.

HIS LORDSHIP: You cannot anticipate what he is going to do.

MR. SMART: Well, he has drawn it.

MR. HENDERSON: You might not understand his style.—A. I have drawn what I understood was asked for in the question and that is a resonant circuit with series tuning which is so marked, and a resonant circuit with parallel tuning which is so marked, and I have made that circuit complete in each case, and including a source of power.

MR SMART: Keep on drawing, Professor, and draw it in its simplest form.

MR HENDERSON: We will get confused if we do not mark these sketches he is drawing.

MR. SMART: Draw for me in its simplest form a resonant circuit.

MR. HENDERSON: Should this not be marked for identification?

HIS LORDSHIP: They are drawn for Mr Smart and unless he or you asks that the sketches be put in I do not think they need go in. Let him finish his work first —A. I have drawn two complete circuits in their simplest form, in which the source of power is simply indicated by a circle marked " AC source " in both cases.

MR. SMART: Q. I still want you to keep on drawing. I want a resonant circuit without a source of power—the simplest form of a resonant circuit. —A. That I did in my first sketch.

Q. The simplest form of a resonant circuit?—A. I am still unable to improve on my first sketch for that.

Q. That shows two; one is not a circuit, but one shows in series a condenser and an inductance. I asked for a resonant circuit.—A. Well, my last sketch shows that.

Q. Without any power input?—A. Without any power input there is no distinction between the series and parallel.

Q. I am asking you for a circuit such as one sees frequently in text-books as a typical resonant circuit without reference to how the power input is applied to the resonant circuit.—A. I can sketch that, but I cannot distinguish between the series and parallel circuit.

Q. Will you sketch that which I last asked for?—A. I have in this case not put in any element of the resistance as not being essential.

Q. And that is what may be termed typical resonant circuit without reference to the power input?—A. I do not understand what it would be typical of. That is the simplest resonant circuit, but I do not regard it as typical of anything.

Q. In that circuit as you have drawn it in this last sketch, would you regard the condenser inductance in series, or is it in parallel?—A. I have already stated that when there are no other elements in the circuit there is no distinction between series and parallel.

Q. Then if I understand your last answer correctly, the three sketches on the piece of paper I now hand you would be all the same if there were no power input?—A. Oh, yes; they differ merely in draughtsmanship.

EXHIBIT NO. 13:—Filed by Mr. Smart, Jan. 17, 1917. Sketches submitted to the witness.

Q. The radio art has developed considerably since 1913?—A. Yes.

Q. And the view we now have looking backward is quite different from the view one would have looking forward in 1913?—A. Yes.

Q. Have you in dealing with the matter this morning intended to convey the impression that a mechanical relay would function at a high frequency?—A. I do not think I made any reference to mechanical relays this morning.

Q. Would mechanical relays as a fact operate at a high frequency of say a million cycles per second?—A. I believe they would operate at a high frequency, but I doubt if they would operate at as high a frequency as a million cycles per second.

Q. What do you mean by mechanical relay?—A. I presume Mr. Smart meant—and I so understood—a relay such as the one used by Schloemilch and Leib; that is, one having an electro-magnet controlling a granular carbon system with various resistance. I was thinking of that in my answer, and I understood that was what was in Mr. Smart's mind.

Q. Do you remember at one time referring to the relays which are used in your mechanical receivers which are used in telephone circuits and stating that they would not function at a high frequency?—A. I do not remember that statement. If you will refer me to it——

Q. I have this statement which I am advised was made by you.

MR. HENDERSON: From what record?

MR. SMART: I will ask him if the statement is correct. You were asked——

MR. HENDERSON: Is that the Twentieth Century case?

MR. SMART: I am putting it as a new question, "If one imposes on a mechanical relay the high frequency which is presently used in broad-

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 14. Louis Alan Hazeltine (recalled). Cross-examination —*continued.*

casting, would a mechanical relay function?"—A. The frequencies involved in broadcasting are from one-half million cycles per second to one and a half million cycles per second. I do not know of any mechanical relay that would function at such a very high frequency as that.

Q. At the beginning of 1913 was there known any vacuum tube relay which would function at those broadcasting frequencies to which you have referred?—A. I do not think that there was such a vacuum tube relay generally known that would function at that high frequency; that is, after Von Bronk's German patent covering such a vacuum relay——

Q. I am not referring to patents. I am referring to physical devices which were obtainable by one skilled in the art. At the beginning of 1913 was there obtainable by one skilled in the art a vacuum tube relay which would operate at modern broadcasting frequency?—A. I believe that at that date some of the DeForest audions would so operate but that all of them would not so operate.

HIS LORDSHIP: Would that be true of May, 1913? Would your answer apply to 1913?—A. There was a rather rapid development around that time. That was the period of time I have been discussing, when Langmuir was doing his developing. Also Mr. E. H. Armstrong was doing an independent development around that time, and the conditions might easily have been different in the latter part of the year from the early part of the year. I am not sure at the moment just how much was known at that time of the work of these two investigators.

MR. SMART: The DeForest audion—that is the three electrode vacuum tube—was obtainable in 1912?—A. Yes, but the improved form of audion was coming out during 1913. That is, they were being developed. Major Armstrong had made up his own audions, and he used a high degree of vacuum, just as Langmuir did.

Q. I understood your previous evidence, that some of the tubes made by DeForest containing three electrodes and available in 1912, would operate to relay frequencies within the range of the modern broadcasting.

HIS LORDSHIP: That would be belief?—A. It is my belief they would so operate if anyone had attempted to so operate them, and if one were fortunate in getting the right individual audions.

MR. SMART: And were there any other three-electrode vacuum tubes to your knowledge available at that time?—A. There were vacuum tubes of the X-ray type used for quite different purposes, and some of them may have had three electrodes. I am not very sure about that. They were not designed for radio or generally known. Then there was the Von Lieben tube which had been developed in Germany which I have discussed generally.

Q. Taking the Von Leiben tube, is it your opinion that it was available in 1912?—A. As far as I know there was none available on this continent.

Q. Anywhere in the world?—A. I understood there was at that time.

Q. Is it your opinion that the Von Leiben vacuum tube was then capable—that is in 1912—of relaying high frequency current?—A. I am not at all sure about that.

HIS LORDSHIP: Why do you limit that question to 1912?

MR. SMART: Just to get the date.

HIS LORDSHIP: Why not say 1913? I do not know what you have in mind, but I am afraid that in the end you may be fighting about twenty-four hours or a day or a week.

MR. SMART: I used it as a convenient date.

Q. When was the Von Leiben tube used?—A. As I remember it, the first patent was the patent of Von Leiben, Reisz & Strauss. I think that was in 1912.

HIS LORDSHIP: Why do you not come down to October, 1913?

MR. SMART: The invention was a little bit earlier.

HIS LORDSHIP: You are going to argue that, and it may be true, but it is assuming a good deal.

MR. SMART: In what way?

HIS LORDSHIP: Do not ask me to accept very hazy and indefinite evidence about conception. I want facts about inventions—not conceptions. Conception is not invention.

MR. SMART: We propose to deal with disclosure as a perfectly definite thing. I do not propose to trouble your Lordship with what was in the inventor's mind but what he disclosed to others is on a different basis.

Q. Is it your opinion generally speaking that the Von Leiben relay would not operate at high frequency?—A. My only knowledge on that point is in connection with the testimony of Schloemilch and Von Bronk which is in evidence, and I have not a very clear recollection of exactly what they said they had done with it.

Q. I am asking for your opinion as to whether the Von Leiben relay was capable of acting as a repeater of high frequency current.—A. I have no direct information.

Q. You cannot give me an opinion as to whether it would operate with high frequency current?—A. Not from my knowledge.

HIS LORDSHIP: Would the Alexanderson tube relay, the first that you knew of which came under your own experience, operate at high frequency for tuned circuit?—A. I do not regard Alexanderson as having been in any way responsible for the development of the relay. I understand that particular development, so far as Alexanderson was associated with it at all, was made by Dr. Langmuir.

MR. HENDERSON: It is covered by the Langmuir patent.

HIS LORDSHIP: They were about the same time anyway.

MR. HENDERSON: They applied about the same time.

HIS LORDSHIP: Q. You say Langmuir was the first?—A. As far as anything that I have seen, or any evidence that I have observed, Dr. Alexanderson had nothing to do with the development of the relay. The development connected with was conducted entirely by Dr. Langmuir.

MR. SMART: Q. There were, of course, disclosures in the United States DeForest patent, a variety of forms of relays, which would relay at high frequency.—A. I do not remember any such disclosures in the DeForest patent.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 14. Louis Alan Hazeltine (recalled). Cross-examination —*continued.*

Mr. Henderson : Q. You knew the DeForest audion ?—A. Oh, yes. I think that his Lordship has one in front of him.

Q. Is that the DeForest audion ?—A. I have not examined it closely, but looking at it from a distance it looks like the DeForest audion with hich I used to work at one time.

Q. Here it is. Take a look at it.—A. This is exactly the same as the audion I used to work with, as the DeForest audion, including some of the marks on it.

Q. Beginning when ?—A. 1915. My personal work on the DeForest audion was not before that date.

Q. You knew of it before ?—A. I knew of it about 1914.

Q. And you knew the termination of which the DeForest was a development ?—A. Yes, I knew of the two-electrode type of tube known as the Fleming valve, a paper DeForest presented as I remember, in 1906, and the word " audion " I believe was introduced into the paper, and I read that carefully at the time it came out.

Mr. Henderson : That is the defence.

(*This witness was recalled, see page* 372.)

No. 15.

Discussion.

No. 15. Discussion, 17th Jan., 1927.

Mr. Henderson : Before we close might I ask my learned friend as to the position with reference to the notebook from Wilmington, Delaware. Is it available ? We feel somewhat strongly that it should be here, and we might procure it by communicating with our correspondent in Wilmington. It might be procured, or a photograph of it, for the argument. I assume those note books are under my learned friend's control.

Mr. Smart : No, the notebook is not under the plaintiff's control in any way.

Mr. Henderson : In whose possession or control is it ?

Mr. Smart : I do not know.

Mr. Henderson : Is that the position my learned friend takes ?

Mr. Smart : Yes.

Mr. Henderson : Really ?

Mr. Smart : Yes. It is not the plaintiff's notebook in any sense.

Mr. Henderson : It is Dr. Langmuir's notebook.

Mr. Smart : This is something my learned friend is offering. I facilitated him to get what he wanted out of it.

Mr. Henderson : If I can produce a photostat copy before the case is over, may I put it in, my Lord ?

His Lordship : The whole book ? What all is in it ?

Mr. Henderson : I do not know. In good faith we tried to cover this sort of thing by stipulation and it is very unfortunate that we should be met with this situation.

In the Exchequer Court of Canada.

Defendant's Evidence.

No. 15. Discussion, 17th Jan., 1927 *—continued.*

MR. SMART: I object to any suggestion with regard to stipulation. The stipulation was given by my learned friend that if I wanted to use some of the pages of that note book that I would give some indication of the pages of the note book to my learned friend before using it. I do not propose to use it.

MR. HENDERSON: The note book could only be used with the writer in the box, and therefore we assume that the writer is going to be in the box and that we are going to have access to the note book.

HIS LORDSHIP: I do not think I can do anything to assist you. I think perhaps you have all you want.

MR. HENDERSON: I think that is more than likely, my Lord. This is the kind of case where we feel we should not leave any stone unturned. If the Alexanderson patent is to be upheld in the way my learned friend seeks to have it upheld, it seems the Radio Corporation of America or the General Electric Company are the only ones who can put radio sets on the market of any kind.

MR. SMART: My learned friend should not make a statement of that kind. Let us reserve this for the argument.

MR. HENDERSON: I want your Lordship to see the importance of it. Prof. Waterman has said that Alexanderson is found in practically every receiver on the market to-day. The arrangement that he calls Alexanderson is the only one found on the market, according to his testimony. We say that arrangement is open to the world. We say that what we are calling Alexanderson as a matter of convenience is not an invention. Our success here means that they can go on and do business just the same as anybody else, and their success means that they are going to get the radio trade; in view of that is it to be wondered at that we should seek to give your Lordship all the information available? It is certainly the most important case I have ever been connected with.

MR. SMART: We are here, if I may say so, suing a particular defendant who uses the particular circuit which we say is the circuit described in and covered by the Alexanderson patent. The decision of your Lordship could go no further than that that circuit as brought before your Lordship is an infringement of the Alexanderson patent which is valid to cover that circuit.

HIS LORDSHIP: That is the sole issue.

MR. HENDERSON: That is as to this particular defendant, but it would practically affect any one using the circuit, and Waterman says that is everybody.

HIS LORDSHIP: That is the issue.

MR. SMART: My learned friend also says that the Marconi patent and Marconi circuit are as good if not better than the Alexanderson so that obviously his statement that it would blanket the whole trade would not be correct.

HIS LORDSHIP: I suppose this is just one radio corporation fighting another.

MR. SMART: Yes, and we are prepared to license the defendant.

No. 16.

Evidence of Irving Langmuir.

DR. IRVING LANGMUIR, Sworn. Examined by MR. SMART:

Q. Please state your residence and occupation ?—A. Schenectady, New York ; Assistant Director of the Research Laboratory of the General Electric Company.

Q. And state in a general way your technical experience and qualifications.—A. I have been connected with the General Electric Company since the summer of 1909, working on problems connected with incandescent lamps, beginning with that year, particularly with the phenomena of high vacuum. Beginning about the summer of 1912 I made studies of electric current in high vacuum, particularly the current of the electrons emitted by hot filaments, and in 1913 and for several years thereafter I was engaged in the making of devices employed for radio telegraphy and telephony.

Q. And you are a member of several societies and organizations ?

HIS LORDSHIP : I am satisfied as to that.

MR. HENDERSON : I am not quarrelling as to that. I stated the other day he was competent and I do not desire to restate it.

MR. SMART : Under what circumstances did you come in contact with the audion or the electrode vacuum tubes ?—A. I first became acquainted with the audion in January, 1913, through various conversations that I had with Mr. Alexanderson. Mr. Hawkins, who was the engineer of the Research Laboratory, who knew of the work that I had been doing with electrical discharges in high vacuum said that he thought some of my work would be closely related to some that Mr. Alexanderson was doing, and Mr. Hawkins arranged that I should meet Mr. Alexanderson and talk these problems over with him, and we did on several occasions in 1913.

Q. What did Dr. Alexanderson disclose to you in January, 1913, with respect to the use of the audion ?—A. Mr. Alexanderson told me of his ideas in regard to tuning in geometric progression, using relays between the successive tuned circuits. He said that the carrying out of this plan that he had would involve relays that would operate at radio frequencies, and that furthermore these relays would need to operate in one direction only, so that the signal could be carried from, say, the first tuned circuit to the second, or that the second would not react appreciably back on the first. That is he wanted a one-way relay.

Dr. Alexanderson then told me of the DeForest audion that he had become familiar with in the laboratory of John Hayes Hammond, Junior, and he told me that according to Hammond the audion was sluggish in its action, and that it probably could not be used successfully for high frequency relaying. He then described to me the construction of the audion and the way in which it was used in radio circuits. And it happened that from some work that I had been doing for a few months preceding that time, I had been thinking along the lines which led me to understand particularly well the operation of a device of this kind. And I knew therefore that I could construct an audion or a three-electrode tube having a hot filament and a grid and a plate, which would operate with a very high vacuum. And I knew also that if I did construct such a tube it would not be sluggish in its action but would respond perfectly well to radio frequency signals, and would constitute an effective relay in the circuit in which Mr. Alexanderson wanted to use it.

Q. Did Dr. Alexanderson disclose to you the circuit in which he proposed to use the audion at that time ?—A. Yes, he gave me a very clear understanding of the circuits and the principles that he had in mind to carry out his plan of tuning in geometrical progression. He explained to me how the energy in one tuned circuit could be passed on to the next circuit in such a way as to build up the signal and increase the intensity of the oscillations in the second circuit, we will say, from the oscillations in the first; and that by the use of several tuned circuits in this way he would gain a very high degree of selectivity, and at the same time have the advantage of broad tuning; that is he would have a circuit by which you could detect radio signals within a certain range of frequencies, and amplify any signal within that range to a very marked degree, and yet not magnify greatly signals that were outside of that range. And he showed me what marked advantages such a system would have over the use of a simple tuned circuit, which would be made very selective by having, say, a very low resistance.

Q. It has already been stipulated in evidence that a copy of the exhibit Z-3, which is the Alexanderson letter of February 4th, 1913, was sent to you. And I would ask you to state whether or not, as one skilled in the art, at that time, the letter formed a disclosure to you of the subject matter of the Alexanderson patent later in suit in this action.

Mr. Henderson: Would it not be better if my friend asked the witness what as one skilled in the art he took the letter to disclose ?

Mr. Smart: Yes. I will put it in that way. Answer the question in the sense suggested by my learned friend.—A. This letter covers practically the same ground as the conversations that I had had with Mr. Alexanderson during the preceding weeks. It gives a very clear summary of Mr. Alexanderson's ideas, and describes the principles involved in the idea of tuning in geometrical progression, so clearly that it would have been sufficient even if I had not had any previous conversation with Mr. Alexanderson, to have enabled me to build the device and obtain the advantages of geometrical tuning which Mr. Alexanderson foresaw.

Not only is the theory of the operation of this system described in this letter, but the means of accomplishing it by use of the audion is clearly described.

Q. Would you have required a diagram to understand the subject matter of that letter ?—A. No, I think it is much clearer than if a diagram had been used. Because a diagram illustrates merely a particular method of carrying out an idea, whereas the letter describes the fundamental principles involved, is much more broad or fundamental than it would have been made by the use of a diagram.

Q. Apart from the question of principle, did the letter disclose the idea of means of devices for carrying out the principle.

Mr. Henderson : That is rather leading.—A. The use of several tuned circuits in cascade is clearly described in this letter, with the audion as a high frequency relay, as a coupling between these tuned circuits. It seems to me that, this description is ample to enable anyone to make the electrical connections and to obtain the advantages of the circuit as described.

Mr. Smart : Q. Reference is made there to an incandescent rectifier. Perhaps you will state how that term was understood at that time, that is in 1913.—A. The actual method of operation of the audion was not generally understood in 1913 ; and as a result, the use of words in describing the operation of such a device were what we would now call rather loose. It was quite common to refer to the audion as a rectifier, and an incandescent rectifier. It is true that the audion is a rectifier, but we do not ordinarily to-day speak of it as a rectifier, because that is not its most important function.

Q. But is it one of its functions to-day ?—A. It does rectify. That is, it allows current to pass in only one direction in the plate circuit. But since it is usually used on direct current, that is not an important function.

His Lordship : That is, it can be made to permit current to pass in one direction only ?—A. Current does pass in one direction only through it for two reasons. First, because a direct current is applied to the plate circuit ; second, because it would allow the current to flow in one direction only, even if an alternating current were applied. That is, current can only flow in one direction from a hot cathode. It is ordinarily used with batteries, which make the plate positive ; so that there is no tendency to make the current flow in the other direction.

Q. That is, it proceeds directly through the plate circuit ?—A. Yes. So that is the direct action of the audion in the plate circuit, at least that of any particular importance ; nevertheless, if the tube had been used with alternating current on the plate, it would still operate and operate in that case as a rectifier in addition to whatever other action it might have as an amplifier ; but the fact is that it was frequently spoken of as incandescent rectifier in those days. Whether it was a justified use of that term or not, it seems to me is not the point.

Mr. Smart : Q. Perhaps his Lordship had direct reference to the question which was discussed earlier in the trial, as to whether an audion of this type is a one-way repeater or a one-way coupling, if you like, for the purpose of coupling circuits, as used in the Alexanderson arrangement. Perhaps you will state as to that.—A. The audion is a remarkably efficient one-way relay. When used with low frequencies it is a practically perfect one-way relay. As the frequencies become higher there is a little back action from the plate circuit into the grid circuit, because of the electrostatic influence of the plate on the grid ; but this action is a relatively insignificant one at frequencies for which we were thinking of using the tube in 1913. And even at high frequencies the device is primarily, you might say, a one-way device. And even if there is a secondary coupling between the plate and the grid circuit, that is, I think, in every case to be looked upon as a sort of secondary effect, which sometimes may be important and in many cases is not important.

In the Exchequer Court of Canada.

Plaintiff's Evidence in Reply.

No. 16. Irving Langmuir. Examination —*continued.*

Q. Would the DeForest audion act as a relay of high frequency currents?—A. Yes, the audion at low voltages, low plate voltages, will operate as a radio frequency amplifier.

Q. After this disclosure of February 4th, 1913, to which you have referred, was any use made by the General Electric Company of the circuits described and the arrangement of Alexanderson described in that letter? —A. Yes. In the middle of January, in my conversations with Mr. Alexanderson, after he described to me the operation of the audion, he said that he would be able to get for me an audion from Mr. John Hays Hammond, Junior.

I was very much interested in getting this, because I wanted to see if it worked in the way that I thought it did; and I wished particularly to improve upon it by using a very high vacuum. Mr. Alexanderson had told me that the audion in operation showed effects of the presence of gas. It showed, for example, a blue glow under certain conditions, which proved the presence of gas, and that it operated only at low voltages and low currents. I knew that I would be able to overcome these difficulties and to use high voltages and high currents, and thereby control hundreds of thousands of times more power than could be used in an audion. This audion arrived about the same time as this letter of February 4th, and I immediately started making measurements on it, and then arranged to have an assistant of mine—or, arranged to have a man, Mr. W. C. White, start in as my assistant—in order to develop three electrode tubes, primarily for the purpose of using them for the geometrical tuning system that Mr. Alexanderson had proposed. That is it was through Mr. Alexanderson that I first decided to work on the three electrode tubes, and the first use we wished to make of such tubes was to build a radio system in which we had tuning in geometrical progression. So Mr. White undertook to build such tubes and had several of them ready early in May, 1913. We then used these tubes to first of all amplify radio frequency signals. That was done about the 9th May. And then a week or so after that we put two of these tubes in series, joining the input circuit to the grid of the first tube, and the signal frequency, and tuning the plate circuit to the same frequency, and making re-arrangements of the sensitiveness, first of all with each of the tuned circuits separately, and then with the two circuits used in combination. And we found that we got the complete advantage of the tuning in geometrical progression which had been predicted by Mr. Alexanderson. The results were that not only did we get a very high degree of selectivity, but the results were entirely in accord with Mr. Alexanderson's predictions. That was about the middle of May, 1913.

We then arranged to get the use of an antenna for radio receiving; because I felt that the use of this circuit together with the vacuum tubes which we had made, and with which we were now able to control very much more power than the DeForest audion, should put us far in advance of others in receiving radio signals. I therefore established another laboratory about two or three miles away from the research laboratory of the General Electric Company, where we would be relatively free from the electrical disturbances that are connected with an electrical manufacturing plant, and where we could test out this circuit and others for radio receiving.

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Plaintiff's Evidence in Reply.

No. 16. Irving Langmuir. Examination —*continued.*

Along at the latter part of 1913, I think it was December, we had this laboratory working at the house of Mr. Kinney.

Mr. Henderson: When was that, doctor?—A. I think it was in December. It was during the whole fall of 1913, but we first had the laboratory I would say in good working order, I think about December, 1913. About January, 1914, we had developed a very satisfactory receiving set, in which we used the Alexanderson system of tuning in geometrical progression, with the improved audions as connecting links. We had tuned antenna and we had a loosely coupled grid circuit, which was tuned, and the first tube for radio frequency amplification. And then, rather loosely coupled, to the plate circuit of that first tube, we had the grid circuit of the second tube, which was also tuned to the radio frequency. And that second tube was a radio frequency amplifier. And then we had a third tube, which was a detector, and the grid circuit of that tube was also tuned for the radio frequency, so that we had three radio frequency tuned circuits in cascade with two radio frequency amplifiers between them. The third tube was the detector. Now those signals that we received at that time —the ones that we were most interested in,—were continuous wave signals as distinguished from sparks. Those continuous wave signals could only be rendered audible in the telephone connected with the detector circuit, by using an auxiliary oscillating circuit to produce a beat note. For this apparatus we use a fourth tube entirely disconnected from the other three, as an oscillator; and we had a coil in that oscillating circuit which we frequently put three or four feet away from the circuits of the other three tubes, but even at that distance the oscillations from this oscillating tube interacted with those of the incoming signal to produce the beats, and thereby rendered the dots and dashes of the signal audible. The results that we obtained seemed to me very striking at that time, for we found that we could hear signals from San Francisco with the utmost ease, and much to our surprise we heard, pretty nearly every evening, signals from Honolulu, which were being transmitted to San Francisco, about six or seven thousand metre wave length; and we frequently picked up the signals from Honolulu which could not be heard at San Francisco, that is, we heard San Francisco calling to have messages from Honolulu repeated, because they had not been able to get them, when we had been able to get every word of them, although we were 3000 miles further away.

Mr. Smart: To what did you attribute that result?—A. To the excellence of our receiving system, which had been rendered possible only by the use of the Alexanderson system of tuning in the geometrical progression.

Q. A few moments ago when you spoke of the amplifying high frequencies with the audion when used with low plate voltages, were you referring to the audion before it was improved by you?—A. Yes.

Q. You heard Professor Hazeltine's evidence this morning?—A. Yes.

Q. I would like you to comment on the distinction that he drew between the series and parallel relation of the capacity in tuned circuits. —A. In a simple tuned circuit, current flows or oscillates back and forth between a condenser and an inductance. Those are the two essential elements of the tuned circuit. We cannot have a tuned circuit with a capacity alone, and inductance alone. It is only when we have inductance and capacity that we can have a tuned circuit.

His Lordship: You need not take that very seriously, because I think Mr. Hazeltine did not say that himself. I am pretty sure I read it in a textbook of some importance. I do not think that it is probably an article of Dr. Langmuir's but I will have a look at it again to-night. But Mr. Hazeltine did not say that himself. You must have capacity and inductance ?—A. Yes.

Q. And the current oscillates between each ?—A. Yes. That is the energy flows back and forth between the inductance and the capacity.

Q. And you must have these in order to have a tuned circuit ?—A. Yes. Now in that simple tuned circuit, as Mr. Hazeltine said this afternoon, there is no distinction at all between the parallel and series connections. We can only talk about a parallel and series connection when we have another circuit. That is the parallel and series connection can only be with refeience to something outside that tuned circuit. For example, if we have an input circuit, or if we have a current flowing through a wire, and that current flows through an inductance, and then comes to a capacity, those are in series with respect to that outside circuit, because the current from the outside circuit flows first through the inductance and then through the condenser. That is an alternating current. Direct current of course cannot flow through such a circuit.

His Lordship: Repeat that last remark about the alternating current, please ?—A. A direct current cannot flow through a condenser. Only an alternating current can flow through a condenser. A condenser consists of parallel plates that are insulated from one another; so direct current cannot flow through; but alternating current can flow through because it charges up the plates and then they can discharge again. So you can have a current flowing into a condenser notwithstanding the fact that the two plates of the condenser are insulated from one another. You simply pass the current in and store up the energy and then it discharges again, like the old experiment of the Leyden jar.

Q. That is its function, to take electrical stress at times and then discharge it.—A. Yes. But you cannot pass direct current—which tends to go continuously in one direction, through a condenser. Now if we consider a circuit in which current flows and at a certain point in that circuit we let the wire divide into parts and let one part of that current go to a condenser and the other part go to an inductance, and then let those two wires join again, we have two pairs side by side. That is what we mean by parallel connection.

But I would like to point out the conception of parallel only means with reference to external circuit, or the circuit that comes in from outside this circuit and then divides and goes through the two parts. We have those two parts alone, inductance and capacity. It has no meaning to talk about parallel waves. Now when we come to a tuned circuit which is involved with another tuned circuit, so that electrical energy from the first circuit is delivered to the second circuit, it does not make any difference how that energy is delivered in general—that is the principle. If you have one tuned circuit coupled to another tuned circuit the oscillations in the second one build up without any reference to a series of parallel connections. When the coupling between tuned circuits is a one-way coupling, so that energy cannot go back into the first, it becomes particularly unimportant whether the second circuit is connected to the first in a series of parallel connections, because no energy can come from that tuned circuit back to the first tuned circuit.

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HIS LORDSHIP: It is just a one-way coupling?—A. Yes. In this diagram, Exhibit 8, there is a tuned circuit connected with a condenser marked 8, and then connected with the second circuit and the plate of the circuit first there is a condenser marked 15. Now if these are connected by an audion so that we have a one-way connection only the oscillations in the first circuit 8 will set up oscillations in the circuit 15, the second one, but these oscillations in circuit 15 will not go back and influence circuit 8, because the audion controls the plate by means of changes on a grid, but in the audion circuit there is practically no energy in the grid. The grid is negatively or nearly negatively charged, where the plate is positive. The energy in the tube is the energy in the plate circuit, and we modify the energy in the plate by changing the potentials on the grid, but without drawing any appreciable power from the grid circuit.

But in an entirely different way the energy of oscillations in the plate circuit cannot work back to the tube, because the changes in potentials on the plate caused by the oscillations in this section of the tuned circuit cannot modify the current flowing to the grid circuit, because there is no appreciable current flowing to the grid circuit. So that it is a one-way device essentially and inherently. There is an entirely secondary effect and relatively unimportant, and that is that the proximity of these two plates makes a small condenser action, so that there is a slight electro-static influence between these two electrodes, the grid and the plate, just exactly the same as though the filament were cold in the tube. That is the only way in which this second circuit can react back on the first, and as I say, that is a secondary effect.

It is an insignificant fact compared with the transfer of energy through the tube, because of the inherent function of the tube, its amplifying power. Since this plate circuit delivers no energy back this way, it does not make any difference how the second tuned circuit is connected to the plate of the tube as far as the oscillations in the second circuit are concerned. For all practical purposes then the tuned circuit of the plate in which the second tuned circuit is a simple tuned circuit, there is essentially no distinction between the parallel and series connection.

If you had a possibility of flowing the current back to the plate then it would be a question of importance as to whether you had a series or parallel connection.

Mr. Hazeltine wished to draw a sharp distinction between parallel connection and a series connection in the plate circuit of the vacuum tube; and he said that the plate circuit or the resonant circuit of the plate circuit was always of the parallel kind. And that would seem to imply that you could have a series connection. Now it was perfectly well known to anyone skilled in the art, I think, in 1912 or 1913, that you could not use a straight series connection at all in the plate circuit of an audion. If you had taken the plate and put it in series with the inductance, and then had put in series with that a condenser, you could not get any current through it. You have no closed circuit. So that it was not a matter that you would have any choice about. If you were going to set up an audion and transfer energy from one tuned circuit over to another tuned circuit it was not only obvious that you should connect it in the way that Mr. Hazeltine has described as parallel connection, but it was the only feasible way to connect it. I do not know of any circuit, any vacuum tube circuit where there has ever been any attempt to connect it in any other way; and that is from the very earliest days when such a circuit was used.

MR. HENDERSON: We are all looking at the clock, my Lord, and it is four-thirty.

HIS LORDSHIP: Q. Was geometric selectivity known before Alexanderson described what was in his mind to you,—was it known to persons like yourself?—A. It was not known to me. The principle seemed to me to be an entirely new one. It was only within the last few years, in connection with patent litigation, that I had even ever heard of this Stone circuit in which they had several loosely coupled——

Q. There was nothing particularly involved in the word "selective"—that is by that you mean you are tuning out undesired waves, and you want to select the others?—A. Ability to pick out a definite frequency or a definite range of frequency as distinguished from all other frequencies. Now, all ordinary radio sets in 1912 were selective in the sense that they used tuned circuits. But Alexanderson came with the proposal which gave a new order of magnitude of selectivity. He compounded his selectivity. If before we had a degree of selectivity which would give us an advantage of, say, 100 to 1 on the desired signal, as compared with the undesired signal, Alexanderson showed how we could get 100 times 100, or even 100 times 100 times 100 of the selected, over the other method.

THE REGISTRAR: The Court is adjourned until eleven o'clock to-morrow.

18th January, 1927.

Q. Dr. Langmuir, I find on looking at the record that you did not appear to complete your answer to a question of his Lordship, which was this:—

> "Was geometric selectivity known before Alexanderson described what was in his mind to you? Was it known to persons like yourself?"

You had just mentioned the Stone circuit, and another question was put to you, so I would like you now to complete the answer to the question which I have just quoted?—A. Tuning in geometrical progression with one-way coupling between the resonant circuits was certainly unknown to me; and I do not know of any one else who was familiar with it at the time.

Q. What kind of one-way coupling do you refer to?—A. Such as that suggested by Alexanderson, the audion. A coupling which would permit energy from one circuit to be transferred to the second, but no energy or no appreciable amount of energy from the second back into the first.

Q. Of what frequency ?—A. At radio frequency. The Stone circuit, with which I became familiar only much later, has a series of tuned circuits arranged in cascade, but to get the advantage of geometrical tuning from such a circuit is impossible.

MR. HENDERSON : If you will pardon me a moment, doctor.

I wish to take the position, my Lord, as I indicated to my friend at the close of Professor Hazeltine's examination that I intend to rely upon the ruling in Brown vs. Dunn, a House of Lords judgment, reported in 6 Reports at page 67. I do not know if your Lordship recollects that rule. It is a judgment of one of the strongest courts we know of: Lord Herschel, Lord Halsbury, *Lord Vaughan and Lord Morris. The rule has been followed, and while it is a rule that is not absolutely inflexible—while I do not pretend that your Lordship's discretion is taken away—it is very improper to contradict what has been said by Professor Hazeltine now and practically not permissible. That has been the rule in the courts of Ontario since that judgment, and in courts elsewhere throughout Canada and in England; and followed by this court in the case of Confederation Life vs. Morris, I think the case was. I submit that my friend has brought himself clearly within that rule.

MR. SMART : I think not. That applies to questions of credibility of witnesses on matters of fact. It has never been applied to questions of opinion.

HIS LORDSHIP : This can only arise in an action where infringement is alleged and where the validity of the patent is alleged as well. The difficulty is as to who should begin. In the case of an infringement, the plaintiff must prove infringement.

MR. HENDERSON : It is not a case of who should begin, my Lord. It is a case now of contradicting his witness on matters of fact when that witness was not cross-examined. Here is the rule.

HIS LORDSHIP : I know the rule. Still, I think it all arises from the difficulty in determining just who should begin, in these cases. The question is whether Mr. Smart should have gone into his case to begin with, fully, or whether he had the right to reserve it.

MR. HENDERSON : Your Lordship will see what the result of it is; they come and say something; it is peculiarly important in a case of this kind, for this reason : Mr. Waterman took the box and made certain statements, just going far enough—properly, I am not criticizing that—going only so far. Then Mr. Hazeltine takes the stand on our behalf, and we cover the ground fully with him. Then these gentlemen come in and differentiate in dealing with the points that Mr. Hazeltine has dealt with, and the last answer of this present witness indicates precisely what I mean, and it is based entirely upon the question of unidirection coupling, as to which Professor Hazeltine gave evidence.

HIS LORDSHIP : I think, Mr. Henderson, that the rule to which you refer cannot be applied in cases of this kind. For instance, Mr. Hazeltine is only giving opinion evidence. Mr. Smart decided not to cross-examine. As I said at the time, it might not be fair for me to say it, because that is

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* *sic ?*

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always a matter for counsel, but it is always at the option of counsel to decide whether they are going to cross-examine or not, and generally there is not much use in cross-examining an expert on opinion evidence, because his opinion is made up, and all he is doing is to give it to you.

MR. HENDERSON: I cross-examined Mr. Waterman at considerable length, and to my own great satisfaction, I may say; and I certainly would not have dared to have accepted many of the things he said.

HIS LORDSHIP: Sometimes it does help, but if counsel chooses not to cross-examine an expert, he has that option.

MR. HENDERSON: But counsel takes the risk.

HIS LORDSHIP: I do not think so. I will receive the evidence.

MR. HENDERSON: However, I am giving my submission, my Lord.

HIS LORDSHIP: Yes.

MR. SMART: Q. Will you continue, Dr. Langmuir? You have just mentioned the Stone circuit as compared with the Alexanderson circuit, which includes the audions coupled.

HIS LORDSHIP: Before that question is answered, in case the question comes up again, it is quite probable that Mr. Henderson will ask to be permitted to recall witnesses and to tender evidence in reply to new matter brought up by you. I propose allowing that.

MR. SMART: I do not think you will find any authority for it.

HIS LORDSHIP: I do not think the case could be fairly tried if in circumstances of this kind Mr. Henderson had not this right. I am not encouraging him to do it, but I do not see how the case could be properly tried without it.

MR. SMART: That involves a further reply, if necessary, on my part.

HIS LORDSHIP: I am not sure about that.

MR. HENDERSON: My understanding is that your Lordship can admit evidence in the case as long as your Lordship pleases. I do not know of any absolute rule to the contrary, and when I mention the rule in Brown and Dunn I only give it as a rule cf convenience. In view of the intimation your Lordship has given, may I suggest that the objection, so far as it is, may be treated as continuing, so that I will not have to be renewing it to that type of evidence.

MR. SMART: The defendant in impeachment cases had a right to begin and offer evidence.

HIS LORDSHIP: This is an action of impeachment.

MR. SMART: But we are proceeding first with the action of infringement.

HIS LORDSHIP: When we were proceeding with one matter we had very little difficulty, but the trouble arises when we proceed with two matters. The infringement is one thing and validity of the patent is another. The whole difficulty arises as to who should begin in each of these cases. In the case of infringement it is quite easy, but when you try both together there is quite a difficulty in determining the question. I do not anticipate any difficulty in this case, because I want to hear all the evidence.

MR. HENDERSON: The point of my objection would be lost in that event.

MR. SMART: Q. You had in your answer arrived at the stage where you were comparing the kind of arrangement with the Stone circuit with that of the Alexanderson, which uses the audion coupling in a tuned circuit. —A. In the limiting case where you have such loose coupling between the tuned circuit that practically no energy is transmitted, the selectivity of the Stone circuit approaches that of the Alexanderson, but this is not a useful arrangement, because you lost signal strength. In the Alexanderson you preserve the signal strength and may even greatly amplify it from stage to stage, and at the same time gain a selectivity as great as the ideal selectivity that you might get in the Stone circuit, even if no energy were transmitted. By selectivity I mean the circuit corresponding to one frequency as compared with other frequencies differing slightly from them. The ratio between the sensitiveness at one frequency, and that for other frequencies is not greatly different. The sensitiveness on the other hand depends on the total amount of energy than can be transmitted to the circuit and will serve to make the signal audible.

Q. I should like to refer to Exhibit Z-1, which are the Vivian notes, and particularly to the diagram on page 38 of those notes, and would ask you to say what in your opinion a man conversant in the art at the time of that diagram would put in to represent the elements of the circuit which are indicated automatically by the dotted line and by the relay?—A. I assume that it is also to be taken for granted that the circuit is a radio frequency circuit, and that the audion is to be the relay that is to be used. On that assumption it is very clear that the circuit is not in any sense complete in itself, or the diagram is not in any sense complete in itself, but is purely schematic. For example, where you have those dotted lines with the designation relay we have on one side of them two wires meeting the dotted line and extending over it to the other side of the dotted line. It is perfectly obvious that that must not be taken literally; that is, the current does not flow from the wire on one side of the dotted line through into the wire on the other side; for if that were the case there would be no relay action. The essential idea of a relay is that the current in one circuit on one side of the relay shall be complete in itself but shall be able to modify another circuit complete in itself on the other side of the relay. In other words, there is necessarily a connection between the two wires that lie on one side of the dotted line from one to the other, and that applies to both sides of the dotted line.

Now with an audion as an amplifier or as a relay, the circuit on the left hand side of the dotted line is obviously to be connected to the grid, or coupled to the grid of the audion, whereas the wires that extend from the dotted line to the right are to be connected in the same way to the plate circuit of the audion, but the manner in which the connection is to be made is not at all indicated in this diagram and is very obviously omitted from the diagram, and therefore must be supplied in ways that are more or less self evident to those that are familiar with the action of the audion.

If therefore I draw the diagram of an audion having a grid and a plate, and I draw a dotted line to the left of that and another dotted line to the right of it, I may include between those two dotted lines what is represented by the single dotted line in this diagram that you show me, and in between those two dotted lines that I draw is therefore the audion and the circuit that is connected to it on both sides. That is the input circuit and the output circuit. Now to the left of the first dotted line I will draw the two wires that lie to the left of the dotted line in the diagram that you have shown me. That represents the two wires that are part of the input circuit. One of those wires will go to the filament of the audion, and the other one will go to the grid of the audion.

In that way the potential that is derived from the terminals of the condensers in the input circuit serves to change the potential of the grid, and therefore modifies the current in the plate circuit of the audion.

Now, the output of the audion is derived from the plate circuit, that is a wire from the plate; the current of the electrons that passes across the tube to the plate must return back to the filament in order to complete that circuit.

As I said yesterday, the circuit in this Vivian diagram, as illustrated in this figure, and which lies say to the right of the first dotted line, is not a circuit through which direct current can pass. That is the electrons which pass across the tube in the plate current can pass in only one direction; and those electrons obviously can not pass through the condenser shown in the diagram. But the plate circuit of the audion in order to be complete must return back to the grid; and therefore it is an obvious thing to do to connect the plate of the audion through the primary of the transformer to the B-battery and back to the filament. That gives you a completed plate circuit and enables you then to transfer the radio frequency energy from the plate circuit into the output circuit.

Q. Was that obvious in 1913 or 1912?

Mr. Henderson: Do not lead, please.

A. Perfectly obvious.

Mr. Smart: Q. And you spoke incidentally of these audion circuits being well known. Are you speaking of the present day or as of that date? —A. As of that date. The current which flows from the plate circuit of an audion is a small circuit at relatively high voltage, and it was well known that to utilize——

Mr. Henderson: Is my friend through marking that diagram?—A. It is not yet finished. That a high impedance circuit should fit into another high impedance circuit. That is the two circuits should be balanced. Now, the circuit that lies to the right of the first dotted line in the Vivian diagram is a low impedance circuit as it stands. And when we in general want to connect a high impedance circuit, that is a high voltage circuit, to a low impedance circuit, or a low voltage circuit, we use a transformer.

It is a very old and standard practice in all electrical engineering work, when you want to connect a circuit of high voltage, for instance, a transmission line of many thousands of volts, with a supply line which runs into houses, for a house circuit to want 110 volts, and you connect the two circuits together through a transformer and step down the voltage. So that where you have here, in a case like this——

HIS LORDSHIP: I suppose after all that means about the same thing as taking water into a house in a small pipe from a larger main pipe?—A. Not quite. I do not know a good analogy in the case of a flow of water to a transformer. A transformer takes a circuit of high voltage and low current and can deliver the energy into another circuit having a low voltage and a large amount of current.

The analogy in regard to a flow of water would be something like this, supposing we have a high mountain in which there was a small stream that delivers a small amount of water but with a thousand feet of head; that is the mountain was a thousand feet high, so that there was a small amount of water coming down at a very high pressure. Although there was a small amount of water, because of the high pressure a great deal of power can be developed.

If somebody wants to use water to run a small water motor in a house, you do not want a high pressure but you want to deliver water to the motor in the house; therefore you have a turbine which will take the high pressure power and operate another pump which will deliver a large amount of water at low pressure. It is possible to take a small amount of water at high pressure, take the power from it and transmit that in the form of power in the form of a large amount of water at low pressure. The power might be the same in the two cases. Now that is what happens in the case of a transformer.

HIS LORDSHIP: What is the distinction between resistance and impedance?—A. Resistance represents the difficulty with which direct current can flow; a steady current will flow in a circuit; that resistance results in the conversion of the energy of the current into heat,—it is all heat. There is no stored energy in resistance.

In the case of alternating currents, when you have inductance, the inductance does resist or oppose the flow of current, but it does it by the way of storing it; it does it in the way a spring does. If you have a spring and try to compress the spring it resists, but you get all the energy back when you take your hand away.

So that when we talk about the difficulty of allowing a current to flow in a circuit, we have to distinguish between the kind of difficulty represented by the spring and the kind of difficulty represented by friction. The resistance part, the difficulty in causing the current to flow, corresponding to the spring-like action is called inductance.

Now, the impedance represents the total difficulty made up of both kinds, that is the combined effect of the resistance and inductance is measured in terms of an impedance; it represents the sort of gross effect or the effect of both things combined together, where we do not wish to differentiate between them.

MR. SMART: You might continue your answer now.—A. Where, then, we have an output circuit, as in the plate circuit of this audion, where the tube itself is a high resistance with a high impedance circuit, makes a high resistance circuit, and we wish to connect it with a low impedance circuit, we step down the voltage by means of a transformer; and for radio frequency that simply means they put two coils, which we couple together by varying the distance between them. And if we wish to step up the voltage, we usually have a small number of turns in the first coil and a large number of turns in the second.

So that what I put between the two dotted lines in this diagram which I have been drawing is the audion with its filament lighting circuit, with two wires that connect the input circuit, the one from the filament and the other from the grid, and a completed plate circuit including its B-battery and a transformer which delivers the energy from that plate circuit into the output circuit, which now represents the part that is to the right of the line or of the first dotted line in the Vivian diagram. So that the two dotted lines which I have in this diagram, which I may call " A " and " B," include the entire relay circuit; and there then extends to the right the two wires which are connected to the inductance and the capacity of the Vivian diagram, and I would complete the Vivian diagram as it is shown, on both sides of the dotted lines, and I will indicate by parenthesis the part of that circuit that is taken directly from the Vivian diagram; and the part that constitutes the relay circuit, which in the Vivian diagram is represented merely by a single dotted line.

MR. SMART: I would ask that this be marked as exhibit No. 14.

EXHIBIT No. 14:—Filed by Mr. Smart, Jan. 18, 1927. Diagram in explanation of Vivian diagram.

WITNESS: May I add just a word here?

MR. SMART: Q. The sketch which you have made is exhibit 14. Is there something more you want to say?—A. I would like to add that the resonant circuit which is included between two of the dotted lines in the Vivian diagram, and which I mark on this diagram by the letter C, is with respect to the plate circuit of the audion a series resonance circuit, but at the same time it is also a parallel resonance circuit with regard to the next relay that is connected to it.

The distinction between parallel and series resonance circuits, when it exists at all, is after all fundamentally only important insofar as it determines the impedance of the circuit; and as I have just said the impedance of the circuit makes no difference if you compensate for it in the usual way of using a transformer.

Q. Will you compare the diagram, exhibit 14, that you have just drawn, with the diagram of the Alexanderson patent, say Fig. 1?—A. It is practically identical with that diagram Fig. 1 in the Alexanderson patent, the only difference being that in the Alexanderson patent an antenna is shown coupled with the first resonant circuit, and a biasing battery is shown in the grid circuit in the Alexanderson diagram.

Q. From the standpoint of a circuit such as shown in Exhibit 14 or in the Alexanderson patent, is the distinction between a series or parallel connection of the inductance and capacity of importance?—A. No, because the transformer renders you quite independent of the particular way; it enables you to adjust your circuit to take care of whatever impedance you may have or may wish to have in the resonant circuit. As a matter of fact this type of circuit is far better than one in which you do not use a transformer but use what Mr. Hazeltine has called the parallel connection of the inductance and capacity in the output circuit of the tube; for in this case by use of the transformer you can get much more flexibility and have in the resonant circuit very much higher voltages than those that are produced in the inductance which is directly in series with the plate of the tube. That has several advantages.

Q. Now referring to the Alexanderson letter of February 4th, 1913, and your subsequent use of the arrangement there disclosed, did you in actually making use of that arrangement obtain any further information from Mr. Alexanderson as to the instrumentalities to be used or the way in which they were to be combined, other than contained in that letter?—A. No. The letter and the conversations that I have had with Mr. Alexanderson prior to the date of receiving the letter, which covered practically the same ground as the letter did, were actually all the information that I received from him as to how to set up the circuit for obtaining the benefits of the tuning in geometrical progression.

MR. SMART: That is all.

CROSS-EXAMINED by MR. HENDERSON:

Cross-examination.

Q. Still talking about the Vivian notes, Dr. Langmuir, will you refer to the form of equation on page 31, I think it is, as to the reference to the relay at the bottom of page 34; resonance curve, at the end of 34, the Vector* diagram, with which we are familiar, and then the diagram of connections, which you have been discussing, and the other diagram. Do you agree with Mr. Hazeltine that all of this referred to a tuned circuit having inductance and capacity in series?—A. Will you show me the pages? I did not get them.

* sic?

Q. Will you just check them. I am not asking you to leave anything out you know, but just calling your attention to the essentials. The paging is shown in the left hand corner, 1 and 4, and then the resonance curves are near the end of the report. You will remember those.—A. I do not remember, because I have never looked through the Vivian report.

Q. I thought you had studied the Vivian report?—A. No, I have never even looked through the pages of it.

Q. Do I understand that you have simply looked at this elementary diagram that was discussed this morning?—A. That is the only page that I have considered at all, yes.

Q. You were not here when Mr. Hazeltine was giving his evidence, were you?—A. No.

Q. He pointed out that after a very careful study of the Vivian report, including the very careful consideration of not only the diagrams, but the calculations which are contained in that report, which he discussed at some length, he pointed out that everything in that report referred to a tune circuit having inductance and capacity, in series. Can you disagree with that statement?—A. Without knowing what the mathematical treatment in this particular paper is.

Q. It will be impossible for you really to express a scientific opinion

In the Exchequer Court of Canada.

Plaintiff's Evidence in Reply.

No. 16. Irving Langmuir. Cross-examination —*continued.*

upon it ?—A. Except this, that I believe the mathematical theory is quite independent of the type of circuit that is used, whether series or parallel.

Q. But can you disagree with Mr. Hazeltine when he says that the whole of that report indicates what I have said and he can find nothing whatever in it to indicate the contrary—that Vivian had in mind throughout a tuned circuit having inductance and capacity in series.—A. In all tuned circuits the inductance and capacity is in series.

Q. That is not an answer to my question, doctor, and pardon me for suggesting that I am going to get the answer. Can you say that that is not a correct statement ? Even if you had studied it, do you think you could say it ?—A. Suppose for example that all through this report Mr. Vivian uses mathematically tuned circuits in which there is simply inductance and capacity, and has an input circuit which he assumes is connected in series with a resonant circuit—it seems to me that that throws no light at all on what he has in mind.

Q. I do not desire to argue with a witness, and I do expect you to give me a fair answer to the question, which is plain to you.

MR. SMART : I think the witness is answering quite fairly. My learned friend asked what might be inferred from those notes.

MR. HENDERSON : I have asked the witness a question, and the witness proceeds to explain that in his opinion the answer to that question may or may not be material.

MR. SMART : Oh no.

HIS LORDSHIP : It is not necessary to have an argument about this. The witness not having read that report, cannot give you any answer at all. He is justified I think in saying, I cannot answer your question ; but if you want his opinion on it, you must allow him to answer on assumptions. I understood him to precede his statement that he was about to make, with certain assumptions.

MR. HENDERSON : I am afraid your Lordship has misunderstood him. May I ask him this ?

Q. Will you be good enough to look over that report now ? I want to know if you can disagree with the statement Professor Hazeltine has made and I am quite content that you should take ample time to examine the report.

HIS LORDSHIP : But, Mr. Henderson, I cannot have an hour put on that. Mr. Hazeltine's statement stands, if it is not contradicted, so it does not hurt you.

MR. HENDERSON : The evidence has been given, and it has been in effect contradicted by this witness in several places.

HIS LORDSHIP : Then cannot you put your question in such a way as to give the witness an idea of what is in the report ? Remember that he has not read it.

MR. HENDERSON : You have not read it, and is that consistent with the statement that you have made ? Can you criticize Mr. Hazeltine's opinion evidence with regard to the Vivian report, without reading the Vivian report ?

—A. I have not attempted to criticize Mr. Hazeltine's evidence, because I have not read it. I do not know what Mr. Hazeltine testified.

Q. You were in court while it was being given yesterday.—A. In regard to this ?

Q. Yes, on this particular point you were in court, and not only that, but counsel—my friend Mr. Smart—was conferring with you from time to time with respect to that evidence, Dr. Langmuir.

MR. SMART : My learned friend is not entitled to say that.

MR. HENDERSON : Is that not a fact ?—A. I don't think so.

Q. Because if you say it is not, I will call witnesses to state the fact. My friend may contradict me. Is it not a fact that Mr. Smart conferred with you during the course of his cross-examination of Professor Hazeltine ? I will put it on record that it is a fact?—A. I do not remember having talked with Mr. Smart at all.

Q. I do not want to give evidence myself.

HIS LORDSHIP : This is not necessary.

MR. HENDERSON : I am going to take Dr. Langmuir as to credibility now.

MR. SMART : I asked Dr. Langmuir what the abbreviation " Ca " meant, and he said it meant " circuit."

MR. HENDERSON : Is your Lordship uncertain as to whether he was in court when the evidence was given ?

HIS LORDSHIP : I am a little uncertian. In fact I do not know.

MR. HENDERSON : He was not here when the earlier evidence of Mr. Hazeltine was given, but he was here all day yesterday.

Q. You were in court all day yesterday continuously, were you not ?—A. Yes.

Q. From the beginning of the sitting to the end of it ?—A. Yes.

Q. Your Lordship will understand that this evidence was given yesterday.—A. I was not listening very attentively to Mr. Hazeltine's remarks on the Vivian report.

Q. You were not.—A. No. I remember very little that he said about the Vivian report.

Q. You were not listening to what he said ?—A. Not very attentively.

Q. Were you listening to what he said ?—A. Sometimes. Sometimes not.

Q. Not on your job, as it were ?—A. Probably not. But it is not my job at all.

Q. Did you know then that you were going to be called upon in answer to the things Mr. Hazeltine was saying ?—A. No.

Q. Did you know that you were going to be called at all ?—A. Yes.

Q. And you say you were not paying attention to what he said ?—A Not very attentively. I had no sense of responsibility.

Q. Will you give me an answer to this question : from your knowledge of the art, and from what you have seen of the Vivian report, do you think that it does refer to a tuned circuit having inductance and capacity in series ?—A. I have absolutely no idea at all from anything except what Mr. Hazeltine said about it.

Q. Have you this morning discussed Vivian's references to series ?—A. I have discussed a diagram in the Vivian report. That is the only thing I know.

Q. And only a diagram ?—A. That diagram, yes.

Q. That is the only thing you have discussed. Well then have you examined the Thomas notes ?—A. No. I have never seen them as far as I know.

Q. Will you be good enough to look at them. They are very short. Will you glance through them, and tell me if they also refer to a series of tuned circuits ?—A. Do you want me to read all this ?

Q. I would like you to. I want to get something concrete and not a lot of glittering generalities. Mr. Hazeltine has said that it is demonstrated from these reports and from the Alexanderson correspondence, that both Alexanderson and these two assistants of his, had in mind up to a certain date a series tuned circuit and nothing else. I want to see what you say to that. —A. In the first place I can hardly tell what was in their minds, if you ask me what was in their minds.

Q. Cannot you tell what is in a person's mind as illustrated by what he puts into writing ?—A. I think not. I believe that in this case the mathematics is the same whether you have a series or parallel connection, and therefore the man may perfectly well have taken a series connection, as a type have used it for the mathematics, and may perfectly well have it in mind all the time that when you come to use the circuit, you would at that time use a parallel connection.

Q. And would that be a disclosure to the public ?—A. This is no disclosure to the public. I am not talking about disclosures to the public.

Q. What you are saying in effect, Dr. Langmuir, is : I can take this letter of February 4th, whether it meant much or little, whether Alexanderson and his assistants understood it or not, whether they could make it operative or not, I, Dr. Langmuir, could take it and make it operate ; that is what you say isn't it ?—A. And I believe anybody skilled in the art at that time could have done the same.

Q. You say anyone skilled in the art at that time could have done the same ?—A. So I believe.

Q. And you leave the suggestion open that there were many skilled in the art at that time.—A. Yes.

Q. Although you yourself have said elsewhere that you only entered the radio art, practically speaking, on the 13th February of that year, have you not ?—A. I do not remember having said that.

Q. I am going to call your attention to it later on. And was Alexanderson in the radio art then ?—A. I think so.

Q. In the sense that you were in it perhaps, that you were a gentleman of scientific attainments having specialized in electrical currents, practically speaking.

Mr. Smart : Is there a question there ?

Mr. Henderson : Yes.—A. What is the question please ?

Q. Have I not put it right? Dr. Alexanderson was unquestionably an electrical engineer, and I may assume of high standing. You also were the same?—A. No.

Q. You are too modest to say that. But neither one of you was as yet in radio practically were you?—A. I considered that Alexanderson was one of the experts in radio in that field at that time; that is my opinion.

Q. You so considered, but he had known nothing whatever of an audion or its action at that time, except some very vague information which he had obtained from John Hays Hammond.

MR. SMART: Is that a question?

MR. HENDERSON: Surely, that is a question. I will repeat it:

Q. Is not that a fact?

HIS LORDSHIP: You put a question but you follow it by a statement.

MR. HENDERSON: And the witness knows perfectly well that it is a statement, my Lord, but does not care to answer it.

HIS LORDSHIP: Oh yes, the witness is answering.

MR. HENDERSON: Q. Dr. Langmuir, is it not a fact that at that date, all that Dr. Alexanderson knew about the audion was the information that he had received from John Hays Hammond?—A. I have absolutely no idea whether that is so or not.

Q. You do not know?—A. No, I don't.

Q. And how much did you know about the audion before that 4th February? I have you under oath again, and I would like you to tell me now.—A. Not absolutely, but I feel very confident that I had read DeForest's papers on the audion in January of that year.

Q. Will you please detail now and let me know the extent of your knowledge of the audion at that date?—A. February 4th?

Q. Yes. And let me tell you why I am asking. You have pictured yourself here as having said to yourself the moment you received this Alexanderson letter: "I know this; I see it and I can do it." Have you not?—A. Yes, and it is true.

Q. And you say it is true. I want to emphasize that. Now tell me what you knew about the audion on the 4th or 5th February?—A. I probably knew more than anybody about the theory and operation of the audion.

Q. Had you ever seen the audion then? A. No.

Q. You had never seen it?—A. No, I did not need to.

Q. What did you know about it?—A. I had seen a diagram of it, and I knew how it was used in radio circuits. I do not know that I know all the ways it was used, but I had certainly been told by Mr. Alexanderson some of the ways that it was used, and I understood the principle of operation because I had been working with electron discharges.

Q. Let me read you this, and ask you if you recollect this question having been put to you before and you having given this answer.

MR. SMART: From what record?

MR. HENDERSON: "Q. Just prior to February 13th, 1913, you were working principally on obtaining high voltages by means of a hot cathode relay, were you not ?—A. I was working on a good many different things, but was spending most of my time in the development of hot cathode apparatus, and applications therefore. The audion at that time was not much more than a toy." Do you recollect saying that ?

MR. SMART : What record is my learned friend reading from ?

MR. HENDERSON : I will tell that when the time comes.

MR. SMART : If you put in a question like that, reading from a record, the witness is entitled to know what record.

HIS LORDSHIP : I think you should state that.

MR. HENDERSON : I am asking him if he recollects saying that.

HIS LORDSHIP : But say where he said it.

MR. HENDERSON : I will tell him that afterwards.

HIS LORDSHIP : No, when you are seeking to contradict a witness, you must give him the particulars of where the statement was made.

MR. HENDERSON : I can ask him that question my Lord.

HIS LORDSHIP : I do not think so. You are reading from an American record no doubt.

MR. HENDERSON : I am quoting now from page 59 of your evidence in Interference Number 41790, cross-question 32, and a portion of your answer, which was a long one ; I stopped before the end. " The audion at that time was not much more than a toy." Would you like to look at it ? I will hand it to you. You see that expression, that the audion was not much more than a toy.

HIS LORDSHIP : He may want to read the context.—A. I notice that this testimony was given in May 1920.

MR. HENDERSON : When your recollection was much better I presume than it is now, but I think you were on the other side then, the shoe was on the other foot then, was it not ? Why study that so long ? Do you realize how long you have been on this point ?

HIS LORDSHIP : That does not matter, Mr. Henderson.—A. I remember certain parts of this.

MR. HENDERSON : I asked you if you remember making that statement ?—A. No, I see that it is in the record, and I believe that I did make it, but I have no recollection of having made it.

Q. What do you say as to it now ?—A. What statement ? What part of it ?

Q. That being a statement made by you in 1920.—A. Are you referring to the particular words, that the audion was a toy ?

Q. That particular reference, yes.—A. I think that is perfectly true, that the audion was a relatively unimportant device and nothing much more than a toy, at that time.

Q. And then in that same Interference at page 55 occurs question 17 :

> " How long had you personally been familiar with the audion on February 13th, 1913 ? "

Your answer was:—"I think about a week."

Do you recollect that?—A. I do not recollect making that statement, no.

Q. Do you see it there now?—A. Yes.

Q. Will you say whether or not you made it?—A. I believe I made it.

Q. How do you reconcile that with the evidence that you gave yesterday?—A. "Familiar with the audion" may mean different things. At that time I meant that I had seen the audion about a week before. That is what was in my mind at that time.

Q. "How long had you personally been familiar with the audion on February 13th, 1913?—A. I think about a week."

And now you say that on the 4th of February, you knew so much about it that you knew you could do what did not happen until some months later?—A. The statement there means that I had seen the audion about a week before. That is what I had in mind, when I answered that other question. When I spoke yesterday, or to-day, about my familiarity with the audion, I had in mind my knowledge as to the method of functioning of the audion, which I had gained by knowing something about the audion, about the middle of January 1913. And then talking a great deal about it after the middle of January, and from the experiments I was making at that time and had made as early as November, 1912, I was very familiar with the action of a third electrode in controlling current between two others. More familiar, probably, than anybody else was in the world at that time.

Q. In your own opinion?—A. Yes.

HIS LORDSHIP: Oh well, Mr. Henderson, is not that a little severe?

MR. HENDERSON: We will now see my Lord, a little more.

Q. I show you what appears to be a paper delivered before the Institute of Radio Engineers, New York on the 7th April 1915, by Irving Langmuir. Was that paper delivered by you?—A. Yes.

MR. HENDERSON: I put this in my Lord. For convenience sake using the proceedings of the Institute of Radio Engineers: the paper in question starting at page 261.

MR. SMART: It is already in, or part of it.

MR. HENDERSON: Part of it. Certain papers are already in evidence, I think. I will put in the whole article now.

THE REGISTRAR: That will be Exhibit Z-12.

EXHIBIT Z-12:—Filed by Mr. Henderson 18 Jan. 1927. Paper delivered before I. R. E. of N. Y. on 7 Apr. 1915, by Dr. Langmuir.

MR. HENDERSON: At page 275 you say certain things about the audion. Did that correctly state your understanding of the audion in 1915? I presume it did doctor?—A. When you say audion, there are various things meant. Do you mean the old audion or the new audion for example?

Q. I am just asking you this: is this an honest statement of the opinion which you held at the time you delivered that paper?—A. Yes, but there may be some doubt as to whether I was referring to the new audion, or the old, or improved audions, or what not?

Q. Perhaps if you think there is some doubt about that doctor, I will just read this:—

> "The three elements, hot filament cathode, grid and anode, are of course similar to the elements of the DeForest audion; however, the operation of the audion is in many ways quite different from that of the pure electron device operating in the way I have described above."

You were describing of course an improved type?—A. And that was an audion was it not? Even the improved type?

Q. An improved type of audion.

> "In the audion as in the Leib and Rice relay, the amplifying action appears to be largely dependent on gas ionization even when the device operates well below the point at which blue glow appears. The action is probably somewhat as follows."

And then you describe the action.

Q. Now you did know then of the Leib and Rice relay?—A. Yes.

Q. Evidently. Did you know of the Leib and Rice relay on the 4th February 1913?—A. No.

Q. You did not?

THE REGISTRAR: Do you put in the whole book as Z-12?

MR. HENDERSON: As a matter of convenience. My Exhibit is only the article contained in that book.

Now the letter we talked about so much of February 4th——

HIS LORDSHIP: What about the Thomas report?

MR. HENDERSON: I would like to finish up the Thomas report.

Q. Can you tell me whether or not you agree with Professor Hazeltine that the Thomas report also referred to a series tuned circuit, as I have stated the Vivian notes said? I think if I recollect rightly the second page reads better than the first.

(Witness reads report.)

A. Well, most of this report does not seem to have anything to do with the question whether the connection was a parallel or series, but the mathematical equations, so far as I have been able to understand them, seem to refer to a series connection. That is the impedance that is calculated is the impedance with reference to an external circuit which is connected in series.

Q. Would you take both those reports during the lunch adjournment and look them over? The letter of the 4th February, in the second paragraph in the first page has the following:

> "The method of suppressing interference by means of tuning consists in using an electric circuit which has a very low admittance to signal impulses of voltage."

Do you recollect Professor Hazeltine telling us about the significance of the word "admittance"?—A. You mean defining it?

Q. Yes.—A. Yes.

Q. Do you agree with his definition?—A. Yes.

Q. Can you state whether that quotation refers to a series tuned circuit or a parallel tuned circuit?—A. Let me see the paper.

(Paper handed to witness.)

Q. The emphasis, I understand, being on the word "admittance." —A. What is the question?

Q. Can you state whether that quotation refers to a series tuned circuit or a parallel tuned circuit? It speaks of an electric circuit which has a very low admittance to signal impulses of voltage. I am told that word should be "single," not "signal." The word "signal" was in the original in typewriting and has been changed to "single impulses in voltages." Unfortunately, I misquoted the most important word in the sentence, next to the word admittance. You are hesitating a long time.—A. That is part of a sentence. The first part of the sentence contains a reference to admittance and the second part says:

> "Whereas a continuous set of waves will act upon the circuit accumulatively, so that each successive impulse adds its energy to the previous impulse."

Q. You may or you may not recollect that Professor Hazeltine yesterday gave us a somewhat lengthy explanation of that, and I would be quite content that you would again look at that and ask my learned friend to show you Professor Hazeltine's evidence. If possible Doctor Langmuir can check that up during lunch hour.

Mr. Smart: Will you give me the page?

Mr. Henderson: It was the second paragraph of the first page of the letter in yesterday's evidence.

Q. Still along the same line, and coming to a point of departure, however, in the letter which Dr. Alexanderson wrote to Mr. Sage under date of May 14th, I find this quotation on the first page:

> "Dr. Langmuir demonstrated to-day to Mr. Hawkins and myself a vacuum tube relay of the incandescent type, which proved to be sensitive enough to respond to the relay for alternating current up to 100,000 cycles, and probably much higher if such frequencies had been available."

Q. Of course you are the Dr. Langmuir referred to in that letter? —A. I suppose so.

Q. And you know Mr. Hawkins of course?—A. Yes.

Q. It is not very easy to read this letter. Do you recollect the incident? The letter is written on the 14th May.—A. I remember the work that we did about that time.

Q. What was Mr. Hawkins' identity? Assisting Dr. Alexanderson? —A. No, he is what we call Engineer of the Research Laboratory, and Mr. Alexanderson was not connected with the Research Laboratory but was in the Consulting Laboratory.

Q. You recollect the incident and you have no doubt it is a fact as stated there, that on the 14th May, 1913, you demonstrated to Dr. Alexanderson and Mr. Hawkins a vacuum tube relay of the incandescent type along the lines stated?—A. Yes, that is true.

Q. Look at the second page. You see this quotation:

" With the present development of the incandescent vacuum relay, as perfected by Dr. Langmuir, it seems that its capacity for handling considerable amounts of energy can be easier increased by employing high voltages than by attempting to handle large currents."

You find that ?—A. Yes.

Q. Will you tell me whether the second quotation is or is not an indication that the vacuum relay is inherently suited to a parallel tuned circuit rather than to a series tuned circuit ?—A. It was well known—this does not throw any additional light on it.

Q. You spoke of the high voltages and the——A. I mean quite apart from the work I have done. Take the DeForest audion——

Q. Keep to this one point. I want an answer to my question.

His Lordship: Let the witness answer. I think he was attempting to answer it.

Mr. Smart: He was attempting to say something about DeForest.

Mr. Henderson: I have a right to stop a witness and say, " That is not what I want."

Mr. Smart: I think not.

Mr. Henderson: Q. You mentioned to his Lordship this morning in your examination in chief just this very distinction, did you not ? I call your attention to this: " Its capacity for handling considerable amounts of energy can be easier increased by employing high voltages than by attempting to handle large currents." I ask you to tell me whether that second quotation is not an indication that the incandescent vacuum relay is not inherently suited to the parallel tuned circuit rather than to a series tuned circuit ?—A. I will answer the question in two parts: First of all I have already stated that the incandescent rectifier or relay audion is adapted for a high impedance circuit such as that which can be obtained by a series connection and inductance and capacity—I mean a parallel connection.

Q. You used the wrong word inadvertently ?—A. That was true of the DeForest audion, and it is not much modified by the fact that I perfected the tubes. That has very little to do with it.

Q. The point I was coming to is the fact that the tube has become a high vacuum tube with relay developments does not alter that fact ?—A. Only in degree.

Q. The degree being unimportant for our present purposes ?—A. Yes.

Q. As a matter of fact is not the vacuum tube relay a relatively high resistance device, relative to its output circuit ?—A. Yes, high impedance also.

Q. And for this reason alone would it not be suited to a parallel tuned circuit rather than to a series tuned circuit ? Am I right ?—A. It seems to me the fact is best expressed by saying that the vacuum tube is adapted to a high impedance output circuit. It is quite immaterial whether it is a series or parallel circuit, so long as it is a high impedance circuit. For example, it can be made a high impedance circuit by means of a transformer, and it does not make any difference how it is accomplished.

Q. Of course, any kind of a doctor can take hold of a very sick person and do something to make him well, can he not?—A. Yes.

Q. And you can take hold of this very lame device and put a transformer and something else into it and make it work?—A. That is not my statement.

Q. You would not like to say that?—A. Never have I thought of it that way. It is perfectly within the ordinary customary practice of electric engineers and radio engineers to adjust the impedance of the circuits to make them what comes to be desirable.

Q. Do you believe Dr. Alexanderson could have done what you did?—A. Yes.

Q. You do?—A. Yes, better than I could have done it.

Q. Now be careful for your own sake. You see what I am coming to?—A. No.

Q. Let me ask you again; do you believe that Dr. Alexanderson could have carried on without your assistance and completed this device?—A. Absolutely. All he would have to do would be to get a few more audions from John Hays Hammond, or anywhere else, and he would have done it without my help.

Q. And you say then that your help was immaterial?—A. It was convenient.

Q. It happened you were the one who did that part?—A. Yes.

Q. Only you?—A. Yes.

Q. And you give the entire credit to Dr. Alexanderson?—A. Yes.

Q. Disclaiming anything for yourself?—A. On this particular part of the work, on tuning the geometric progression.

Q. *And still in Canadian patent No. 196,390, I find Irving Langmuir* claiming as his invention the combination of a plurality of electron discharge devices, each having an electron emitting cathode, a co-operating anode and a current-controlling grid, connections between the electrical circuit of one device and the grid circuit of the second device, means for impressing variable potentials on the grid circuit of the first device and means for detecting a variable current in the grid circuit on the second device?

Mr. Smart: Will you give the witness a circuit diagram?

Mr. Henderson: Be good enough not to interrupt me now. This is fair cross-examination.

His Lordship: I think the question is fair. Perhaps he is not able to follow it.

Mr. Henderson: Were you able to follow this question? Let me ask you first: I presume you did not yourself prepare the actual claims for this patent No. 196,390?—A. No.

Q. That was done in the Patent Department?—A. Yes.

Q. And is the phraseology of the claim your phraseology or that of the Patent Department?—A. That of the Patent Department.

Q. What you did in this case was simply to tell somebody something and let the Patent Department work it out?—A. As far as drawing of the patent was concerned.

Q. Will you look at this document? You swore to this did you not? A. I suppose so.

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No. 16. Irving Langmuir. Cross-examination —*continued.*

Q. Why do you say you suppose so ? Why do you smile in that off-hand way ?

His Lordship : Swearing to a patent is not a very serious matter. It has got to be sworn to.

Mr. Henderson : I should say it is a very serious matter. I am afraid they do get into loose habits in these large concerns.

His Lordship : And in small concerns—every concern.

The Witness : I do not recognize this patent. You pass it to me and I do not know anything about it. This particular Canadian patent I do not remember anything about.

Q. Even though it is taken out in your name ?—A. No, I do not.

Q. Have you with you either the original or a copy of your contract with the General Electric Company ?—A. No.

Q. It is a fact, is it not, that in that contract you agree to assign all of your inventions to the General Electric Company ?—A. Yes.

Q. I am not even hinting that there is anything wrong about that but you are a research man ?—A. Yes.

Q. Employed for the purpose of making inventions and for the making improvements leading to inventions ? And these belong to the Company, —I am not even criticizing the practice, but that is what happens ?—A. Yes.

Q. And when you have an idea, it is, I presume, for the Patent Department to say whether or not a patent will be applied for ?—A. Yes.

Q. And that is what happened in this case, but may I ask, however, for your own opinion ? Will you be good enough to read that claim now.

His Lordship : Do not ask the witness to give his opinion about patents which are not in question.

Mr. Henderson : Not as a matter of law, my Lord.

His Lordship : Nor as anything else.

Mr. Henderson : Would not your Lordship think it proper that I should ask him whether in his opinion he thought Dr. Alexanderson is the inventor of what is mentioned in that claim ?

His Lordship : I would not think so. Why complicate this issue ?

Mr. Henderson : Because, my Lord, I am basing a serious argument in law upon it, your Lordship will see. This is not merely to worry the witness. Your Lordship will have to decide it.

His Lordship : It is very difficult to ask a man like Dr. Langmuir to give an opinion as to a claim in a patent. Probably the man who drew it did not fully realize what was in it, but made something comprehensive so as to comprehend everything that possibly could be thought of. Is there any other way by which you can get at it ?

Mr. Henderson : Q. Does that not describe what you have been talking about this morning and what you have just said was invented by Dr. Alexanderson ?

His Lordship : Look at the drawings, too. You can make a legal argument on the point.

Witness : What is the question ?

Mr. Henderson: My last question was, Does not that claim cover the apparatus which you have just said was invented by Dr. Alexanderson? —A. I suppose it is broad enough to cover it, if it is valid. I do not know anything about that.

Q. I am not talking about the legality of it, but that is plain enough as it stands?—A. I think it is wide enough to cover it.

Q. Now I show you a printed copy of an interference in the United States Patent Office, the record of an interference in which you yourself were a party against Peers and DeForest? It was triangular, was it not, between yourself, Peers and DeForest? I refresh your recollection, as far as possible, Dr Langmuir, by looking at it. This appears to be evidence taken on the 4th May, 1916, before Miss Orford, acting as a notary public, and you were called and you gave evidence. Do you not recollect the incident?—A. No I do not, not this particular one.

Q. Do you have so many of these things?—A. Yes, I have them every few weeks or every few months at least. If I could look through the patent and find out what the subject matter is, I would probably recollect it.

Q. I find on page 7, at the foot of page 7, question 12 put to you by your own counsel, apparently:

> "Did you during January or February, 1913, invent or conceive an apparatus for amplifying electrical impulses by means of two or more audions or similar devices connected in series?"

to which you answered:

> "A. During January or February, 1913, I did invent an apparatus for amplifying electrical impulses by means of two audions connected in series."

Do you see that? Was that a true statement, Dr. Langmuir? Of course the issue was on the other foot then also?—A. I think this refers to the radio frequency amplification?

Q. It has reference, I think, to either the very same patent which was patented in Canada or under your American practice a division of it, and I think you will find that if you check it up, and I am quite content that you should check that also, if you will, and take all the time to check anything that you may wish. But how do you make these statements square, doctor?

Mr. Smart: The witness is asked about documents dealing with two or three different patents, which the witness has never seen.

His Lordship: Do you know, Dr. Langmuir, what that refers to? —A. Yes sir.

Mr. Henderson: Did you not now reach the very top of page 8 of this record,—did you not turn over the page and read it?—A. No, I do not think so. I glanced at it.

Q. I will read it to you now. You were asked:

> "Will you fix more definitely if you can the date when you made a sketch or diagram of this invention, if you made one?"

and this answer to your own counsel was:

> "A. On February 16th, 1913, on page 285 of notebook 413 I drew a sketch disclosing two audions in which there was a conductive

> connection between the plate of the first and the grid of the second. This arrangement of two audions in series was devised for the amplification of electrical impulses."

Do you recollect stating that ?—A. Yes.

Q. And is that statement true ?—A. Oh, I notice the conductive connection between the two, and that was not Alexanderson's idea.

Q. Is this a true statement ?—A. Yes.

Q. And is this the notebook that was referred to yesterday when you were in court ?—A. Oh, I think so.

Q. And is page 285 one of the pages referred to ?—A. Undoubtedly.

Q. Containing this sketch. Now will you let me see the notebook, please ? And was not the notebook at that time discussing the Alexanderson arrangement, at page 285 ?—A. May I see the diagram ?

Q. I have not got it here. Do you not remember your own note book ? A. No.

Q. We will let it speak for itself. Now I show you a photostat copy of an affidavit made by Irving Langmuir, yourself, in re the application of Irving Langmuir, serial number 797,985 in the United States Patent Office. I suppose the fairest thing is to ask you first of all, is that a photograph of your signature ?—A. Yes.

Q. And do you know Miss Helen Orford ?—A. Yes.

Q. She is the same lady that acted in this last interference. By the way, she is, I understand, a clerk in the office of the General Electric ?—A. I do not know what her position is.

Q. Don't you know ?—A. No. She is in the Patent Department, I know.

Q. I find in this affidavit, the second operative paragraph :

> " In the course of my investigations I conceived a system of electrical connections for electron discharge devices containing three electrodes, in which a plurality of these devices are connected in series or cascade so that the grid circuit of one device was changed "——

should not that be " charged " ?—A. " Changed " does not mean anything. " Charged " is not very much better, but it would mean something.

Q. So that we will call that " charged," and look upon it as another inadvertence :

> " was charged from the electrode circuit of another device for the purpose of amplifying weak electrical impulses. This invention being set forth by claim 1 of the above entitled application. It was my habit and custom to make entries in my notebook at frequent intervals describing observations and inventions conceived by me. On February 16th, 1913, I drew a sketch disclosing an arrangement of two amplifying devices in series, as shown on the accompanying photographic copy of pages 285 and 286 of my notebook."

Now was that correct ?—A. I believe so.

Q. You think that was correct ?—A. Yes.

Mr. Smart : Will my friend let me see the document ?

Mr. Henderson : I am using it at present.

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Plaintiff's Evidence in Reply.

No. 16. Irving Langmuir. Cross-examination —*continued.*

Q. Then, in the United States patent of Mr. Alexanderson, with which I presume you are familiar, are you not ?—A. Oh, I do not think I am particularly. I have not read it recently.

Q. I thought, doctor, you would have been really better equipped before coming here.

HIS LORDSHIP : Well, Mr. Henderson, I am very glad to see that he is not, for expert evidence coming here prepared in the sense that they must read everything which comes up in the statement of somebody else, would not be expert evidence but advocacy. I do not think you should criticise Dr. Langmuir.

MR. HENDERSON : I am not criticizing.

MR. SMART : Dr. Langmuir did not come here as an expert but as a fact witness.

MR. HENDERSON : In the patent he speaks of a cascade connection of electron discharge devices irrespective of tuning to secure selectivity. As described and claimed in a co-pending application, serial number 11,512, filed March 2nd, 1915, by Irving Langmuir. You are of course the Irving Langmuir therein referred to, are you not ?—A. Yes.

Q. Do you recollect that there was a co-pending application ?—A. Yes.

Q. We are calling it that because it is called such. Did you know at the time that these two applications were being made together ?—A. Yes.

Q. Then may I ask you, please, which suggested the cascade connection to the other, you or Alexanderson ? I am referring now to a cascade connection of electrode discharge devices irrespective of tuning to secure selectivity. That was a part of the apparatus, was it not ? Which suggested that ? Did you suggest that to Alexanderson or did he suggest it to you ? Whose idea was it ?

MR. SMART : Well——

HIS LORDSHIP : Let the witness answer.—A. I think I can clear the whole thing up, if I may be allowed to tell you informally what the whole situation was.

MR. HENDERSON : Will you tell me first which of you suggested it to the other ?

HIS LORDSHIP : If you can, answer that, and then follow it with a direct statement.—A. Mr. Alexanderson suggested it to me, using tubes in series with geometrical tuning. He never suggested a tuning connecting tubes in series without geometrical tuning. I did certain things which we considered novel, and besides at that time I believed, and I suppose Alexanderson believed, that many of the things that we did with these tubes could not have been done with the audion. We thought the audion was sluggish, although we had no proof of it.

Q. That is at the beginning ?—A. That is at the beginning. And that is what led us to make some of these. Some of these things, patent applications, were made for me that were subsequently modified, and I do not know just what the history in the patent office was ; but there were considerable changes there due to the fact that our point of view changed, as we realized later on, due to the fact that in the beginning it seemed as though it was possible only to amplify radio frequencies by means of the new tubes I was making, it looked as though I ought to be able to have a claim on radio frequency amplification. The fact that I had for the first time made a tube which could amplify radio frequency made us feel that we ought to have a patent on that. And besides that, I worked out a great many different kinds of circuits with tubes in cascade with direct metallic connections between the plate of one circuit and the grid of the next, a resistance coupling, and various circuits that I worked out at that time which had not been suggested to me by Mr. Alexanderson. And we filed various applications on them. Then while those applications were still in the patent office——

Mr. Henderson: Q. Pardon me, what patent office, the patent office branch, or the patent office of the General Electric?—A. The Patent Office of the United States. Before the patent was issued, in a good many ways our understanding of the thing increased so that we began to realize, possibly also because we found by references of other people having done some of these things before some of the claims had to be dropped and modified and some of the claims that were made for me were later put over into Mr. Alexanderson's case, because of the fact that I came to realize that with the old DeForest audion you could have amplified radio frequency signals. The old DeForest audion as it existed in 1912 certainly was capable of amplifying radio frequency signals, and if we had tried it at that time, instead of making the new tubes which I made, we would have had the same result, although not as striking, because it was using more power and higher voltages, although that was not important. And to many of the details of these claims,—you mentioned one claim here in which was spoken of a cascade connection.

Q. A cascade connection of electron discharge devices irrespective of tuning to secure selectivity. Did you suggest that to Alexanderson or did he suggest it to you?—A. The general idea of cascade arrangement of audions was certainly suggested to me by Mr. Alexanderson.

Mr. Smart: Shall we have a little more time for lunch, as Doctor Langmuir is to look over these documents?

His Lordship: Court will adjourn now until twenty-five minutes after two.

Q. I have been looking over the last answer you gave, the lengthy answer, Dr. Langmuir, and throughout that answer you were speaking of a period of time commencing with the time when you thought it would be necessary to improve the audion in order to use it for high frequency. You recollect what I mean, do you not?—A. Yes.

Q. And, not intentionally, this reads as though you might have been speaking of a period beginning with the date of your application, and then throughout the proceedings in the Patent Office. You see what I mean, do you not?—A. Yes.

Q. Did you intend to limit this development of opinion to that time, or did you intend it to commence from the beginning of your discussions with Dr. Alexanderson?—A. The latter.

Q. The latter, I would have thought?—A. Yes.

Q. I just wanted to make that clear. That is to say, when Dr. Alexanderson first came to you, and first discussed this question with you, he emphasized the sluggishness of the tube?—A. I do not know that.

Q. Or you may have. I am not at the moment distinguishing between the two of you. The sluggishness of the tube was in your mind at least ?—A. Well, he told me that he had been told that the tube was sluggish.

Q. So I understood. That was my recollection. You did not then have a familiarity enough with the tube to have any definite opinion as to that, is that it ?—A. Why, it seemed to me reasonable that it should be sluggish, or that it might be sluggish at any rate.

Q. And, because of that sluggishness, was not adapted for use with high frequencies ?—A. Again, probably. We neither of us knew from our own experience and we were not concerned with that, because I knew definitely that I could make a tube that would have the advantages of the audion without the sluggishness and therefore I was not much interested in trying the audion.

Q. Did you ever make a test of the tube for direct current ?—A. What tube ?

Q. The DeForest tube, or the tube that Hammond sent you, the tube of that day.—A. Yes, I did.

Q. And what was the result ?—A. Well, we made measurements of the current that flowed to the plate and the grid, when we put different voltages on the plate and grid, and in that way got the characteristics of the tube.

Q. And what were they ?—A. They were plated in the form of various curves. It showed me that the tube gave an amplifying action with plate voltages up to a certain low value, 25 volts and so on.

Q. Are you able to set a limit ?—A. It was not sharply defined. It depended on the filament temperature.

Q. But as your study of the subject proceeded, you say you reached the point when you thought you would be entitled to a claim for high frequency amplification in the United States. Am I right ?—A. I think so. I do not know whether I decided that, or our Patent Department; but the results are about the same.

Q. The result is the same. I presume, and I am only asking for information—if I am wrong you will tell me, doctor—that you would work a matter out in your own mind and you would then present it to certain parties in the patent office as experts, as to whether or not the idea was patentable ?—A. No, not usually.

Q. Well, how would it work out ? Because you see I am applying myself now to what you say you did or the patent office did ?—A. I knew nothing about patent procedure at that time. I think at that time I had taken out at the most one or two patents, or had applied for one or two patents, and I knew practically nothing about the patent procedure, and I do not remember any case where I called any matter to the attention of our patent department. The relation of the laboratory and our patent department was different from that. There were certain men in the patent department who made it a frequent practice to come into the laboratory, and to talk with the different men, and ask them what they were doing; and they were usually the ones that pointed out to us that this or that thing was likely to be patentable, and they kept records of the progress of the

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No. 16. Irving Langmuir. Cross-examination —*continued.*

work until they finally decided that the time was appropriate for filing an application.

Q. And you say that there was a point at which you reached the conclusion that—I quote your own words :—

> " I ought to be able to have a claim on radio frequency application."

A. Yes.

Q. And you reached that conclusion in conjunction with the patent office. I am not particular as to that ?—A. Yes.

Q. That is right. May I ask you if you will perhaps agree, or correct if you agree with me that it should be corrected, this answer. As you stated it this morning, or as the stenographer took it, you say :—

> " We realized later on, due to the fact that in the beginning it seemed as though it was possible only to amplify radio frequency by means of the new tubes that I was making."

Should not that read :—" As though it was possible to amplify radio frequency only by means of the new tubes I was making." That is the " only " is in the wrong place ? I got the reporter to extend that answer for me ?—A. Yes, that would be a proper change.

Q. That is it would convey your idea more accurately if you put the word " only " after the word " frequency."—A. Yes.

Q. And then having reached that idea, you did make application for a patent on it, did you not ?—A. A patent that contained that among a good many other things.

Q. And that was the patent application which resulted in the Interference which we talked about this morning ?—A. I think so, yes.

Q. And to which DeForest and Peers were parties ?—A. That Interference, I understand was only on some of the issues of the case. Only some of the claims were involved in that.

Q. At that time, when you had that idea that you should have a claim on radio frequency amplification, did you know of Schloemilch and Von Bronk's work ?—A. No.

Q. But in point of fact Schloemilch and Von Bronk were cited against you in the Patent Office, were they not ?—A. I do not remember.

Q. Don't you remember the Interference proceedings in the Patent Office ?—A. No.

Q. You did not as a matter of fact abandon voluntarily at any time your claim to high frequency amplification, did you ?—A. I don't remember what happened to it. I don't think it is in the patent as issued in the United States.

MR. HENDERSON : Your Lordship will pardon me a moment. I want to be accurate about this.

MR. SMART : These are all matters of record.

MR. HENDERSON : No, I understand that the DeForest Interference did not have to do with high frequency.

Q. Do you recollect what the DeForest Interference did have to do with ?—A. You mean this one in which DeForest appeared ?

Q. Yes. I understand now that the DeForest Interference had to do with your broad claim to audions arranged in cascade ?—A. Yes, I think that is right, probably.

MR. SMART: My learned friend is speaking about a legal procedure. He should refer to the procedure.

MR. HENDERSON : Yes, I think it would be better to put it in. I put in, my Lord, so as to have no question about it, the Langmuir record in the Interference proceedings to which I am referring.

MR. SMART : I do not question that this is a copy of what it purports to be a copy, but I can see no relevancy as an Exhibit in this case. This is a whole record.

MR. HENDERSON : I offer it to show what the Interference was. I am not putting it in for the evidence, but for a specific purpose.

MR. SMART : It is not proper to use it as evidence in that way.

HIS LORDSHIP : What is the purpose ? Is there any particular application of it, Mr. Henderson ?

MR. HENDERSON : I am putting it in for the purpose of the issue, my Lord. The first part of the book shows that there will be no question between us as to what the issue was.

MR. SMART : It is a statement of procedure under the United States law, where the issues are defined in technical language.

HIS LORDSHIP : I would rather you proceeded with your questions first, Mr. Henderson. This is not a matter that I would take the trouble to look at.

MR. HENDERSON : I offered it merely to anticipate my friend's objection to it, and to please my friend I thought. I am not anxious particularly to have it in. I will withdraw it for the moment.

Q. But you continued to contest the interference with DeForest relating broadly to audions arranged in cascade, did you not ?—A. I don't think so. I think that the claims that were in interference with DeForest were much narrower than that.

Q. What do you think they were ?—A. I think they were limited in various ways.

Q. Can you tell me in what way ?—A. I don't remember. It may have been the resistance coupling. I think all their claims were limited to something more narrow than merely audions in series.

Q. We will see as to that. Then you said you thought you ought to be entitled to a claim for high frequency amplification in the United States, and you applied for it. Did you obtain that claim ?—A. I don't think so.

Q. Do you know who did ?—A. No.

Q. Do you not know that Schloemilch and Von Bronk obtained a patent on it ?—A. I did not notice that.

Q. Are you now familiar with the Schloemilch and Von Bronk patent ?—A. No.

Q. But you did not obtain that claim ?—A. I don't think I have any claim in any of my patents, on high frequency amplification. In the broad sense at least.

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Plaintiff's Evidence in Reply.

No. 16. Irving Langmuir. Cross-examination *—continued.*

Q. Then I have here and I will ask you to look at it, a photostat copy of the file wrapper of a claim filed in your name as assignee to the General Electric Company, and it is called broadly : A system for amplifying variable current. I ask you if you can identify this as a claim made by you ? I am turning it over rapidly but you will stop me if I am turning it too rapidly.

MR. SMART : If my learned friend has a certified document, I do not object to him stating what it is, and I will accept it as such.

MR. HENDERSON : This is a file wrapper. I will put in, my Lord, if my friend does not object, the file wrapper and contents in the matter of Letters Patent to Irving Langmuir, Number 1,282,439, which resulted in the granting of a patent as of October 22nd, 1918.

MR. SMART : This is a heavy record that is now being offered to your Lordship and I cannot see how under any circumstances it can be relevant to the issues in this case. What was done in the United States, with respect to the procedure in the Patent Office there and with respect to a different patent not in issue here.

HIS LORDSHIP : Certainly not, if it has to do with what the United States Patent Office did. That would have nothing to do with me, but I understand Mr. Henderson is not presenting it for that purpose. He intends to make a legal argument in some way.

MR. HENDERSON : I will tell my friend and your Lordship. I am presenting it for the purpose of showing that certain objections were taken in the Patent Office and were met in certain ways by the witness or those legally representing him on this application.

MR. SMART : How can the proof of representations which were made to the United States Patent Office with respect to a patent which is not in issue here, be relevant to this case ?

HIS LORDSHIP : I understand Mr. Henderson is later to make some legal argument by which he seeks to impeach the validity of Alexanderson's patent for the reason that certain phases of his work were performed by Dr. Langmuir. Something of that nature.

MR. HENDERSON : It will result in the horns of a dilemma.

HIS LORDSHIP : It is very hard for me to say, strictly speaking, what is properly receivable and what is not.

MR. SMART : I am only anxious to exclude a large amount of irrelevant matter.

HIS LORDSHIP : I do not care what the United States Patent Office did. Do not add to the record please by saying what they did.

MR. HENDERSON : Your Lordship of course is not bound by what the United States Patent Office did. Not judicially or officially, but it is simply evidence of what this witness says. It includes the affidavit, a portion of which I read this morning.

HIS LORDSHIP : I think if you will put your question directly to Dr. Langmuir, he will answer, and if there is any point, I will allow you to leave it and get it afterwards. Dr. Langmuir will tell you anything you want, if he knows it, I am sure.

MR. HENDERSON: I will come back to it.

MR. SMART: Does the record go in?

HIS LORDSHIP: Not for the present. Reserve it for the present. I do not see any objection to your putting the patent in.

MR. HENDERSON: The file wrapper?

HIS LORDSHIP: I understood first you were putting in the patent.

MR. HENDERSON: No, I put in the file wrapper. I will leave it for the moment and ask my associates to work out the particular matter.

HIS LORDSHIP: There must be some way by which you can summarize and put it directly to Dr. Langmuir.

MR. HENDERSON: I am going to do that and will call attention to these things, but your Lordship will understand that he has been dealing with so many of these things that it is hard to carry them in his mind, but I will refresh his recollection.

HIS LORDSHIP: The reason Dr. Langmuir does not memorize these details is that it is not a part of his business. It belongs to another department of the organization.

MR. HENDERSON: I am not blaming him for that at all. His mind is on his work, and I am not adversely criticising him. He is being watched by the patent office and communicating with them, and when it reaches the other stage it is their business and not his. When he is called to give evidence in a particular matter I have no doubt he does so to the best of his ability, and I am not questioning his integrity at all.

What I propose to do is to compare the claim as originally made with his affidavit and see how they vary—as bearing upon what he said this morning. That is all I intend to use it for.

Q. Have you during the lunch hour had an opportunity to examine the Vivian notes?—A. Yes.

Q. And having examined them can you answer the question I put to you this morning, do you agree with Professor Hazeltine that all that is referred to there is in reference to a tuned circuit having inductance and capacity in series.—A. No.

Q. In what respect do you differ from that?—A. The Vivian notes deal with the general principle of the mathematical development of the theory of tuning in geometric progression. In certain places mathematical equations are given that involve the impedance of the resonant circuit. Those equations seem to me to prove definitely that he had in mind a parallel connection of the inductance and capacity—parallel with reference to the relay from which the impulses were coming into the oscillating circuit in question.

Q. Will you be good enough to take the notes and show where in the notes you find that?—A. The notes do not deal specifically with the circuit involved in the relay. There is no reason why they should, because the discussion is a discussion of the selectivity of the circuit and in no wise depend upon the circuit in the relay.

Q. I should have said computations in the notes?—A. In the computations he calculates the impedance of the oscillating circuit, and the oscillating circuit consists of capacity and inductance in series from the viewpoint of the current he is considering.

Q. Can you show me that in the computation?—A. He gives, for example——

Q. Perhaps my mind operated too quickly. You say he shows in series in the computation?

Mr. Smart: In parallel.—A. Let me draw a diagram and I will show what I mean.

Mr. Henderson: Q. What was the last answer? I did not catch the end of it?—A. I think I said that the equations show that the——

Q. I started to ask another question, and I was informed you said "in series."—A. The equations given for the impedance in the notes——

Q. Page what?—A. All the way through wherever it occurs.

Mr. Smart: Would it not be better to have the explanation and go back to it afterwards?

Mr. Henderson: I want to identify what the equation he is talking about is.

Mr. Smart: Let him complete his general answer.

Mr. Henderson: I will let him finish.

The Witness: In the fifth line from the bottom of D-5——

Q. Finish up, please?—A. That equation gives impedance, a series impedance, of the oscillating circuit. Now if I place an inductance and a capacity in a closed circuit I have an oscillating circuit and when the implied impressed voltage acts on such a circuit it sets up oscillation, the strongest oscillation when the impressed frequency corresponds to the natural frequency of the resonant circuit. In any such circuit whether it is in the parallel connection with regard to some other circuit or not, there is an impedance along that circuit. The current that flows in that circuit is the important element to be considered, and in that circuit you have inductance and capacity in series, and you calculate impedance of that circuit with reference to the current that circulates in that circuit, and that is what is done in this case.

Now, that is the natural way to calculate the impedance that is effective in causing oscillation in what Hazeltine calls the parallel connection, or what I described this morning in the diagram that I drew where I had a series connection fed by the secondary of the transformer which was coupled with the plate circuit of the tube. Now these notes show parallel distinctly—that that was what the writer of those equations had in mind, if I can judge at all what he had in his mind from what he wrote down; that is, he is describing here the circulating current in the circuit which is not connected, not in series, at least, with the plate of the audion. If it were to be connected in the plate circuit of the audion, those equations are not applicable. They are only applicable to a circuit which is either connected in parallel, as Mr. Hazeltine said it should be connected, or better still, inductively coupled—that is through a transformer—to the plate circuit in the way I described this morning, in a separate circuit.

The fact that is of significance here is that in the equations here calculating impedance, he does not have any term that corresponds to the impedance of the relay; that is the resistance of the circuit. He has this inductance and capacity, but there is nothing in the equation that deals with the inductance and impedance or any of the characteristics of the relay, showing very clearly, I think, that this circuit was not a circuit in which the current would flow through the plate circuit of an audion. He would have gone at the thing entirely differently mathematically if he had wished to consider a circuit in which the plate was in series with the inductance and capacity. So that my conclusion is just exactly opposite to Dr. Hazeltine's.

Q. Is there anything that you can find in the Vivian notes referring specifically to the parallel connection?—A. It does not refer to either series or parallel connections. It is quite beyond. It has nothing whatever to do with that particular circuit involved. These equations do not refer to the circuit as a whole. They refer to the oscillating part of the circuit. In the oscillating part of the circuit, whether the circuit is in parallel or in series, the inductance and capacity in the oscillating circuit are in series. That is, the current flows first through one and then through the other, and therefore the equations for the series circuit come in and can properly be used in the theory that deals with the parallel connection with reference to the relay. This difficulty that he has been getting into illustrates very well what I have said this morning, that we have no right to consider or to lay any emphasis on the distinction between parallel and series connections. The whole viewpoint should be properly the impedance of the circuit—to get the best results, to be properly matched to the impedance of the tube, and that can be done with either a series or parallel connection of the resonant circuit.

Q. In your answer a few minutes ago you referred to a source of voltage, do you remember?—A. Yes.

Q. Will you please indicate that by a sketch, or indicate that in the sketch on the Vivian notes?—A. *I did that this morning.*

Q. You have just drawn a sketch. Have you indicated the source of voltage in it?—A. Well, this drawing that I have made does not really mean anything, because I have been adding a few lines here and there while I was talking.

Q. Will you draw a sketch of what you have been talking about indicating the source of voltage?—A. I have an inductance and a capacity, the inductance "L" and the capacity "C," and the source of voltage marked "V." Now that source of voltage may come from the transformer, or it may come from voltages that are introduced in the inductance "L" from the next magnetic field. It does not make any difference where the voltage comes from as far as the mathematics are concerned.

Q. Is that a circuit such as would fit the mathematics of the Vivian note?—A. It is if you consider that "V" is the source of voltage.

Q. Is it a series or parallel circuit with respect to that source of voltage?—A. A series connection.

Q. Then will you refer to the resonant curve at the end of the Vivian notes, and note the symbols 1 over Z and 1 over Z-2? Do these refer to the series or parallel circuit?—A. Either one or both.

Q. Either one or both, you say ?—A. Yes. It depends upon what impedance you have in mind.

Take a simple resonant circuit consisting of inductance and capacity ; if I consider the impedance around that circuit I will find it is a minimum when the circuit is in tune with the impressed frequency, but if I consider the impedance between the point A and the point B, I find the impedance is a maximum when the circuit is in tune with the impressed voltage ; that is in one and the same circuit, the impedance may be either a maximum or a minimum, depending upon what you have in mind, how you define the impedance and between which points you take it.

MR. HENDERSON : To avoid confusion, I am going to have the sketch you have just drawn marked, No. 1 being the one you referred to a few minutes ago and the other one the one you have just drawn.

EXHIBIT NO. 13 :—Filed by Mr. Henderson, Jan. 18, 1927. Sketches drawn by witness.

Q. In drawing the resonant curve in which way did Vivian take the circuit, in series or in parallel ?—A. The drawing shows here he was considering the impedances in the enclosed circuit, round the circuit.

Q. In series ?—A. I would not say in series. I do not wish to imply that it is in series, but in every part of the circuit. Just as Professor Hazeltine said yesterday, if you have nothing but inductance, without an external circuit, the terms " series " and " parallel " are entirely ambiguous for such a circuit as that last one that I drew. There is no distinction between parallel and series except with reference to something else. It is a pure matter of relativity. If I am considering a circulating current, the impedance for that circulating current is the impedance of the two elements in series. If, however, I am drawing that with reference to some wires connected to it in any way, the same circuit, the same oscillating current is a parallel circuit, and if you have an oscillating circuit connected, for example, with a relay, whether it is connected in series or in parallel with that relay, you have to consider mathematically only the circulating current in that, and from the viewpoint of that circulating current you always consider as a series the two things in series from the point of view of the inside current. The current flows through one and through the other, but because of the fact that the current flows from the capacity to the inductance does not make it in any sense at all a series or parallel connection with reference to the relay.

Q. In a simple series tuned circuit is the impedance a maximum or a minimum when it is resonant ?—A. With reference to what ? An input circuit ?

Q. A simple series tuned circuit ? Perhaps you can explain it better if you just take this sketch I have just given you. A simple series tuned circuit, with a source of voltage ?—A. You want a series tuned circuit with a source of voltage ?

Q. Yes ?—A. That is the first diagram.

Q. That is the upper diagram on Exhibit Z-13 ?—A. With reference to the source of voltage that is a series resonant circuit.

Q. Then in that circuit is the impedance a maximum or a minimum at resonance ?—A. It is a minimum.

Q. In a simple parallel tuned circuit is the impedance a maximum or a minimum at resonance ?—A. There again, to make it clear, what is meant by parallel ? It is parallel with reference to the implied impressed voltage.

Q. That is what I mean ?—A. I have drawn here a resonant circuit in which there is an inductance " L " and a capacity " C " and a voltage impressed on these two in parallel.

Q. The source being—— ?—A. The source of voltage being "V." Now in this circuit there are two impedances which may be considered and usually are taken into consideration.

Q. Will you answer my question as to both ? What I am interested in is as to the source ?—A. The meaning of impedance—impedance gives the relation between voltage and current. The higher the voltage necessary to produce a given current, the higher the impedance. There are two currents here. There is the current that is supplied in the circuit, we will say " M," and there is the circulating current in the resonant circuit which I might call " N." Now the impedance of the circuit—that is the relation between the current in the wire " M " and the voltage " V "—is such as to give an impedance which may be considered the parallel impedance or the impedance of the parallel resonant circuit. That will be a maximum without any resonance.

Q. That is the one we are concerned with.—A. I think the Vivian notes were concerned with the other one. I think that is where the confusion in Professor Hazeltine's mind has occurred. In this circuit which Hazeltine calls the parallel connection there is a circulating current in that resonant circuit, and that is the larger part of the current. It is the important part of the circuit, and that circulating current has a voltage and a current.

And there is an impedance in that circulating circuit ; and that impedance, mind you, in the same circuit which we have been talking about before, in the same set off, becomes a minimum when the other one becomes a maximum. So that you can see that if one person talks about one of those impedances and the other person talks about the other one, they are likely to talk at cross-purposes.

Q. The latter portion is simply in series, as the other ?—A. This is an impedance in a circuit which Mr. Hazeltine has called the parallel resonant circuit ; and that is the only impedance which could have been in the mind of the man who wrote the equations, for example, in Mr. Vivian's report. It is the only impedance which will fit the equations given in Mr. Vivian's report.

Q. In the circuit which you sketched this morning, and which is marked Exhibit 14, purporting to explain the sketch of the Vivian notes, is the impedance of the system connected between the plate and the filament a maximum or a minimum at resonance ?—A. I do not know just what you mean. The circuit that is connected between the plate and the filament ?

Q. Is the impedance of the system connected between the plate and the filament——?—A. For example, what I presume by C is coupled to that, but whether it is connected to it or not I do not know, just what you mean by " connected with " or " connected "——

In the Exchequer Court of Canada.

Plaintiff's Evidence in Reply.

No. 16. Irving Langmuir. Cross-examination —*continued.*

Q. The impedance measured as between the primary terminals of the transformer which you have drawn ?—A. If the secondary, for example, is disconnected or open circuited ?

Q. Just as it is ?—A. Why, I think that will depend a great deal upon the particular constants of the different parts of the circuit.

Q. What constants do you assume in your drawing ?—A. I have not assumed any.

Q. Then will you on that exhibit add to that exhibit now the values of the circuit perhaps suitable for a broadcasting receiver ?—A. I am not familiar with the values ordinarily used in these circuits for broadcast receiving.

Q. Values of constants are always important, are they not ?—A. I have not worked in this field for quite a number of years in the actual putting in of particular numerical values of those.

Q. But you know that Mr. Hazeltine has, do you not ?—A. Why, yes, he specializes in that.

Q. And you know that he has given his evidence based upon very elaborate calculations ?—A. I do not know what he has based them on.

Q. Would you care to take his calculations overnight and see if you can criticize them, Dr. Langmuir ? We would be pleased to let you have them ?—A. I have no interest in them at all.

Q. We are agreed, of course, that the value of constants is always the foundation of the kind of statements that you have been making ?—A. No, I do not agree with that.

Q. You do not agree that the value of constants has always been considered ?—A. Certainly not.

Q. I thought so from the first thirty pages, as I say, of the book, when I first commenced this study. Is not that one of the first things a student is taught ?—A. Sometimes ; sometimes not.

Q. Is it not proper teaching ?—A. I do not know.

Q. And you say you are not sufficiently familiar with this art to make that statement ?—A. I could calculate a good many of them, but they are entirely unimportant, because I know that they can be so chosen in order to get certain results ; for example the impedance of these different circuits can be adjusted by methods that are perfectly well known to the ordinary electrical engineer. For instance one of the references you made this morning was entirely dependent upon the size of the condenser and upon the constants used. You can make a very innocent looking thing upon paper very dangerous in practice, can not you ?—A. Oh, you can do almost anything, I suppose, if you wish to be dishonest, yes.

Q. Yes, you can make all kinds of a sketch. Then, have you during the lunch adjournment looked again at the letter from Dr. Alexanderson to Mr. Davis, that is the February 4th letter ?—A. Yes.

Q. And are you now able to answer the question I put to you with reference to the quotation from the second paragraph of the first page, which I will give you again :

> " The method of suppressing interference by means of tuning consists in using an electric circuit which has a very low admittance to single impulses of voltage."

Can you state whether this quotation refers to a series tuned circuit or to a parallel tuned circuit ?—A. He has no reference to either.

Q. Do you agree with Professor Hazeltine that the statement in that question is in accordance with the notes of Vivian and Thomas ?—A. Well, in a general way, yes, but not in the particular way that Mr. Hazeltine tried to make out.

Q. I will take that answer subject to the discussion as between a series and parallel that has already taken place, Dr. Langmuir. I understand from your evidence of yesterday, on page 590 of this record, that you are of the opinion that a series tuned circuit is not applicable to the plate circuit of an audion wholly because the series condenser would interrupt the circuit for direct current. Is that a fair way of stating your opinion, that your reason for saying that a series tuned circuit is inapplicable in this discussion is because the series condenser would interrupt the circuit when direct current was being used ?—A. That is only one factor. There are others.

Q. What were the others? I gather that you gave them and I do not want to take you over it again ?—A. That is the difficulty that, of course, would have to be overcome.

Q. Did you not give that at page 560 of the record as the main and I think the only difficulty you mention there—page 590 I should have said ?—A. I think perhaps not right there but in some of my discussion I emphasized the impedance.

Q. I read this last night, at page 590. You see what you said there, "Mr. Hazeltine wished to draw a sharp distinction between parallel connection and a series connection in the plate circuit of the vacuum tube; and he said that the plate circuit or the resonant circuit of the plate circuit was always of the parallel kind. And that would seem to imply that you could have a series connection. Now it was perfectly well known to anyone skilled in the art, I think, in 1912 or 1913, that you could not use a straight series connection at all in the plate circuit of an audion. If you had taken the plate and put it in series with the inductance, and then had put in series with that a condenser, you could not get any current through it. You have no closed circuit. So that it was not a matter that you would have any choice about. If you were going to set up an audion and transfer energy from one tuned circuit over to another tuned circuit, it was not only obvious that you should connect it in the way that Mr. Hazeltine has described as parallel connection, but it was the only feasible way to connect it. I do not know of any circuit, any vacuum tube circuit, where there has ever been any attempt to connect it in any other way; and that is from the very earliest days when such a circuit was used." That, you see, was the last thing you said last night. Were you intending to mention any other ?—A. I think I had previously mentioned others.

Q. Well, dealing with that, are you not aware that this difficulty could be obviated by employing a well known device ?—A. The choke coil ?

Q. The choke coil ?—A. Yes.

Q. That is the common name—you knew that at the time ?—A. I do not remember having thought of it at the time.

Q. You did not think of it when you were giving this answer, did you ?—A. Yes, I did.

In the Exchequer Court of Canada.

Plaintiff's Evidence in Reply.

No. 16. Irving Langmuir. Cross-examination —*continued.*

Q. Well, why did not you say it ? You said here, " You could not get any current through it." —A. You could not, with the straight series connection, without adding an auxiliary device, which I understand is the matter of a patent which has been rather recently issued.

Q. But that would be an obvious thing to do, would it not ? —A. If you wanted to. But my point is this, that you could not do, even if you wanted to, what Mr. Hazeltine suggested that Vivian had in mind, without running into a serious difficulty. Now, it is true that if you had wanted to do it badly enough, an engineer at that time could have thought of a means of getting around the difficulty ; but, if he had given the matter as much thought as that he would have seen that there were much better circuits to use, and therefore he would have had no desire to do it.

Now as a matter of fact the thing can be done in that way, and, under certain conditions, it is a rather good thing to do ; but it is a way that is very difficult, and it would be adopted only as a last resort. Whereas the natural thing to do is to do either one of the two things we have suggested, either use a straight parallel connection or use any kind of a tuned circuit with a transformer between the tuned circuit and the output circuit of the tube, in order to balance up the impedances.

Q. I was just going to ask you that, and I want to repeat it. You referred a short time ago to matching the impedances of the vacuum tube to the impedances of the output circuit. Was that known in 1913 ? —A. Why, it was done in 1913.

Q. Was it done knowingly ? Did you yourself have knowledge of it, real knowledge of it, at that time ? You were doing many things then without knowing that you were doing them ? —A. What we did usually in 1913, and I think that is probably true of most people who were working in the field, is that we put together a lot of things and tried them out without measuring them. We never calculated the constants of the circuit. We did not calculate the impedances of the tube ; but we did know the fundamental principles in a general way ; and we knew that in order to get the right results you had to try out a lot of different circuits and get the best results. Now, what was accomplished by that method was the planning of the circuits.

Q. At that time, in other words, you would in the course of trying things out, at times, balance the circuits ; but you did not call it that then, did you ? —A. No.

Q. You did not really know that you were doing that then, did you ? —A. We knew we were getting——

Q. You knew you were getting something ? —A. But, remember, it is not essential to absolutely balance the circuits. When we tried this out, this tuning in geometrical progression, we made some rough calculations to design some of the coils and get certain voltages, a certain order of magnitude of the applied voltages ; but we did know the general function of a radio frequency transformer, and we knew that by varying the coupling and varying the number of turns, that——

Q. That certain things would actually happen ? —A. Yes, but that was largely empirical.

Q. Precisely, and you actually had to build a thing before you really knew what you could do ?—A. Not in a case like this.

Q. Is there not a difference between theory and practice there ?—A. In some cases there is.

Q. But in this case, right in this thing, you had certain theories in your mind which you believed in, I dare say, but you actually had to build the thing before you proved your theories to be correct, did you not ?—A. I do not think that. I know we did not have to do that in the case of this particular invention of Alexanderson's.

Q. What is the invention of Mr. Alexanderson,—a mere idea ?—A. The tuning is geometrical progression.

Q. The idea of tuning in geometrical progression ?—A. I hope you do not wish me to define the invention from any legal point.

Q. When did you first actually tune by what you call the Alexanderson system in geometrical progression ?—A. In May, 1913.

Q. Not until the 14th May, 1913 ?—A. Yes, thereabouts.

Q. Now, prior to that time you thought you could do it, believed you could do it,—put that as strong as you like, and that was the situation, was it not ?—A. Oh, I should say we knew we could do it under proper conditions.

Q. You knew you could do it if you could do it ?—A. You might fail the first time because you had not tried long enough. If we had not succeeded the first time we would have kept on until we had ; and the only reason we could not have done it the first time is because we had not done what Alexanderson had told us to do

Q. It is fair to say, Dr. Langmuir, that at that stage of the proceeding you knew things were happening pretty rapidly in the radio art, did you not ?—A. No, I was not even conscious of that.

Q. But your patent office was, surely ?—A. They were getting to be, but——

Q. I will admit they were mightily slow in some ways ?—A. A year later, I would say, the activity started.

Q. Is it likely that either you or they would have wasted any time when you even had something ?—A. Why, we did not waste any time.

Q. I thought not ?—A. I do not know just what you mean by that.

Q. Now, passing to a slightly different matter——?—A. May I just add something there to that ?

Q. If you wish to, certainly ?—A. It never has been the policy in the General Electric Company, as far as I know, to file applications extremely rapidly. As I understand the law, you are amply protected if you keep good notes ; there is no particular hurry in filing an application as long as you are working in the field actively. There is no great haste. I have never been impressed with any great haste to patent things.

Q. I am not assuming that people tumbled over one another, but others were moving and it is a fair assumption that they moved with reasonable promptitude, is it not ?—A. I do not know that we knew that others were moving in this field. We thought we were rather pioneers of it.

Q. At all events we have the 14th May as the date, and we can compare that with the other dates,—the 17th May was the date, and I was wrong in saying the 14th May,—when you actually did the thing experimentally ?

—A. I do not remember the exact date. I know it was before the 18th, but I do not know just how long before the 18th. I think it was several days before the 18th.

Q. Then my friend, Mr. Smart, asked you as to when you made some use of the system, and you told him of *something* you did at the home of Mr. Kinney?—A. Yes.

Q. And I understand that he was some three miles out of Schenectady?—A. No, from the General Electric Company's plant, but still in Schenectady.

Q. From the General Electric plant, which I took to be Schenectady.—A. It was still in the city, at one end of the city.

Q. You went out there, I gather, to avoid interference?—A. Yes.

Q. To get away from urban interference?—A. From disturbances occasioned in the General Electric Company's plant.

Q. I did not think of that at the moment. I suppose there are all kinds of electrical disturbances there?—A. Very serious disturbances.

Q. Will you describe the apparatus which you made use of there,—what was it?—A. I do not suppose you want a description of the antenna circuit, do you?

Q. You told us that you had the advantage of an antenna there and so on. I have not the page. Could you draw a sketch of the apparatus which you used there?—A. It is practically identical with the sketch in the first figure, figure 1 of the Alexanderson patent, except for the oscillating circuit which was added, the fourth tube that was used to produce the oscillations.

Q. How far apart were the coils in the different stages?—A. Well, we used pretty large coils. I can give you a general idea.

Q. What I have in mind is this, I have heard mention of ten inches apart and twenty-four inches apart,—were they either of these distances or about that?—A. The coils were cylindrical coils, I would say, about twelve inches in diameter, and we used different numbers of turns on those. We had a great many different taps coming out on them.

Q. To experiment on the different taps?—A. Yes, so as to be able to vary the frequencies of the signals we received there. And we tried out the combinations which gave the best results in each case; and those coils were varied in distances, from a few inches apart up to at least twenty-four inches, I would say.

Q. What would you say was "a few inches"?—A. In a few cases they were probably placed almost in contact; but usually, I would say, they were from ten to twenty inches apart.

Q. And up as high as twenty-four inches?—A. Yes.

Q. Did you ever build any practical apparatus before this Kinney test?—A. You are referring now particularly to the Alexanderson circuit?

Q. Oh yes, that is what I am talking about, what we are calling here the Alexanderson circuit?—A. Well, of course, this test that I spoke of, where we received the signal from Honolulu, was not by any means the first test we made.

Q. What was the date of the Kinney test, by the way?—A. The one of which I spoke when we received the signals from Honolulu was in the early part of January, 1914.

Q. What was the date at Kinney's ?—A. That is where it was.

Q. That is where you received the Honolulu signals ?—A. Yes. But we had been working,—there was a continuous series of experiments in between May and January of the next year.

Q. Those were laboratory experiments ?—A. Laboratory experiments and in Mr. Kinney's house.

Q. In Mr. Kinney's house you commenced in January, 1914 ?—A. Oh no.

Q. When did you commence there ?—A. As far as I have mentioned, we ended there.

Q. When did you set up the apparatus in Mr. Kinney's house ?—A. It came about rather gradually. Mr. Kinney already had a small antenna and was a radio amateur. He was connected with the General Electric Company, but not in the research laboratory. He was the most successful amateur we knew.

Q. Were antenna rare in those days ?—A. No, but not good ones.

Q. Did he have an exceptionally good one ?—A. Probably one of the best at Schenectady.

Q. In what regards,—in height ?—A. I suppose it was sixty or seventy feet high.

Q. What on,—steel towers ?—A. A wooden pole on top of his house.

Q. Up from the top of his house ?—A. Yes sir.

Q. That would be rather an exceptional height for an ordinary amateur, using the word " amateur " in the sense of an ordinary layman, of what the newspapers call a radio fan, but he had an antenna at least sixty or seventy feet high ?—A. I should think so, yes.

Q. And the length would not matter particularly ?—A. On the long wave length I suppose it would help.

Q. When, now, do you think you started to experiment at Mr. Kinney's house ?—A. Well, Mr. Kinney started the first experimenting himself; and we gave him some of the tubes that we had been making; and just what he did with them I do not know. I know he began to get very, very good results with them, receiving radio signals; such good results that we decided that we could utilize his experience and work with him.

Q. Do you know what arrangement Mr. Kinney was using, what kind of set he had ?—A. Prior to that time, before we gave him the tubes ?

Q. With which he used these tubes which you gave him ?—A. Why, I do not know. To begin with, I suppose the straight DeForest connections, the DeForest audions, but he used higher voltages and he got more power and got much better results.

Q. In those days did the sets have names—I thought they did, even then, although please understand that my practical experience commences very much later than that ?—A. I do not really know what Mr. Kinney had before he used the circuits that we suggested.

Q. You see, we have got a gap between May, 1913, and January, 1914. Mr Kinney, I gather from what you say, was a well-known amateur ? —A. I would not say " well-known."

Q. Well known to you?—A. No. He was not known to me at all.

Q. To the General Electric men?—A. No.

Q. How did you get into touch with him?—A. Mr. White was the man who was developing these tubes.

Q. Was he a friend of Mr. White?—A. He was a friend of Mr. White, or Mr. White knew him.

Q. When would it be, in the summer of 1913 or the Fall?—A. During the early summer of 1913, I think.

Q. I just want the fact. Let us get something definite. In the early summer of 1913, you say, Mr. White supplied Mr. Kinney with some tubes as they went along, and Mr. Kinney took them out?—A. Mr. Kinney and Mr. White worked together very largely, quite a good deal, in testing out tubes for radio purposes.

Q. I am quite content to take it from you. When do you say it was, in June or July?—A. I could not place it closer than two months,—as far as I know any time between June and August.

Q. Some time between the 1st of June and the 1st of August, would you say?—A. Yes.

Q. Do you know what Mr. Kinney did?—A. No, I do not know what he did, not at first.

Q. Then was it during that summer that you went out to Mr. Kinney's?—A. Not that summer, no, the fall.

Q. You went out to Mr. Kinney's?—A. Several times.

Q. Would Mr. White be out there?—A. Mr. White used to go there very frequently.

Q. Now tell me this, were the tubes available to Mr. Alexanderson and yourself during the period from February, 1913, to May, 1913, unidirectional coupling devices?—A. Substantially so, yes.

Q. Is that the best way you can answer it, "substantially so"? Let me ask you, Is it not true that there was electrostatic coupling between the grid and the plate of the tubes you were using there?—A. Some, yes.

Q. When did you first discover that fact,—I do not want to know the day?—A. About June, I would say, 1913.

Q. How did you come to discover it?—A. When we got a tube to oscillate without any external coupling between the grid and the plate circuits.

Q. Did you ever put that electrostatic coupling between the grid and the plate to any use?—A. Yes, to produce oscillations.

Q. Did you use the oscillations for any particular purpose?—A. Yes.

Q. For what purpose?—A. To get the heterodyne notes sometimes.

Q. When did you do that?—A. Along the early summer, June or July, 1913.

Q. Then did you attach any importance to that in the summer of 1913?—A. Well, in what way? I do not know.

Q. In any way. You say you used it to produce oscillations. Did you attach any importance to that?

Mr. Smart: While I do not wish to restrict my learned friend, if my learned friend is going into the question of other inventions and not the questions in this action, I do not think the cross-examination should go that far.

MR. HENDERSON: I give my friend credit for rising to the defence of the witness when he sees the cross-examination is coming to something dangerous.

MR. SMART: I do not think my friend should say that.

MR. HENDERSON: Will my friend look at page 579 of the record and see if he still objects. It is very unfortunate that my friend should interrupt. If he does not know of the record, he should. And I would ask my friend not to interrupt at this point.

MR. SMART: It is for his Lordship to rule. My objection is taken with regard to leading the inquiry into heterodyne circuits and other matters which are not in question in this action.

MR. HENDERSON: I am not leading into heterodyne circuits and have no idea of it.

HIS LORDSHIP: It was mentioned by one of you.

MR. HENDERSON: By the witness. Q. Did you at that time attach any importance to it?—A. I do not know really what you mean by importance, or whether I did or did not attach importance, in the sense that you mean.

Q. To the use of the electrostatic coupling between the grid and the plate?—A. We thought more of the magnetic coupling that we got from an external coupling between inductance from the plate circuit and the grid circuit.

Q. But you did make use of it?—A. We made use of it. I do not mean deliberately and consciously.

Q. Oh, that is another thing that you know now that you were doing, is it?—A. We knew then that we were doing it.

Q. But you said yesterday, This action is a relatively insignificant one at frequencies for which we were thinking of using the tube in 1913? —A. That is perfectly true. I was talking about radio reception.

Q. You were talking about the audion as an efficient one-way relay, as you called it, and you said:

> "The audion is a remarkably efficient one-way relay. When used with low frequencies it is a practically perfect one-way relay."

What do you say, Dr. Langmuir, as to the present day vacuum tube as a uni-directional device?—A. The same as I did then.

Q. Is it still regarded in the art, as you understand it, as a uni-directional coupling device?—A. Specially for second order effects, yes.

Q. I ask you this, if you think that is a fair answer to my question? —A. In all of this I suppose you have reference to Alexanderson's patent in geometrical tuning, rather than to some circuits that are now in use.

Q. I am asking you this question because we are dealing with Alexanderson's patent, but I am asking you the question, Dr. Langmuir, if in the art to-day the vacuum tube is generally looked upon as a uni-directional coupling device?—A. All those things depend upon the point of view. When Mr. Hazeltine works out a neutrodyne circuit, he is considering

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that as the very basis of his work; his patent deals with the capacity of the electrostatic coupling; that is what is in his mind as the most important thing, and he tries to find a means of overcoming its bad effects. But if we put ourselves back into the position of 1913; a man who did not have a method of geometrical tuning—to that man the audion is a most remarkably efficient one-way device.

Q. My question to you was as to how the vacuum tube is looked upon in the art to-day. You have said that in your opinion it is substantially a uni-directional coupling device. I ask you, is it so looked upon in the art to-day?—A. I think it is, except by those people who are particularly considering this electrostatic coupling which you have discussed. In other words, it is a question of relativity. Is a thing large or is it small? It is only in relation to something else that it is large or small.

Q. To the average user who suffers from the effects of squealing and howling, how is it? Can you answer that?—A. Why, even to him it is a one-way device, in so far as it is a relay. Its relaying action is a one-way relay. It only amplifies in one direction, for example. That is the essential property of a relay is to be able to amplify. Now its amplifying action goes in one way only. It is true that there is an electrostatic influence of one of the circuits upon the other, while there is this apart from the tube, the circuits react the one on the other, and unless you put each circuit in a separate copper box, the circuits act on one another, but that has nothing to do with the property of a relay; the relay is a one-way relay and this secondary effect you speak of, the capacity, is something that is intimately connected with its relay action, and it is a small effect, a very small effect at long wave lengths such as we were using in 1913.

Q. Have you made any tests as to that?—A. Tests as to what?

Q. Tests as to the extent of the effect?—A. Why, yes; I have not personally, but the various men in the laboratory have.

Q. Not personally. I want to know what the basis of your statement is?—A. I am very intimately associated with several men in the laboratory who have specialized in methods of studying the characteristics of tubes, including the electrostatic effects that you speak of.

Q. We are going to hear more about them. Do you recollect the interference between yourself and Armstrong, Number 40,227?—A. I do not remember the number. I don't know.

Q. I don't expect you to remember the number. Do you remember the Langmuir and Armstrong interference?—A. Did you say Armstrong?

Q. Yes, Armstrong.—A. On oscillating circuits?

Q. Yes.—A. Yes, I remember.

Q. I find at page 11, and question number 19,—put to you apparently by your own Counsel:—

> "In your answer to question 15 you stated that a coupling between the resonant receiving circuit, and resonant detector circuit takes place through the audion itself. What is the nature of this coupling?"

Your answer was:—

> "The resonant receiving circuit is coupled to the detector circuit in two ways."

Will you be good enough to take the book?

> " First by the electrostatic coupling between the electrodes within the bulb; and second by the action of the audion itself by which the electron current flowing to the plate of the audion is controlled by the potential of the grid of the audion, the electrostatic coupling would be practically the same whether the filament of the audion were heated or not; whereas the second kind of coupling exists only when the audion is functioning normally."

Do you remember that?—A. I don't remember making that statement, no.

Q. Do you still adhere to that statement?—A. Yes.

Q. Will you be good enough to tell me what circuit you had in mind when you made that statement?—A. I don't remember.

Q. Would it read on the Alexanderson arrangement?—A. No.

Q. Why not?—A. Well, I presume that I was talking about the subject matter of this interference; that is about the production of oscillations in the tubes.

Q. What is there in this that would not apply to the Alexanderson arrangement? Will you be good enough to look again at question 19, which you answered.

> " A coupling between the resonant receiving circuit and resonant detector circuit takes place through the audion itself."

What is there in that which would not apply to the Alexanderson circuit? —A. Well, it does apply to the Alexanderson circuit, but in that case the electrostatic coupling becomes relatively unimportant. That is, it is not a useful function. It limits the affection* of the Alexanderson device, or circuit. It is true that if there were no such coupling, you could get a greater degree of advantage by the tuning in geometric progression. * *sic?*

Q. Do you do anything in Alexanderson to control it?—A. We do not need to.

Q. Do you attempt to?—A. That was not Alexanderson's idea.

Q. In any use to which you have known Alexanderson to be put, was any attempt made to control it?—A. Why of course, in Mr. Hazeltine's circuits and various other circuits, there are special means now of avoiding that. We did not do that in our tests when we received these Honolulu signals. We had no difficulty in getting these signals although there was this electrostatic coupling. It was absolutely negligible at that time compared to the advantages we were getting from the tuning in geometrical progression.

Q. But why don't you need to control it, in Alexanderson of course, I mean. Can you tell me why?—A. You do not need to control it unless you get oscillations, and there is a large operating range in which you can use the Alexanderson circuit without having trouble from oscillations.

Q. Don't you want to use it fully?—A. Why, we did not want to: we were quite content with the results we got.

Q. Did it ever occur to you to attempt to control it, or did you know it was there?—A. We knew that under certain conditions our sets oscillated.

Q. Did you know why?—A. We knew it was because of coupling between the plate circuits and the grid circuits.

Q. Did you know that coupling was there? Did you recognize that? —A. Yes, we knew there was an electrostatic coupling, but I believe, or I think it is still true, or I still believe, that in the tests that we made at Mr. Kinney's house, it was not the electrostatic coupling in the tube that produced the howling or the oscillations, but it was the electrostatic coupling between our various coils, various wires, that was the source of trouble.

Q. Speaking of the tests at Mr. Kinney's house when you received Honolulu, when San Francisco could not receive it, you remember that time?—A. Yes.

Q. Do you attribute that result to the selectivity of the system?—A. Very largely. Yes, mainly.

Q. Mainly?—A. Well of course there were undoubtedly at that time various atmospheric disturbances which prevented San Francisco getting the signal from Honolulu.

Q. That might have been, but you did not intend to suggest that it was because of local conditions at San Francisco that you could hear when San Francisco did not, did you?—A. I did not intend to suggest anything one way or the other.

Q. You intended to suggest the superiority of the Alexanderson system, did you not?—A. Yes.

Q. Let us assume that that was the superiority of the Alexanderson system alone; was that due to the selectivity of the system? Were there any interfering stations that had to be tuned out?—A. No, but there was static. Lots of it.

Q. That is a word I do not like to hear?—A. Well that is what we called it in those times.

Q. That is what you called it?—A. Yes. Noise. There was lots of noise in the telephone receiver, which we did not like.

Q. In the light of your present day knowledge, would you say that noise was due to interfering stations?—A. Not due to stations, no. There were no stations interfering.

Q. There were no stations to interfere, were there?—A. Not in that wave length.

Q. Then in any of your conversations with Dr. Alexanderson during January and February, 1913, did he suggest that the selective system which he had in mind also included the element of amplification?—A. Will you repeat that please?

Q. In your talks with Dr. Alexanderson in January and February, 1913, did he suggest that the system which he had in mind and which was talked about as a system of selectivity, also included amplification?—A. I do not remember whether he suggested that or not. The question of amplification—of course we knew that the audion amplified.

Q. When did the question of amplification arise between you and Dr. Alexanderson? Can you recollect that?—A. No.

His Lordship: Did it ever arise?—A. I mean not in the form of a question between us.

Mr. Henderson: I do not mean in the form of a question. You did make claims on amplification during that summer. When did that arise?

MR. SMART: I think the witness is endeavouring to answer, if my friend will permit him.

HIS LORDSHIP: The witness does not quite understand the sense in which you have put it.

MR. HENDERSON: Will your Lordship care to put it? Or shall I put it again?

HIS LORDSHIP: No. Put it again.

MR. HENDERSON: You understand what I mean is this, Dr. Langmuir. You have told us that in the early part of 1913, in January and February you and Dr. Alexanderson had frequent conversations with respect to something that he had in mind and which matured into the Alexanderson invention that we are concerned with, and you have talked about that as a system of geometric selectivity. Now I find later on amplification crept into it. I want to know if amplification was discussed between you and Dr. Alexanderson in January and February?—A. I have not any doubt but what it was, in connection with the use of the audion in the first place; and in the second place, in connection with the tuning in geometric progression; and then I thought a great deal about amplification in connection with lots of other applications that year. After that, in the next year, I spent a great deal of time in working out applications of the vacuum tube that involved amplification.

Q. I know you did. That is why I am trying to ascertain whether or not you and Dr. Alexanderson discussed amplification in the early part of the year?—A. I have no conscious recollection of having discussed amplification with Dr. Alexanderson except as an incident in connection with the use of the audion, and the use of the system of geometrical tuning.

Q. Have you any conscious recollection of having discussed it with him even as an incident of geometrical tuning?—A. I have no recollection of the specific occasion, but I know I must have done so.

Q. Then you are merely reasoning back?—A. Yes.

Q. But you cannot recollect it. It was your habit generally, was it not, doctor, to make notes of conversations that had any significance?—A. I have very irregular habits in that regard. I write down those things that interest me, and generally I do not write things that do not interest me.

Q. Coming now to what you said about the Stone patent, I gather that you did not even hear of its existence until somewhat recently?—A. Well, perhaps within the last five years or so, somewhat along there.

Q. That will be sufficient for the purpose, probably. You said in connection with litigation?—A. Yes, but I imagine it was prior to that.

Q. I suppose that was recent litigation?—A. I think I had heard of it perhaps four or five years ago, but even then it may have been in connection with litigation.

Q. Were you familiar with or have you since become familiar with the paper read by Mr. Stone at Montreal? I show it to you. We have it in evidence. It was read away back in 1905 at Montreal?—A. No, I am not familiar with that.

Q. You have never heard of it?—A. No.

Q. Have you since become familiar with it?—A. No.

Q. You have never read it ?—A. No.

Q. Then can you fix with any reasonable degree of accuracy, when you first heard of Stone ? When I say heard of him, I mean his work ?—A. Do you mean with this particular circuit ?

Q. Yes ?—A. I think I heard of Stone's work when I visited John Hays Hammond Junior in probably April, 1913.

Q. When you visited John Hays Hammond in April, 1913, and you think that was the first time ?—A. Yes.

Q. I suppose it is a fair assumption that you had kept track of Marconi's work, or had you ?—A. No, I had not, except in regard to fundamental principles of radio telegraphy, many of which originated with Marconi.

Mr. Henderson : As a layman I am rather surprised at that. Have you not followed up the different stages of Marconi's development ?—A. No.

Q. You know now there are different stages ?—A. I am not familiar with them.

Q. Have you at any time examined the different Marconi patents ?—A. I think I have seen one or two of his patents several years ago, but I am not at all familiar with them. I do not remember what is in them in detail.

Q. I do not know what your practice is. You may be superior to ordinary sources of information, but are you in the habit of reading standard text books ?—A. Not on radio.

Q. Not on radio ?—A. No.

Q. Did you know of the Flemming tube ?—A. Yes.

Q. And in 1913 of course you knew of the Flemming tube ?—A. Yes.

Q. Had you read Flemming's book then ?—A. No.

Q. Will you be good enough to look at what we have in evidence, page 807, of Mr. Flemming's book, where there is a prospective view of the Marconi tuner as it was called. Had you seen that at that time ?—A. No.

Q. Had you heard of it ?—A. I do not remember.

Q. Had you any idea as to how it worked ?—A. No, I do not remember if I heard of it, therefore I would not be likely to remember that I heard how it worked.

Q. Looking at it does not refresh your recollection ?—A. No.

Q. Do you know now what it is ?—A. No. It is three coils on top of the box. That is all I notice.

Q. Had you ever seen the Schloemilch and Leib system ?—A. No.

Q. I show you now Fig. 1 of the Schloemilch and Leib patent and ask you if since 1912 and 1913 you have ever seen it ?—A. No, I have never seen it.

Q. So that it seems rather difficult to understand what you did know of this matter ?

His Lordship : Dr. Langmuir did not come here to be examined on prior art. He was not called for that purpose. He frankly states he does not know.

Mr. Henderson : I am not questioning his statement as to his belief at that time. A man who knows the prior art says, " I believe so-and-so." If he has no knowledge of it, of course there is not much reason for asking him the grounds of his belief. If he says, " I believe Alexanderson was the first," of course the value of his belief depends upon his knowledge at the time.

MR. SMART: Whether he believes it or not is immaterial. It is the fact we are interested in.

MR. HENDERSON: It comes to be a question of fact.

HIS LORDSHIP: He is not attempting to decide whether there was invention or not. I do not suppose he spends his time reading patents unless he is paid for doing so, and I do not suppose it is part of his duties.

MR. HENDERSON: Some lawyers do not even open their reports, but we are supposed to.

HIS LORDSHIP: The witness says he does not know anything about Marconi and the others whom you have mentioned.

MR. HENDERSON: Did you know Lorenz ?—A. No.

Q. Did you know Von Bronk ?—A. No.

Q. Schloemilch ?—A. No.

Q. Did you know any of their work ?—A. No.

Q. Or any of these men in combination with one another ?—A. No.

Q. You knew nothing about what had been done about these patents ?—A. No.

Q. Or about the work these men had done ?—A. No.

Q. Can you mention anyone who might possibly be conversant with the prior art, whom you did know ?—A. No.

Q. Who had dealt with selectivity, whether geometric or otherwise, or had dealt with relays before ?—A. In the first place up to January, 1913, I had never taken any active part in the field of radio.

Q. I think that is probably the explanation. Until January, 1913, you had taken no active part in the field of radio ?—A. No. But I had done things that gave me a new viewpoint which was particularly useful to me in the field of radio, so that I probably did better and accomplished more than I would have if I had known about it, which is frequently the case.

Q. A little knowledge is a dangerous thing ?—A. No, but a fresh viewpoint is a valuable thing.

Q. You said the Alexanderson arrangement permitted selectivity with a broad tuning path ?—A. Yes.

Q. Do you agree with the evidence of Professor Hazeltine that the Marconi or Stone arrangement as you know it now might actually be superior to Alexanderson in this respect ?—A. I have not heard his testimony.

Q. He gave testimony with drawings based upon very elaborate calculations, which I would be very pleased for you to take overnight if you wish, and he stated that in the result the tuning band of the Marconi arrangement was actually superior although not very much so. He stated that the difference was not serious, and in the second stage he stated that it was practically as good, the difference being slightly but quite immaterially in favour of Alexanderson. Is that a fair paraphrase ?

HIS LORDSHIP: How can the witness answer that ?

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No. 16. Irving Langmuir. Cross-examination —*continued.*

Mr. Henderson: Are you in a position to differ from Professor Hazeltine in that regard, in a comparison between Marconi and Alexanderson?—A. I do not know what particular Marconi circuit you are referring to, and I do not know what Professor Hazeltine said about circuits and what assumptions he made on which he based his discussion.

Q. I show you the chart he produced, 5 and 6, showing the comparison. These are Exhibits "I" and "J" Would you be in a position to differ from Professor Hazeltine as to this?—A. I suppose he gave several weeks' consideration to this matter, and you show it to me now and ask me for an opinion in a few seconds.

Mr. Henderson: Not only several weeks, but a great deal more than that. He has known the subject for a long time back?—A. But that does not make me feel inclined to accept his conclusion. I have an entirely open mind on his conclusion.

Q. If I give you his computations overnight will you be willing to take them and say in the morning whether or not you can differ from them?—A. I will be glad to look them over and tell you what they mean to me.

Q. And take these charts with you?

His Lordship: I think you must hurry along Mr. Henderson.

Mr. Henderson: These are technical matters, and the witness has made a broad statement differing from Professor Hazeltine. I will hand the witness the computations of the chart and ask him if he will tell me in the morning whether or not he can differ from him.

The Witness: Very well.

Mr. Henderson: I will show Mr. Smart the file wrapper. It will be much shorter if I put it in, indicating the pages, rather than taking the witness over them.

His Lordship: Was the witness going to say something?

The Witness: Except to ask if this is complete, or whether Mr. Hazeltine has made some remarks about it. This is almost pure mathematics and hardly any conclusion.

Mr. Henderson: Everything is there excepting the numerical work. He did not put these computations in evidence, but you can very easily find them in the record. My learned friend could show you what Professor Hazeltine did say.

Mr. Smart: I do not think the burden should be placed on Dr. Langmuir and I am particularly anxious to finish his evidence to-night. My learned friend says he is nearly finished and I have practically no re-examination.

Mr. Henderson: If my learned friend will agree that I may put in, without examining Dr. Langmuir on the different points, the extracts from the file wrapper which I will have copied out——

Mr. Smart: Yes.

Mr. Henderson: And if Dr. Langmuir is anxious to get away to-night——

Mr. Smart: Yes.

MR. HENDERSON: Then I will not press this matter except that I offer the opportunity of checking the computations and figures, and the same thing will be open to any of my friends in the same interest.

MR. SMART: I understand you are finished.

MR. HENDERSON: In view of what you said I am finished with Dr. Langmuir.

RE-EXAMINED BY MR. SMART:

Q. I have not anything specific in mind, although it occurred to me once or twice that you had something more to say about the Alexanderson letter. You may have covered it in your examination, and if so, you will say so?—A. I only would like to say that Mr. Alexanderson's letter to me and the results of the work of the mathematical treatment or the discussion in Mr. Vivian's report, for example, seems to me to be an unusually clear exposition,——

MR. HENDERSON: That was said in chief.

HIS LORDSHIP: We will finish with him more quickly if we let him go ahead.

A. (Cont'd). In non-mathematical language of a theory of an electrical circuit, which in mathematical language would be extremely complicated. A mathematical discussion of the single pulses, as compared with radio waves, the effect of such single pulses or such waves on a series of tuned circuits is very difficult from a mathematical point of view. And in this letter we have the essential things picked out of that mathematical theory and stated in words that it seems to me are as clear as they could be made. And that must be kept in mind, I think, in reading that letter, that it is not a mathematical statement. Mr. Hazeltine, for example, has said that the word "admittance," as used in the second paragraph of that letter of February 4th, is a highly technical term. It is not used as a technical term there. It is used in its general significance.

Strictly speaking, the word "admittance" can not be used at all in a strict sense for single pulses of energy. It can only be used for alternating currents of definite frequency; and that very fact that he uses it in that connection shows that he is dealing with the term in broad, ordinary language that Mr. Davis, of our Patent Department, could understand, without considering the precise technical uses of the terms. I think that is all.

Q. One more short question. You gave an analogy there in respect to the inductance and capacity, referring to inductance by way of comparison, I think, to a spring, and I wondered whether sometimes it was applied to a capacity as well?—A. Yes, I gave the illustration this morning of a spring corresponding to an inductance. That was just given on the spur of the moment; and, although I could justify it insofar as in many different ways that use of the word or that kind of an analogy may be used, it is the commonly accepted analogy between an electrical oscillating circuit and a mechanical model of it, to compare the inductance of the electrical circuit with the moving mass in the mechanical system, and to compare the capacity of the electrical circuit with a spring in a mechanical system. As a matter of fact what we really have is a change of energy between two

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No. 16. Irving Langmuir. Re-examination —*continued.*

forms. Energy is stored up first in the inductance, and then it is stored up in the capacity; and the energy oscillates back and forth between those two, just the same as the energy in the case of a pendulum changes back and forth from the gravitational energy when the pendulum is at its upper position. There is an interchange of energy in the pendulum, and so there is in the oscillating circuit, between the spring and the mass that is set in motion by the spring.

MR. SMART: That is all.

THE REGISTRAR: Court is adjourned until to-morrow morning at eleven o'clock.

19 January 1927.

MR. HENDERSON: Your Lordship will remember that yesterday I produced a file wrapper on the application of Mr. Langmuir which resulted in Patent Number 1282439, and it was agreed that extracts should be made. I have made those extracts and have handed a copy to my learned friend, and I now put this in, subject to a checking which my learned friend may want to make. If there is anything he calls attention to it will be considered.

THE REGISTRAR: This will be Exhibit Z-14.

EXHIBIT Z-14:—Filed by Mr. Henderson, 19 Jan., 1927. Extracts from Number 1282439.

MR. SMART: The objection as to the relevancy is reserved.

MR. HENDERSON: That remains of course.

MR. SMART: I will call Colonel Watts.

No. 17. George W. Watts. Examination

No. 17.

Evidence of George W. Watts.

GEORGE W. WATTS, Sworn. Examined by MR. SMART:

Q. Your residence and occupation, Colonel Watts?—A. I am employed by the Canadian General Electric Company as Manager. I live in Toronto.

Q. How long have you been employed by the Canadian General Electric Company?—A. Since 1892. From the organization of the company.

Q. What was the nature of your work with them in 1913?—A. I had general charge of their works, and patent matters.

Q. This action as you may know is in connection with the Alexanderson Canadian Patent 208583 filed as Exhibit 1. My learned friend has filed as Exhibit V a photostat copy of the docket of 17604 of the General Electric Company in Schenectady, which bears the notation: "Copy of this case sent to Canada 11-14-1913." It also appears that the Canadian application was filed on September 17th, 1920, and I would ask you to state if there are any reasons for the delay in the filing of the application in Canada?—A. What number did you say this was?

Q. That is the docket number I quoted ?—A. What has that to do with this ? It is not the same docket.

Q. Give whatever explanation you can in a general way.

MR. HENDERSON : Of course my Lord, I assume your Lordship will listen to the evidence ; but I suppose it is understood that it cannot affect the operation of the Patent Act as to delay. It is too late now.

HIS LORDSHIP : That is a matter of argument. I will hear the evidence.

MR. SMART : Will you give a general statement ?—A. This docket 18270—I do not know anything about that. 17604—may have been received by us about the end of 1913, and may not have come until some time later. It would not arrive in our possession in any case until after the patent was filed in the United States. Their practice was not to send us any dockets until they had filed them. They did not in all cases send them at that time either.

Q. During the period following 1913 how were you personally engaged ? —A. Immediately following the beginning of 1913, we would take no action upon that docket for a period of time, in order to give the United States Patent Office time to act on that application. About the 1st of August, 1914, the European War started, and our activities in patent matters practically ceased until the close of the war, except on such things as we were already manufacturing ; because our people did not feel justified in investing a lot of money in manufacturing facilities until they knew just what was going to happen. They were fully occupied with war work.

Q. They were themselves engaged in war work ?—A. Yes.

Q. And during that period you were the one who would deal with patent matters in the Canadian General Electric Company ?—A. Yes, I was the one who would deal with them, and I occupied myself personally from early in August, until 1920 or 1921 with general matters, for practically sixty per cent. of my time.

Q. In what way ?—A. I served first of all on the Shell Committee. I was one of the original organizers of that Committee. Then I served on the Munition Resources Commission afterwards, until some time after the close of the war, when it was wound up.

Q. And what was your position during that period generally with regard to radio applications ?—A. They were new with us, and we were not prosecuting them until such time as the war situation was cleared up, early in 1919 or the latter part of 1918. After the war was over, and the Armistice came, we began to look into what we had been neglecting, and we started in to file on our radio applications amongst others, and in the beginning of 1919 and through 1919 we had filed a great number of applications. This application we did not file at that time, because we had no right. That is, it had issued more than two years before that time in the United States. Therefore we could not file. And it was not until the Peace Treaty, some time I think in 1919 or 1920——

Q. The 14th April, 1920 ?—A. When legislation was put through, that we had the right to file and we then filed.

MR. SMART : The witness is yours.

HIS LORDSHIP: When was the application sent to Ottawa by the Canadian General Electric Company of Canada?

MR. SMART: All we can find is the docket which says "Copy sent in 1913."

MR. HENDERSON: It gives the date, my Lord, U.S. docket the 14th day of November, 1913.

HIS LORDSHIP: That is the memo on the docket.

MR. HENDERSON: That is the memo on the Schenectady docket.

MR. SMART: Colonel Watts tells me the dockets are not the same number.

HIS LORDSHIP: He says this came into Canada in the latter part——

MR. HENDERSON: He says assuming it did. May I take him over it again? My understanding of what he says is that assuming this reached him as this docket would indicate his practice was not to act upon it until the patent application was——

HIS LORDSHIP: Was dealt with in the United States.

MR. SMART: I am going to ask him whether by that he means filed in the United States.

HIS LORDSHIP: I do not think it makes much difference.

MR. HENDERSON: They are relying on the Treaty of Peace. My learned friend agrees with me that unless the Treaty of Peace helps them this application was too late.

MR. SMART: I do not concede the point.

HIS LORDSHIP: You have nothing else to ask the witness?

MR. SMART: May I ask a question to clear up the matter? Tell me what the docket number indicates?—A. The number 18,270 is the docket number of the docket in the Schenectady office.

Q. You have just read from Exhibit No. 1?—A. Yes.

Q. You have just read from Exhibit 1, and the docket number of this file Exhibit "V" is what?—A. 17,604.

Q. What would the difference in the docket number indicate to you?—A. It indicates that it is a different docket—an earlier docket.

MR. HENDERSON: Do I understand that you have a specific recollection of this particular transaction, what we now call the Alexanderson patent?—A. By itself, no.

Q. You shake your head?—A. Yes.

Q. How do you say that the additional delay in 1919 was due to the fact that you realized that it was too late to apply for it at that moment, and that you felt that your right to apply was, shall I say revived by the Treaty of Peace?—A. I am afraid I have lost your question. It is rather long.

Q. I think you said to Mr. Smart that your work accumulated during the war, and that at the close of the war you had a large number of patent applications which had not been made and that you did make a great many patent applications in 1919; that is right, is it not?—A. Yes, that is correct.

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No. 17. George W. Watts. Cross-examination —*continued.*

Q. But you said you did not make this particular application because under the law as it then stood it was too late ?—A. Yes.

Q. But that later when the Treaty of Peace became effective, you thought you could then make this particular application, and you did make it ?—A. That is correct.

Q. Relying on the Treaty of Peace ?—A. Yes.

Q. Might I ask you if then special attention was given to this application to see if it was governed by the Treaty of Peace ?—A. Our attorneys determined that it was.

Q. You are not a lawyer ?—A. No.

Q. *Might I ask you then, Colonel, why was the mis-statement of fact* made in the oath ?—A. Was there a mis-statement ?

Q. Yes, it states that it had not been patented in any other country ?— A.—*I do not know anything about it.*

Q. You do not know why ?—A. I do not know that it was so, and I do not know anything about it.

Q. *Will you take my word that it was so ? We have it in evidence ?*— A. Yes.

Q. We have the Canadian file wrapper. I want to see who took the affidavit. Of course, Alexanderson took the affidavit, but do you know who sent it over to Schenectady ? Would that come under your jurisdiction ?— A. Probably that would come from Featherstonhaugh's office.

Q. So that you do not know anything about that ?—A. No.

Q. How do you explain the fact that Alexanderson was neglected during the war period, and the corresponding Langmuir was not ?—A. The corresponding Langmuir patent was issued.

Q. The corresponding Langmuir patent was filed in Canada in 1919 and issued in 1920. Was there a distinction between it and Alexanderson's on the ground of date ?—A. Probably that would be the only reason I know of.

Q. Who told you this ? Where did you get this information that the reason this was not filed was because it was out of date ?—A. In my own mind.

Q. You are not a lawyer ?—A. No.

Q. What do you recollect ? What do you know about it ?—A. I absolutely know why I filed those applications and when.

Q. You told me in the beginning you had no specific recollection of this particular one, Alexanderson ?—A. Well, Alexanderson was issued in the United States some time before.

Q. But when did you find out it was too late ?—A. I found out in 1919 it was too late.

Q. But you did not tell me you did not recollect this specific case ?— A. Not this specific case, but all those cases not filed in 1919 and afterwards filed in 1920 were thrown aside because of the date being wrong.

Q. When did you first find out this was one of those cases ?—A. I found it out in 1919 or 1920—in 1920, the Treaty of Peace.

Q. When did you prepare yourself to give the evidence you are giving to-day ? When did you refresh your recollection for that purpose ?—A. My recollection has been perfect on that point ever since it was made.

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No. 17. George W. Watts. Cross-examination *—continued.*

HIS LORDSHIP : At a certain stage he discovered that under the Patent Act he could not file in Canada.

MR. HENDERSON : He says so.

HIS LORDSHIP : Now they say they rely on the Treaty of Peace. That is the answer.

MR. HENDERSON : I do not like these blanket statements.

HIS LORDSHIP : The witness is very frank. He says they are relying on the Treaty of Peace.

MR. HENDERSON : But I think he has been told this by his legal department.

WITNESS : No, he has not been told it by the legal department at all. The legal department have not instructed me on this matter.

MR. HENDERSON : The record is there to speak for itself.

Q. Do you know if this case was ever consolidated with another one ?—A. I do not.

Q. You recollect these things ?—A. There has been no consolidation that I know of in Canada.

Q. In this reference Mr. Smart makes, do you notice this remark : " 17,604 consolidated with this case marked 1914." What does that reference mean ?—A. I have no knowledge.

Q. You have no knowledge of that ?—A. No.

Re-examination.

MR. SMART : On another branch of the case, are there any Canadian companies manufacturing and selling under the license granted under patent Exhibit 1 ?—A. There are five or six. The Marconi Company was licensed in 1920, and the Bell Telephone Company, the Northern Electric Company, the International Western Electric Company, the Westinghouse Company, the Standard Radio Corporation, and the DeForest-Crosley Company.

Q. Practically all, if not all, take these licenses automatically under general agreements which they have with the General Electric Company, do they not ?—A. I do not understand your question.

Q. Take, for instance, the Northern Electric, the Bell Telephone, and the Marconi ; you have a broad working agreement with these companies, have you not ?—A. We had not at the time of the Alexanderson or Marconi.

Q. But you have now ?—A. Yes.

Q. Does that apply to all these companies ?—A. With the exception perhaps of the DeForest-Crosley Company and the Standard.

Q. With those exceptions these companies are all companies with which you have working agreements and they have a right to operate under all your licenses ?—A. Yes.

Q. And that is the way in which you say they operate under Alexanderson ?—A. Yes.

Q. And have you given any of these companies including DeForest-Crosley and Standard specific license to operate under Alexanderson ?—A. By itself ?

Q. By itself ?—A. No.

Q. It comes in in the way Waterman says, that you find Alexanderson in the modern radio set ?—A. I cannot say that.

MR. SMART: I do not think Colonel Watts is informed on this specific point. The licence to the DeForest Company and the Standard Company is under——

MR. HENDERSON: Please do not give evidence on that.

HIS LORDSHIP: I do not see that it is of any importance at all. They are licensed and that is all there is to it.

MR. HENDERSON: Q. Then these license agreements that you speak of are all of comparatively recent date?—A. 1920 on. None before 1920.

Q. We have some references in evidence here to a number of sets, the super-heterodyne set, the regenoflex set, the radio 10 and others?—A. I do not know.

Q. Are they not all produced under the auspices of your company?—A. I cannot say.

Q. Is it not a fact that none of the sets were in the market until after 1923?—A. I cannot tell you.

Q. You do not know that?—A. No.

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No. 18. Ernst F. W. Alexanderson. Examination

Evidence of Ernst F. W. Alexanderson.

ERNST F. W. ALEXANDERSON, sworn. Examined by MR. SMART:

MR. SMART: I happen to notice one correction in the record, which might be of some importance. On page 637, yesterday's volume, in the third line from the bottom of the page, where Mr. Henderson is quoting an extract from certain evidence. The word is written "inductive connection" and it should be "conductive."

MR. HENDERSON: That is right.

MR. SMART: And the same mistake occurs in the first word of line four of page 638.

MR. HENDERSON: My friend is quite right, and I am glad that my friend called attention to it, because something turns on it.

MR. SMART: Q. Doctor Alexanderson, will you state your residence and occupation?—A. I reside at Schenectady, 8 Adams Road. I am employed by the General Electric Company as consulting engineer, and I am also Chief Consulting Engineer of the Radio Corporation of America.

Q. How long have you been employed with the General Electric Company?—A. Since 1902.

Q. What was the general nature of your work in 1912, say?—A. In 1912 I was consulting engineer of the Company and interested in several lines of engineering, such as designs of power machinery, generators, induction motors, railway apparatus, motors and controls for locomotives, and also radio.

Q. Perhaps you will state generally the nature of your association with radio from the early days to the present?—A. I became interested in radio in 1904. At that time I was designer in the alternating current engineering department, and Professor Fessenden made a request to the General Electric Company for the design of an alternator for 100,000 cycles per second, which he wished to use in a new system of radio communication which he was developing. I proceeded to design such a machine, had a number of conferences with Professor Fessenden, and delivered to him a machine for 60,000 cycles, which was used in his first test of radio telephony.

From these associations with Professor Fessenden I learned about the nature of the system which he was interested in. It is the system which has become known as continuous wave system. I became convinced that this continuous wave system would supersede the spark system which was then in use, which as a matter of fact has happened.

During the following years I therefore proceeded to work out various problems in the development of the continuous wave system. I perfected the design of the alternator, and I also worked on other problems which pertained to the practical use of radio telegraphy and telephony.

In Fessenden's tests of radio telephony, he had used a large water cooled microphone to modulate the antenna currents generated by the high frequency alternator. And I realized that this could not be the ultimate solution, because a great deal more power would be required for the telephony on a large scale that was contemplated, such as trans-Atlantic telephony. I therefore proceeded to investigate the possibilities of the development of a high frequency relay and I tried several types of high frequency relay. One was of the alternator type; another was of the magnetic amplifier type with a saturated iron core, which is at present used in our large trans-Atlantic stations, and which was used immediately after the war for telephoning across the ocean. I furthermore tried a relay of the three-electrode mercury arc type. Yet I felt that none of these solutions would be the final one.

Q. I was just interested in getting more of your general experience with the radio field, say prior to 1912. Was there any more prior to that which you think should be mentioned?—A. This history leads directly up to the work that leads to this invention.

Q. Yes. Perhaps I will put it in this way: You are the inventor, I take it, of the subject matter of Exhibit No. 1, the Alexanderson patent in suit in this action?—A. Yes.

Q. Will you state the history of the development of the invention described in Exhibit No. 1?

HIS LORDSHIP: I think he was dealing with that.

MR. SMART: Yes, but it did not quite follow from my other question, so that I thought it would be more convenient to have it in answer to a question of this type.

MR. HENDERSON: He drifted to it unconsciously?—A. In 1912 I visited the laboratory of John Hays Hammond, Jr., who had ordered two of our high frequency alternators for use in a system of torpedo control which he had developed. While visiting with Mr. Hammond we discussed extensively our plans and hopes of development of a world wide system of radio communication. One of the essential features of such a world wide system would be selectivity, because we anticipated the use of a large number of sending and receiving stations operating on different wave lengths.

Q. That was about what time?—A. In 1912.

Q. What time of the year?—A. In the later part if the year. Mr. Hammond had been interested in a particular kind of selectivity, the use of a receiver which could be operated, or, if I may say, unlocked only by a peculiar kind of radio wave; and contemplated producing this peculiar radio wave by the use of my alternator and my magnetic amplifier. I was, on the other hand, most directly interested in the general use of the continuous wave system for communication, and desired to develop means for high selectivity which would operate with receiving sets receiving simple continuous waves.

In the course of these discussions Mr. Hammond explained to me the use that he was making of DeForest audion; and it immediately occurred to me that DeForest audion might be improved and used as a high frequency relay, which I had been looking for some time. When I thus realized that it would be possible to relay high frequency currents I conceived the idea of using a high frequency relay in a high selectivity system which I called tuning in geometric progression, which is the subject matter of this patent.

Q. Perhaps you could explain that system a little more fully. What would these circuits contain?—A. The elements of the circuits are a series of electric oscillating circuits coupled by vacuum tubes operating as uni-directional relay couplings.

Q. What was the date of that conception?—A. That was in the later part of 1912.

Q. And what did you do following that, with respect to it?—A. I wished to investigate the electrical characteristics of such a system, and I asked one of my assistants, Mr. Vivian, to make certain calculations in order to show those characteristics graphically.

Q. Did Mr. Vivian proceed with that work on your instructions? —A. Mr. Vivian proceeded with that work and made quite extensive calculations. The work was later followed up by Mr. Thomas, who made a report.

Q. Is the work of Mr. Vivian represented by the notes, exhibit Z-1, which I hand to you?—A. Yes.

Q. And the work of Mr. Thomas by exhibit Z-2?—A. Yes.

Q. To what other persons did you specifically disclose the invention in the early part?—A. I discussed my ideas with Doctor Langmuir.

Q. At what time?—A. In January, 1913.

Q. And what did you disclose to Dr. Langmuir, with respect to the invention, exhibit 1?—A. I explained to Dr. Langmuir the advantages which I expected to gain from my system of tuning in geometric progression, and the reason why I needed a uni-directional high frequency relay to accomplish this.

Q. And following that?

Mr. Henderson: Of course, my Lord, evidence of conversations is open to the usual objections. He can state the fact that he had a conversation with Dr. Langmuir.

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MR. SMART: And he can state what he told Dr. Langmuir.

MR. HENDERSON: No, I submit he can not say what he told Dr. Langmuir. Dr. Langmuir *might* state what he was told.

HIS LORDSHIP: Dr. Langmuir has gone into this.

MR. HENDERSON: I just wanted the objection noted. It is not proper.

MR. SMART: Q. What at that time was the practice followed in the General Electric Company with reference to disclosing inventions when they had reached a completed stage?

MR. HENDERSON: I think the time has come, my Lord, to take objection that evidence of practice is not evidence.

HIS LORDSHIP: We have had that at some length.

MR. HENDERSON: I thought the time had come to shorten this trial. I am getting a little weary of it, and I thought your Lordship was.

HIS LORDSHIP: I think you could pretty nearly give the answer to that in your question, Mr. Smart.

MR. SMART: The witness will no doubt make a short answer to it, —shorter than the objection of my learned friend.

Q. Will you answer?—A. Different individuals had different practices, but my practice was to write a letter to the Patent Department to embody the nature of my invention; and to distribute copies of such letters among other interested parties.

Q. And did you write a letter for that purpose with respect to the invention exhibit 1?—A. Yes.

Q. Is that letter the letter of February 4th, 1913, exhibit Z-3?—A. Yes.

Q. With respect to the disclosure of that letter, and dealing with the art as it was at that time the letter was written, will you state whether or not in your opinion it constitutes a disclosure to one skilled in the art of sufficient character to enable such a person to carry out the invention?

MR. HENDERSON: I object, my Lord, that that is for the Court on the question as put.

MR. SMART: The Court is entitled to have evidence before it, of course, on that point.

HIS LORDSHIP: It is a proper question, as put, if any one knowing the art could take up this information and construct the thing referred to.

MR. HENDERSON: That is not the question as put. If the witness will answer the question as your Lordship puts it, I will not object.—A. The object of my letter was to give a complete disclosure, sufficient information for reduction to practice.

MR. SMART: Q. The question was whether in your opinion it was sufficient to enable anyone to practically carry it out at that time?—A. Yes.

HIS LORDSHIP: The term "geometric selectivity" was a terminology known and used by those conversant with the radio art?—A. It was a terminology which I adopted in order to describe my invention. Because the term "geometric progression" or "series" is a term well known in mathematics.

Q. Geometric what? I do not hear you.—A. Geometric progression, I wished to describe my invention by that mathematical definition because I expected to gain an advantage in selectivity which increased in geometrical progression with the number of circuits increased in arithmetical progression.

MR. SMART: Professor Hazeltine said he knew no use of the term before that, before it was used by Dr. Alexanderson, although he knew that the devices that were known would accomplish that.

MR. HENDERSON: I agree with my friend that Professor Hazeltine said that up to that time no radio series or system had been so described, but the use of the term would be readily understood by any inventor.

HIS LORDSHIP: If he accomplished what he said he did, the term is perfectly logical and natural.

MR. HENDERSON: The term is perfectly proper.

HIS LORDSHIP: The word "selectivity" has no particular significance, has it? You might have used other words?—A. Yes, there are other equivalent words.

MR. SMART: What was the nature of the selectivity obtained by your invention?—A. The kind of selectivity which I was aiming at meant the suppression to a very high degree of the interfering signal coming from a nearby station, while you were listening to a weak signal from a distant station.

Q. And what do you say as to the relation of the strength of the signal during its selection?—A. A very high ratio of signal strength; the interfering signal being very much stronger than the received signal.

HIS LORDSHIP: What elements did you introduce into this which make your patent different from anything that had been known before? Can you describe it so as to make it as plain as possible to me? And also explain to me what a uni-directional high frequency current or relay is.

MR. SMART: Relay.

HIS LORDSHIP: Yes, relay.—A. A tuned circuit has selectivity favouring the frequency for which it is in tune and excluding to a certain degree other frequencies. Such a circuit can be made more or less selective, dependent upon the efficiency of the design. But my conclusion was that it was not practical to improve the selectivity of the receiving circuit beyond certain limits. Therefore I assumed a certain practical limiting of the receiving circuit which we may call 100. A discrimination at the rate of 100 to 1 in favour of a desired signal. But I wanted a selectivity of a very much higher order. So I conceived the idea of repeating this selection by discriminating at the rate of 100 times 100, that is 10,000 to 1, and then repeating it again, and getting 100 times 10,000. That means a selectivity of a million to one. This could be accomplished by repeating the signal of the first circuit in a second circuit without disturbing the oscillations of the first circuit. For this reason I wanted uni-directional coupling. I wanted to repeat without reacting; that is without the second circuit re-acting back upon the first circuit. If I had means of such repetition without reaction, I would be able to duplicate this progressive selection I had desired.

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MR. SMART: And what means did you suggest?—A. I suggested a vacuum tube used as a radio frequency relay.

Q. The point of his Lordship's question is then, what would you say that you added to the selectivity of the coupled circuits of the prior act, and combined with them?—A. I added means for increasing the selectivity indefinitely by repetition.

Q. And the device by which that took place was what?—A. The vacuum tube.

Q. Now I think there is another branch of your Lordship's question as to uni-directional coupling?

HIS LORDSHIP: Yes.

MR. SMART: Will you explain how in the circuits of the type shown in your patent, the vacuum tube acts as a uni-directional coupling. You can illustrate by means of Exhibit 8.

HIS LORDSHIP: Was this tube always a uni-directional device? Did the tube always have that quality of uni-direction?—A. The tube is essentially, by its nature, a uni-directional device. And when it departs from that idea by capacity coupling, as has been mentioned in previous testimony, that is a secondary effect which is of no importance if the receiving set is properly designed.

MR. SMART: For the purpose of this invention, is a vacuum tube, as known in 1912, a uni-directional coupling?—A. Yes.

Q. And the present vacuum tube?—A. Yes.

Q. Now will you proceed with the other question.

HIS LORDSHIP: I think I can follow it on that diagram.

MR. SMART: Yes, on Exhibit 8.—A. Here is a tuned circuit at "8" which discriminates to a certain degree. The potential generated in this circuit is embraced between the filament and the grid of the vacuum tube, and the vacuum tube functions in such a way that a current will flow in the plate circuit which repeats the change in voltages impressed upon that grid. You have in this winding, which is the primary of the transformer, a current which repeats the voltage fluctuations of the first tuned circuit. The current in this coil produces a magnetic field, which in its turn induces an electromotive force in this winding.

MR. SMART: The winding opposite what?—A. Opposite transformer 12. The electromotive force thus induced acts upon the closed circuit consisting of the coil and the condenser "15" connected with that coil. The impedance of the closed circuit follows the law of a resonant circuit. That means that the impedance is a minimum when the circuit is given resonance, and that the current becomes a maximum under those conditions; and the current flowing in the oscillating circuit, an alternating current voltage, across the terminals of the oscillating circuit, that voltage is in its turn impressed upon another relay, a vacuum tube relay, and this process is repeated so far as desired.

Q. Now Dr. Alexanderson, I would like you to compare the effect produced by a repetition through vacuum tubes, through a plurality of tuned circuits such as is found in your invention, with the selectivity that would be obtained when a plurality of tuned circuits is coupled magnetically without the vacuum tubes, such as is found in the Marconi patent, Exhibit G-14, and has also been referred to as being present in certain inventions of Stone, which are described in these patents.

HIS LORDSHIP: Is that the Marconi?

MR. SMART: Yes.—A. When a series of tuned circuits is linked by a magnetic coupling, the energy that maintains oscillations in its circuits is introduced through electro-magnetic induction. If we consider the first circuit alone without any coupling to any succeeding circuit, then the impedance of this circuit will follow the simple law which has already been discussed. Its minimum impedance is equal to the resistance in the circuit, and the energy introduced in the circuit from an outside source is consumed by that resistance. If we now couple another circuit to this first circuit, electromotive forces will be induced in the second circuit.

Q. Magnetically?—A. Induced by magnetic action in the second circuit, and there will be a tendency for current to flow in the second circuit, but the flow of current is accompanied by loss of energy, and energy that is to maintain oscillations in the second circuit is withdrawn from the first circuit; therefore the amplitude of the oscillations in the first circuit must necessarily be reduced in order that there may be any energy left over to maintain oscillations in the second circuit. If we now add a third circuit, the energy to maintain oscillations in the third circuit has been withdrawn from the energy existing already in the first circuit and the second circuit, so that ultimately when we couple together such a series of oscillating circuits we must spread out the energy in all three circuits which would otherwise be consumed in the first circuit alone; and therefore the currents we can build up in the three circuits is necessarily lower than the currents that can be induced by the same cause in the first circuit alone. Therefore the magnetic coupling does not repeat the oscillations of the first circuit. It changes the oscillations of the first circuit and reduces them; and while we do get oscillations in the succeeding circuits, they are much weaker than they would be if there had been a true repetition by a non-reacting coupling.

Q. Now when you use your vacuum tube coupling, what is the effect of repeating the signal from one circuit to another?—A. The vacuum tube used as a relay, consumes practically no energy, so that it does not withdraw energy from the first circuit, and therefore does not modify the oscillations of the first circuit to any appreciable degree.

Q. And what effect has a Stone and Marconi type of magnetic coupling on the selectivity?—A. The Stone and Marconi system, for selectivity is efficient up to a certain limit, but it is not adapted for producing selectivity of the high order which I was aiming at. At least for practical purposes it is not adapted for that, because the selectivity of the geometric progression can be secured by Stone's circuit only when so little energy is withdrawn from the first circuit to create oscillations in the second circuit, that it does not materially disturb the first circuit. That means that the amplitude of the oscillations in the second circuit is so much lower than the oscillations in the first circuit, and again the oscillations

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in the third circuit are very much lower that the oscillations in the second circuit, therefore if we wish to approach the selectivity of geometrical progression with the Stone circuit, we loose out very materially in signal strength.

Q. Perhaps I should have said, when your Lordship referred to the Hazeltine tests, that I proposed to show that that test was not a test of a Marconi circuit, but of a special circuit. Have you verified in any way these differences to which you have just referred, as between the Stone and Marconi type of magnetically coupled circuits, and the coupled circuits of your patent, using the vacuum tube ?—A. Yes, I have investigated that subject from both a theoretical and practical point of view, and my conclusions are those which I have stated.

Q. When you say theoretical, I suppose that would be mathematical calculation ?—A. Yes.

Q. And practical ?—A. By test of practical apparatus.

Q. Some reference has been made to the oath executed by you in connection with the application for patent Exhibit 1. Have you any knowledge of the circumstances under which that oath was actually executed ? —A. I do not recollect the circumstances.

Q. How do you usually deal with such papers ?

Mr. Henderson : I object. He cannot say what he usually does.

His Lordship : I will allow the question.

Mr. Smart : What is your usual practice in connection with papers for a patent application ?—A. A representative of the Patent Department comes to my office, and I execute the oath in his presence.

Q. And you verify the facts contained in the oath yourself, or do you rely on the Patent Department ?—A. I verify to the extent of identifying the material with some work with which I am familiar, but for the details I rely upon the Patent Department.

His Lordship : When you speak of the path of a wave current, what does that mean ? That the wave currents are flowing along the course of the connections, or is it passing anywhere ?—A. I did not understand the first word ?

Q. The path. I notice that word used a great deal. The path of the wave current.—A. When we discuss a diagram of connections, in which wires are represented, the wire may be the path.

Q. The wire is the path ?—A. Yes. But the condenser may also constitute a path.

Q. And outwards from the condenser may be a path, regardless of wires ?—A. Yes, that might also be a path. Then we think of that path as radiation, or capacity induction.

Mr. Smart : Do you know when the arrangement used in your patent Exhibit 1 first went into commercial use by the General Electric Company or by the Radio Corporation.—A. The arrangement of my patent was in use in the receiving stations erected for the reception of trans-oceanic signals by the Radio Corporation.

Q. In what year ?—A. In 1920.

CROSS-EXAMINED BY MR. HENDERSON:

Q. Just to clean up this question of the unfortunate character of the oath, Dr. Alexanderson, I gather that you having made what either you or the patent office considers the subject matter of a patent, you pass the matter on to the patent office—or the patent department, I should say—of the General Electric?—A. The patent department of the company prepares the patent application.

Q. They prepare the patent application, and when the papers are brought to you, you merely identify the matter as one of yours, and rely upon the officers of the patent department for the accuracy of the document?—A. The patent department usually consult me about the patent application before it is finally written up, and I go over a draft of it, so that by the time the papers are presented to me for the oath, I am thoroughly familiar with the papers.

Q. They draw the claims and you revise them, I suppose?—A. Yes.

Q. I do not expect to differ from you at all as to this. I want to shortly state the facts. But as to the oath, you simply relied on them for the accuracy of the oath; seeing that it was an oath with respect to your application. What I want to point out is this, Dr. Alexanderson: personally, I do not believe for a moment that you would intentionally mis-state the facts. You did not intentionally mis-state the facts?—A. Of course not.

Q. I like your answer: "of course not." You know now, however, or you did know then, did you not, that you had obtained a patent in Germany as well as in the United States, or did you not?—A. I am not always conscious of in what countries the patents have been taken out. They take them out in a great many countries.

Q. And it would be for the patent department to keep you straight in that regard?—A. Yes.

Q. You would understand that it was the duty of the patent department to see that the affidavit or the oath was correct as to these matters?—A. Yes.

Q. And when you took this oath you did so in good faith, relying upon the patent department having done its work properly?—A. Yes.

Q. That is a fair way of putting it is it not?—A. I think so.

Q. And may I repeat once more that I do not believe for an instant that you would have done it intentionally?

HIS LORDSHIP: We may assume that.

MR. HENDERSON: Yes, I think so. Now I want to try to shorten matters if I can.

Q. You were in court yesterday were you not, and the day before?—A. Yes.

Q. Did you listen to Mr. Hazeltine's evidence and to that of Dr. Langmuir?—A. Yes.

Q. Were you interested in it?—A. I was interested in it, yes.

Q. You heard the discussion—if I may so term it, with a view of shortening matters—which took place between Professor Hazeltine on the

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one hand and Dr. Langmuir on the other, as to the parallel or series circuit ? —A. Yes.

Q. And I think you followed it intelligently did you not ?—A. Yes.

Q. Now then coming first of all to the Vivian notes. I understand Mr. Vivian was an assistant of yours, and he having conceived the idea as you have described it, you instructed Mr. Vivian to work it out, am I right in saying, mathematically ?—A. I gave Mr. Vivian instructions to work out a mathematical treatment for a certain phase of the problem.

Q. And the result of what he did is shown by the pages of the note-book which we have referred to ?—A. Yes.

Q. And I understand, Dr. Alexanderson, that you were not satisfied with that result ?—A. Mr. Vivian worked out a fourth degree curve. I had given him instructions to work out a fourth degree curve, because I wanted to go to an extreme in my first investigation, and when I received the figures, I saw that they had so many decimal places that they were not adapted for graphic representation. At that time I had some work for Mr. Vivian to do, and Mr. Thomas joined my staff, and I therefore turned the matter over to Mr. Thomas to work out the subject in a form that would lend itself better for demonstration in the report.

Q. Did you turn the matter over to Mr. Thomas to carry on from where Vivian left off, or was he to start at any particular point or afresh ?—A. I left it to him to complete the work with certain changes.

Q. Along the same line as Vivian or a different line ?—A. Yes, working out the third term of the series.

Q. Then may I ask, keeping at the moment to the Vivian note, do you find in them a parallel or a series system of tuning ?—A. For the purpose of Mr. Vivian's calculations I did not have to make any distinction between the parallel series of tuning, because I wanted him to consider only a typical tuned circuit which it has been said before is neither parallel nor series. It is a closed circuit, and from that point of view it is always a series circuit.

Q. You remember later, in May, 1913, that for the first time you spoke of what describes a parallel circuit, parallel tuning. Can you point out anything in the written notes or correspondence—that is, either in the written notes or in the letters—which would indicate that you had parallel tuning under consideration prior to the month of May, 1913 ?—A. I do not know whether I made any such statement in the notes, but I think it is quite immaterial whether I did or not, because for the purpose of this investigation there is no distinction.

HIS LORDSHIP : Perhaps you had better show him the letter.

MR. HENDERSON : You have in mind the letter to Mr. Sage. Look this over and see if you can find any reference there. In the Sage letter I think for the first time you had described a system which would work out as parallel ?

HIS LORDSHIP : That was the first time he mentioned it.

MR. HENDERSON : He does not use the word "parallel."

HIS LORDSHIP : And it is not mentioned elsewhere. Is that correct ? Because if that is so it can be disposed of.

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Mr. Smart: The difficulty is to know what the words mean. There are arrangements described which imply this parallel connection.

His Lordship: But the witness can give the explanation. As a matter of fact it is only in the letter to which Mr. Henderson refers that that terminology is employed.

Mr. Smart: I have not checked the documents. They will speak for themselves.

Mr. Henderson: In the Sage letter I find this paragraph:

"With the present development of the incandescent vacuum relay as perfected by Dr. Langmuir, it seems that its capacity for handling considerable amounts of energy can be easier increased by employing high voltages than by attempting to handle large currents."

Q. Professor Hazeltine says that that statement indicates your opinion that the vacuum tube is inherently a high resistance device and therefore suited to a parallel output tuned circuit rather than a series output circuit. Do you agree with that? Do you follow my statement?—A. I followed your statement but I conclude that I had in mind that the vacuum tube is a high resistance device.

Q. And therefore suited to a parallel tuned circuit?—A. A high resistance device may be used for a parallel tuned circuit, but may also be used with a series tuned circuit, if you are going to make that distinction, provided you couple the circuit with a suitable transformer.

Q. In describing your system with reference to the chart, Exhibit 8, which is at your right hand. you refer to a minimum impedance at resonance? —A. Yes.

Q. Is it not a fact that impedance of the output circuit in each vacuum tube relay is on the contrary a maximum in resonance?—A. The vacuum tube itself has not any resonance.

Q. The external circuit between the terminal of the transformer?—A. Here is the circuit on the diagram. This circuit, I understand, is completed by the battery——

Q. Is it a fact that the impedance of the output circuit of the vacuum tube relay is a maximum at resonance not a minimum?—A. You speak of the combination of this and that circuit as if it were a maximum.

Q. As measured between the primary terminals?—A. Yes, that is right.

Mr. Smart: The letter of May 14th does not in itself refer entirely to that.

Mr. Henderson: I said it did not use the word "parallel."

His Lordship: I thought you read from it and it did use the word "parallel."

Mr. Henderson: No, my Lord.

Mr. Smart: I think there is a misunderstanding about it.

Mr. Henderson: I read a passage from the Sage letter which does not use the word "parallel," and I asked him if that statement did not indicate that about that time he realized the fact that the vacuum tube is inherently a high resistance device, and therefore suited to a parallel tuned output rather than to a series tuned output. His answer was that while suited to the parallel tuned output, it might be so used as to be suitable to the series tuned output also. I am only taking what he says. I will go back and make it clear if my learned friend wants me to. The point I am trying to make is that Professor Hazeltine says that this is the first time either in the notes or correspondence that he finds anything that one skilled in the art would take to be a direct reference to a parallel tuned circuit.

HIS LORDSHIP : That is the letter to Sage.

MR. HENDERSON : Yes. He says that up to that time every reference he finds in the notes or correspondence reads on a series tuned circuit. Here he finds what may very well be, giving the witness credit for it, a departure.

Now, we will ask you to do what we have been asking the others to do. Will you tell me when you first sketched a diagram of connections for your system of geometric selectivity ?—A. The first diagram showing the principle of geometric selectivity was contained in the Vivian notes.

Q. Is the first diagram in existence bearing upon the system in the Vivian notes ?—A. Yes.

Q. May I ask if anyone else made a diagram of that up to the time when the appliance reached the patent form ? Did you ever make a diagram yourself at all ?—A. I do not recollect making any complete working diagram.

Q. Of any diagram ?—A. I may have made other diagrams than the one that contained the Vivian notes, but to make another diagram is quite unessential for carrying out his idea because the matter of series and parallel coupling and methods of using the transformer to adapt the impedance of one device to another did not involve any problem at all.

Q. Did I understand you to say that making a diagram is not an essential ?—A. No, it is not essential for carrying out the idea.

Q. I hope the reporter got you correctly because at first I thought you said the making of a diagram was quite an essential thing ?—A. No.

Q. Obviously, you did not. I show you Exhibit 14, a sketch which Dr. Langmuir drew yesterday, and ask you if you could supply constants suitable for broadcasting. Would you like to take that over the lunch hour ?—A. I can answer this question now. I can, without difficulty, give sufficient directions for designing a broadcasting form.

Q. Can you give me now constants applicable to that diagram suitable for broadcasting purposes ?—A. I have not figures in my mind that I would like to give the constants in the form of inductance and capacity, but I can without difficulty give practical directions from which anybody skilled in the art could make such a set for broadcasting.

Q. Will you do that ? Can you answer that question or do you want to make a calculation ?—A. I think I can answer your question.

Q. Then please do so.

(Witness draws sketch.)

HIS LORDSHIP : You have finished, have you, doctor ?—A. Yes.

MR. HENDERSON : Q. You hand me a diagram and I see you have marked the number of turns for each coil, in that way answering my question as you understood it ?—A. Yes.

EXHIBIT "Z-15":—Filed by Mr. Henderson, Jan. 19, 1927. Diagram prepared by witness.

Q. In the Langmuir sketch, exhibit 14, which you still have before you, or in your sketch is the impedance of the output circuit of the relay, as measured between the primary terminals of the transformer a maximum or a minimum at resonance?—A. The impedance in the primary winding is at maximum at resonance.

Q. Then will you tell me when you first experimentally tried out this system of geometric selectivity?—A. It was tried out by Mr. White.

HIS LORDSHIP: Perhaps he can affirm what was said by Doctor Langmuir—did you not take Doctor Langmuir over that?

MR. HENDERSON: I did, at very considerable length, but I think I can shorten it here.

Q. You yourself did very little with it after you had made the disclosure which has been spoken of,—am I right in that understanding,—Mr. White made certain experiments?—A. Yes, sir.

Q. And we know the result of Mr White's experiments. On the 17th May, 1913, Mr. White became satisfied for the first time that your idea was a practical one, that it would work, in other words?—A. Yes.

Q. And I suppose that result was reported to you?—A. Yes.

Q. Then did you yourself try it out experimentally after that? Doctor Langmuir said he did not know about Doctor Alexanderson?—A. I do not remember making any specific test. There was no question in my mind about its operativeness.

Q. You were content from that time on, were you? For instance, we were told that there were some tests made out at the house of a Mr. Kinney. Did you take part in those tests?—A. I visited Mr. Kinney's house occasionally.

Q. And Dr. Langmuir says, as I recollect it, that these tests were made at Mr. Kinney's house in the earlier part of the Summer of 1913, that would be the latter part of May or in June and along that time these tests were being made. Did that correspond with your recollection?—A. His recollection would be more accurate than mine.

Q. You see, we have the date May 17th, when Mr. White had completed his experiment up to that time. Then was it carried on right after that? I gather that the experiments were then moved out to Mr. Kinney's house so as to avoid the interferences which would naturally be around the works? A. Yes.

Q. And that would be right after Mr. White's experiment in May?—A. Yes.

Q. And during that Summer you went out visiting while these tests were being made at Mr. Kinney's. We have heard of the one occasion on which they got Honolulu,—that was later on in the following January, you remember,—do you recollect that?—A. I do not recollect the dates.

Q. You did not set up any system of your own?—A. No.

Q. Now then, passing back a bit: at the beginning you did not think that the audion as it then existed would be suitable for the purpose?—A. I did not have any first-hand information on that. As soon as the audion

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was described to me I believed that it would be suited to the purpose; and that is the reason why I asked Mr. Hammond for a sample of the audion. And while I was told that it would not relay high frequency current, I really did not believe that statement. I believed that the device constructed as the audion was ought to relay high frequency currents.

Q. At that time—I do not want to make any offensive references, and I do not mean them as such—but I have understood the situation to be this, doctor, that Dr. Langmuir would more naturally carry on with the audion than you?—A. Yes.

Q. And that was one reason for bringing him into it?—A. Yes.

Q. And that on the 4th February, 1913, at least, you had an idea that geometric selectivity would accomplish the good results that you have referred to if the audion could be made satisfactory for that purpose?—A. Yes.

Q. And that would be the audion that John Hays Hammond had shown you, would it not,—it would have to be improved?—A. I did not know whether it had to be improved or not; but I believed that the device at that time, possibly improved, would accomplish the purpose.

Q. Just to make the matter short, in your testimony——

His Lordship: Perhaps you could make it shorter by just putting a question.

Mr. Henderson: Q. Was it not a fact that the first important question to be settled was whether the improved tube could be used as a relay for high frequency currents, and that that is the problem which you passed on to Doctor Langmuir?—A. Yes.

Mr. Smart: What page is that?

Mr. Henderson: I am sorry I have not got it.

Witness: In answering this last question, may I see this reference again, to see which connection was given.

Mr. Henderson: Yes, I would be sorry to think that in my anxiety to hurry on I was taking any advantage of you, because I am not.

His Lordship: Doctor Langmuir really perfected the audion which he claims to have used. Doctor Alexanderson does not claim to have done that himself.

Mr. Smart: Oh no, not Doctor Alexanderson himself. The old audions were termed "soft"; the improved audion which Doctor Langmuir developed became "hard" tubes; and those are the present day tubes, and he patented them.

His Lordship: And Alexanderson used them.

Mr. Henderson: Q. I think the time has come to get this into a plain layman's statement of the situation. As I understand the matter it is this, and will you follow me, Doctor Alexanderson, taking away all the technicalities in this, in the early part of the year 1913, January and the beginning of February, you had an idea that geometrical selectivity would become an accomplished fact if the audion could be made so as to operate as a high frequency relay?—A. Yes.

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HIS LORDSHIP: Put it in this way, if it would relay or be made to relay.

MR. HENDERSON: I am content.

Q. If it would relay or be made to relay?—A. Yes sir.

Q. You did not know, and you had never seen an audion except when you went to see John Hays Hammond.

MR. SMART: He had on February 4th.

MR. HENDERSON: I am talking about prior to February 4th. You had seen an audion at Mr. Hammond's, but you did not have one?—A. I did not have an audion until I received it.

Q. Incidentally is it a fact that as late as the 8th March, when you wrote to Dr. Steinmetz, you called it an "audeum"? Unfortunately we have not the original of this letter here.

MR. SMART: We have a stipulation that the original was corrected.

MR. HENDERSON: We have nothing of the kind.

MR. SMART: Let us settle it now.

MR. HENDERSON: Is my friend going to attempt a trick of this kind?

HIS LORDSHIP: It is settled that this copy is the exhibit.

MR. SMART: This copy is corrected.

MR. HENDERSON: It is not corrected. I am asking the witness a simple question.

Q. Is it or is it not the fact that on the 8th March, 1913, when you wrote to Doctor Steinmetz, you spelled the word "audeum"?—A. The misspelling of the word is obviously a stenographer's mistake. She had never heard the word before.

Q. You signed the letter, did you not?—A. Yes.

Q. Did you know how to spell it at that time?—A. I think I did.

Q. Will you swear you did, or put the blame on the stenographer only?—A. I do not know. I can not swear that I did, but I think it highly probable that I would not have spelled it the way they spell it in that letter.

Q. It is a fact, is it not, that the letter as you sent it to Doctor Steinmetz spelled it "audeum"?—A. If I did not correct that spelling before I sent it to Doctor Steinmetz, it was an oversight.

Q. Is the correction, which appears in this photostat, in your writing?—A. I can not tell whether it is or not.

Q. If you had been making a correction, would you not have drawn your pen through the "eum"?—A. I probably would, yes.

Q. So you can not tell whether the "ion" which appears above that word in each of the two places is a correction made by you or a mere notation made by someone else?—A. I can not tell for sure.

Q. It would not be to your discredit, would it, at that date, that you knew very little about the audion—there were very few people knew much about it?—A. I have recently become acquainted with the device.

Q. That is you had become acquainted with it in the sense of knowing it existed, and having seen one at Mr. Hammond's, and having recently had one sent to you—that is it, is it not?

HIS LORDSHIP: He had seen the audion at Hammond's prior to the date of that letter?—A. I am not quite sure on my recollection whether I actually did see it or not at Hammond's; but I discussed the use of the audion with him quite extensively; and the diagrams used in connection with the audions; so that so far as the use of the audion, I was better acquainted with it by that kind of knowledge than I would by seeing it.

Q. That is prior to the date of that letter?—A. Yes.

HIS LORDSHIP: Well, Mr. Henderson, my decision of this case will not turn upon that.

MR. HENDERSON: Q. But is it not a fact, as I gathered from this correspondence, that at that time you and Doctor Langmuir both thought that the audion as it then existed was too sluggish for your purpose?—A. The opinion had been expressed that it was too sluggish for my purpose.

Q. You hoped it might not?

MR. SMART: My Lord——

HIS LORDSHIP: There is nothing wrong, Mr. Smart. The witness has answered.

MR. HENDERSON: Please do not let me interrupt you, but insist upon completing your answer.

HIS LORDSHIP: I thought it was a very good answer. He says somebody had suggested it.

MR. HENDERSON: Q. Were you and Doctor Langmuir not under the impression that that suggestion was well founded?—A. I can not say for Doctor Langmuir just what he had in his mind; but I had perfect confidence that if it were so with the DeForest audion, Doctor Langmuir could correct the matter.

Q. That is precisely my understanding. You had great confidence, may I say the greatest confidence in the ability of Doctor Langmuir to perfect an audion which would work—is not that true?—A. Yes.

Q. And you passed it on to him for that purpose, as it were?—A. Yes.

Q. But he says that he himself did not know then that the DeForest audion would work at high frequencies,—am I right in understanding that you also did not know of that?—A. I did not know it.

Q. When did you learn that the DeForest would work at high frequencies, or did you learn that at all?—A. I can not say as to the date when I learned it, but I did learn in time that other experimenters had been using the audion at high frequency.

Q. Did you know at that time of any other type of vacuum tube relay which was available?—A. The audion was the only one I knew of at the time, that was suitable for this kind of work.

Q. Is not the situation very plainly summed up, the extent of your knowledge, in this letter to Doctor Steinmetz of the 8th March, 1913, where you say that

> "In order to make use of this system, it is necessary to have a relay for high frequency currents and it is probable that such a relay can be made on the principle of the incandescent rectifier which is already used under the name of 'Audeum' in the wireless art, although in its present form it is too sluggish for relaying one high frequency current to another current of the same frequency. However,

with the improvements that the Research Laboratory expect to make on the construction of the 'Audeum,' this difficulty is expected to be overcome."

Does not that very accurately describe the situation as you understood it on the 8th March ?—A. If I had been very careful in wording that letter, I might have said, instead of saying that it is too sluggish, "It is alleged to be too sluggish."

Q. You would like to make that correction now ?

HIS LORDSHIP : No, he does not want to correct it, but he says if he had been writing with perhaps greater care, he might have used the words with "alleged."

MR. HENDERSON : And, as I say, with that correction that would have completely represented your knowledge and understanding at that time ?—A. I think so.

Q. And it would really be a very accurate statement of your understanding at that time ?—A. I think so.

Q. And it was not until the 17th May when Mr. White completed his experiment, that you knew as a result of that experiment, that the thing would work ? It was a matter of hope, expectation, confidence, or some such word in the meantime, was it not ?—A. The only matter which involved any question there would be whether the audion could be made to work as a relay for high frequency ; and I think that that was quite clear from Doctor Langmuir's work previous to February 4th, because he was quite positive when I first discussed this with him, that in view of what he knew about vacuum discharge, it was only a matter of having a glass blower work out the details of it, not a question about scientific facts.

HIS LORDSHIP : I suppose, Mr. Henderson, you can take this up again after lunch.

THE REGISTRAR : Court will stand adjourned till 2.15 this afternoon.

Q. Prior to the month of May, 1913, did you know how to arrange the tuning elements :—In the complete circuit of the vacuum tube ?—A. Yes. I understood the action of the audion, it was perfectly clear to me how that should be done.

Q. It will not take a minute to draw a sketch showing your understanding as of that time.

You have drawn it ?—A. Yes.

Q. I take the sketch which you have made, and ask that it be marked as Exhibit Number Z-16.

EXHIBIT NO. Z-16 :—Filed by Mr. Henderson, 19 Jan., 1927. Sketch of action of audion as of May, 1913.

Q. Did you at or about that time, prior to May, 1913, make any sketch of this nature which is still in existence ?—A. Yes, I made a sketch in October, 1912.

Q. What became of it ?—A. I think it is available here in court.

MR. HENDERSON : I ask my friend to produce it.

MR. SMART: There is a copy of it in the record, which I am quite satisfied you should use. In the Splitdorf record, page 438 of the defendant's exhibits.

MR. HENDERSON: I show you a sketch which appears at page 438 of the Splitdorf record and purports to have your signature attached to it, and ask you if that is a photographic reproduction of a sketch made by you?—A. Yes, that is the sketch I refer to.

Q. Is the date appearing on it, October 21, 1912, the date upon which you made it or as of which you made it?—A. Yes.

Q. Is that sketch an embodiment of your invention?—A. It is not an embodiment of the tuning in geometric progression.

Q. What is it an embodiment of?—A. It is a result of my discussions with John Hays Hammond. He was developing a selective system for torpedo control, and one of his problems was that a very strong signal might be sent by the enemy that would interfere with the operation of his torpedo receiver.

Q. Pardon the interruption, I do not know that this is necessary unless you desire to continue it?—A. I was trying to answer the question.

Q. Then if you wish, proceed.

HIS LORDSHIP: He had better proceed.—A. One of the difficulties he anticipated was that the audion, being a very low power device, would be overpowered by the signals of the enemy. Therefore I wrote to him and suggested a method of using audions in such a way that interfering impulses would be distributed between several audions, as for instance a four-audion series, each audion would only get one quarter, and therefore it would not be overpowered as it would be if a single audion were used.

Q. It was in that connection that this sketch was made?—A. Yes.

MR. HENDERSON: My friend does not want to part with this particular book. May I treat this as marked, and my friend has been good enough to say he will let me have a photostat copy.

Perhaps I might say that as far as we are concerned, we will have no objection to your Lordship looking at the Splitdorf record in whole or in part at any time.

HIS LORDSHIP: Why? Because I have all I can do now—What is the idea of putting that in? It does not seem to have anything to do with the case.

MR. HENDERSON: I am not anxious to put it in, but I wanted to see if he has any other sketches, and this is the only one. I take it from his present answer that your Lordship is right, that it really has no bearing on the case.

MR. SMART: I am not asking to put it in.

MR. HENDERSON: Then I withdraw my application to have it marked. We will treat it as inconsequential.

Q. Then does the sketch which you have made and which is Exhibit Z-16 illustrate loose coupling between the primary and secondary circuit?—A. Considering the secondary circuit as a wholly closed circuit it illustrates loose coupling.

Q. Does the disclosure of your patent include loose coupling between the primary and secondary circuits which are interposed between successive vacuum tubes ?—A. Figure 1 in my patent shows exactly this arrangement.

Q. Which does include loose couplings ?—A. Yes, it indicates loose couplings by the way in which these coils are combined.

Q. Is there anything in your patent showing close coupling ?—A. I think there are some diagrams in the patent which do not indicate whether the coupling is close or loose.

Q. At all events it does not indicate close coupling ; it does not indicate whether close or loose ?—A. No.

Q. I am content to leave it at that. Do you believe yourself to have been the first person to tune the plate circuit of a vacuum tube to the same frequency as a grid circuit ?—A. My understanding is that Armstrong worked with audions at a time when I had not personally made any use of them.

Q. Then do I understand that you now believe that Armstrong was ahead of you in that regard ?

MR. SMART : This witness cannot give evidence as to when Armstrong made any device.

HIS LORDSHIP : I do not see any objection to it. Strictly speaking the question as to whether Alexanderson was the first to use it is for the Court.

MR. HENDERSON : Of course, my Lord, but if the witness answered in the negative it would be of great assistance to the Court.

MR. SMART : It is objectionable.

MR. HENDERSON : I am asking this witness, and I am not questioning his integrity in making oath in connection with the patent. I am not using it in that sense.

MR. SMART : Armstrong has not been set up in evidence in any way. Why should this witness be asked about it.

HIS LORDSHIP : He brought it out himself. I think he can answer the question directly, answer yes or no

MR. HENDERSON : His Lordship suggests you may answer the question which I am going to repeat, yes or no. Do you believe yourself to have been the first person to tune the plate circuit of a vacuum tube to the same frequency as the *grid* circuit ?

HIS LORDSHIP : Can you answer that question ?—A. Yes. I can answer it. My conception of the use of the vacuum tube to tuned circuit in the system of tuning in geometric progression was, so far as I know, earlier than Armstrong's tests of the audion in connection with his work.

MR. HENDERSON : You do not know the date of his conception. That is obvious. Will you answer this question, yes or no ? Do you believe yourself to have been the first person to tune the plate circuit of the vacuum tube to the same frequency as the grid circuit ?—A. In the first place, I had not to do it ; Mr. White did it in carrying out my idea, so that I would want to be sure what the question means.

Q. I am quite content to treat what Mr. White did as what you did. In that sense do you believe you or Mr. White to have been the first persons to tune the plate circuit of the vacuum tube to the same frequency as a grid circuit?—A. No, I do not.

Q. Will you be good enough to look at defendant's Exhibit D, which I may tell you is a sketch drawn by Mr. Waterman. Do you agree that this represents an embodiment of your system?

Mr. Smart: It seems to me that is a matter of construction of the patent.

His Lordship: There cannot be any objection to that question. —A. It was in a sense an embodiment of my invention but not in its more desirable form.

Mr. Henderson: Mr. Waterman was asked—I am not giving his exact words—to give it in its simplified form, I think he said the most simple embodiment.

Mr. Smart: With a crystal detector.

Mr. Henderson: Is that right? With a crystal detector?—A. It had a crystal detector.

Mr. Smart: There is no crystal detector shown in that.

Mr. Henderson: You agree with Mr. Waterman?—A. With this specification that there should be a crystal detector as simple as possible, and I agree, although the simplification here has led to make the system less advantageous than it would be in a set designed for practical use.

His Lordship: What difference does it make?

Mr. Henderson: I do not think it makes any difference.

Q. It is still your system?—A. Yes.

Q. Will you compare that with the defendant's Exhibit P, the blueprint attached to the German evidence, and state whether or not they are fundamentally the same?

Mr. Smart: I object to that type of question being put to this witness, who is offered as a fact witness. My learned friend is putting up the prior art which has been discussed by experts, and which may or may not have been studied by this witness.

His Lordship: The witness must have a chance to understand the drawings to which he refers.

Mr. Smart: He would have to read all the German evidence relating to it in order to be able to comprehend the drawing.

Mr. Henderson: I am referring to Fig. 6 of that exhibit, so that he will not have to study more than is necessary.

Mr. Smart: It is for your Lordship to draw the inference as to what that German evidence means.

His Lordship: I do not see why Mr. Henderson cannot ask this witness to distinguish if he can the drawings which embodied his own invention and the drawings of another invention.

Mr. Smart: The drawings must be taken with the evidence.

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HIS LORDSHIP: Yes, the witness may be at a great disadvantage in answering that question. He may never have seen this before and he may have to answer it with a reservation.

(Drawings shown to witness.)

WITNESS: This diagram does not give me sufficient information to say what the inventor intends to accomplish.

MR. HENDERSON: Does it give you sufficient information to answer my question which was as to whether or not that diagram, Fig. 6, is fundamentally the same as the Waterman diagram, Exhibit " B " ?—A. No, it does not give sufficient information.

HIS LORDSHIP: Suppose it were fundamentally the same, does it make any difference. Drawings are not a proof of anything.

MR. HENDERSON: I would have expected the consulting Engineer of the Radio Corporation of America to look at a circuit diagram and say what it is.

HIS LORDSHIP: After they finish their own work and complete their own invention they are through.

MR. SMART: Circuit diagrams may mean different things.

HIS LORDSHIP: A diagram does not prove anything. It illustrates.

MR. HENDERSON: It illustrates what is meant, and I have had to do with radio experts in the last few months, and I find as a rule that they will see very much more in a diagram than in a receiving set.

HIS LORDSHIP: I was speaking from the standpoint of the Court.

MR. HENDERSON: Of course, I am talking to the Consulting Engineer of the Radio Corporation of America.

HIS LORDSHIP: I suppose the drawings of all these things resemble one another very much.

MR. HENDERSON: Can you point out any fundamental differences between the two sketches ?—A. The sketches are far from identical and they consist of symbols, and unless it is understood exactly what those symbols intend to convey, they may have more than one meaning, and a diagram can have several meanings unless it is accompanied by explanation as to the intention.

Q. I ask you if you will assume, please, that the grid circuit is tuned to the same frequency as the plate circuit; can you find any fundamental difference ?—A. There are some circuits in this diagram which do not appear in the other diagram and I do not know what they are for.

Q. I am taking the essential part of Fig. 6, the part which is comparable with Exhibit " B."—A. Of course, the two diagrams have a certain resemblance and they have certain differences.

Q. If you say you cannot point out the differences I will not press you. Can you say there are differences which are fundamental ?—A. I can say that it is possible to make up an apparatus from this diagram and make up another apparatus from that diagram, and use that apparatus in such a way that they accomplish entirely different purposes.

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HIS LORDSHIP: If this is a combination patent, it means that everything in it is old. It is putting old things together to accomplish an object. The question is whether by an arrangement which we call a combination patent it has accomplished something not known before.

MR. HENDERSON: We say it was done before by Bronk.

HIS LORDSHIP: That is for argument.

MR. HENDERSON: I want to see if the witness can point out any differences.

HIS LORDSHIP: Q. You have never studied that patent itself?—A. I have never seen the patent.

HIS LORDSHIP: Q. What is the patent?

MR. HENDERSON: Schloemilch and Von Bronk.

WITNESS: I have seen the American Schloemilch and Von Bronk, but not the other.

MR. HENDERSON: This is not a diagram taken from the Schloemilch and Von Bronk American patent. This is a diagram of something they say they used at an earlier date in the evidence. Unfortunately we did not read the evidence. This is a diagram made at the time they used it.

HIS LORDSHIP: You have the witness' answer, and I think that is all you can get.

MR. HENDERSON: He says he cannot point out any fundamental differences, and one reason he gives for that is that he has not sufficient acquaintance with the situation.

Q. Do I understand from you that you disclosed to Dr. Langmuir the cascading of audions?—A. I disclosed to him the idea of cascading the audions for the purpose of tuning in geometric progression.

Q. And you made that disclosure to Dr. Langmuir?—A. Yes.

Q. Not he to you?—A. No.

Q. Is the cascading of audions a part of your invention?

MR. SMART: I object.

MR. HENDERSON: Surely it will assist your Lordship in reading the claim.

HIS LORDSHIP: I do not care what the witness says about that. Your question is, does he claim that as one part of his invention?

MR. HENDERSON: Yes, does he understand himself that he is claiming that?

MR. SMART: What he is claiming is in the patent.

MR. HENDERSON: Surely I can ask him.

MR. SMART: You cannot ask him to construe the patent.

HIS LORDSHIP: No.

MR. HENDERSON: Your Lordship will find that that is quite different from the Langmuir patent.

MR. SMART: You cannot ask him to construe it.

MR. HENDERSON: I think I can ask him to construe it.

MR. SMART: But he did not draw it. You can ask the man who drew it.

MR. HENDERSON: Are we going to be solemnly in Court put in a position of saying that the inventor does not know the meaning of the claims that he has sworn to? My learned friend is pressing that argument pretty far.

HIS LORDSHIP: Where a layman makes an invention and somebody prepares his specifications and claims, the layman does not really know what his invention is. You frequently come across a litigated case where the parties are unable to describe their invention.

MR. HENDERSON: With great respect I cannot be a party to the proposition that the oath does not mean what it purports to be.

HIS LORDSHIP: I am not giving any opinion about that.

MR. HENDERSON: In this particular matter, I think the inventor can be asked whether or not he intended to claim a particular thing referred to in the specifications.

MR. SMART: It has generally been held that the construction of a patent is a matter for the Court. The document is here, and after a patent is issued the inventor cannot go before the Court and say, "What I meant was so-and-so."

HIS LORDSHIP: The trouble about the objections is that they take too much time, and the witness has answered the question before. You can get it quickly by asking the witness, "What are the different elements in your invention?"

MR. HENDERSON: Is the cascading of audions one of the elements ot your invention?—A. I do not believe that my patent contains any claim as broad as that.

HIS LORDSHIP: Is it one of the elements in the make-up of your invention?—A. Yes, my invention contains a cascading of audions.

Q. If that were left out it would not be your invention. Is that what you mean?—A. If it did not have audions as couplers between the circuits, it would not be my invention.

MR. HENDERSON: Prior to the making of your application were you familiar with the selective system of Marconi?—A. I was familiar with the method of using a tuned antenna and a loose coupling with a detector attached to the secondary oscillating circuit. I understood this system was extensively used, but I did not know of the Stone arrangement or the Marconi arrangement for cascading a chain of tuned circuits.

Q. I think that is a fair description. Professor Hazeltine has stated in evidence that he has made certain tests and a series of calculations which have satisfied him that the Marconi system may actually be superior to your system in giving a high degree of selectivity with a broad tuning band. Would you differ from that?—A. I assume that Professor Hazeltine understands the Marconi system here as the simple loose coupling, because that is the only Marconi system I knew about at the time. Am I correct in that understanding?

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Q. Yes, with this qualification; with or without an intermediary circuit. I show you Professor Hazeltine's charts 5 and 6 which were marked as Exhibits "I" and "J" in this record, each of which has a diagram attached, and I ask you to look at this and say if you would differ from him as to the result shown.

MR. SMART: My learned friend is giving the witness the facts.

MR. HENDERSON: Surely the witness is competent to say whether or not he differs from him.

HIS LORDSHIP: I do not see why you want to get these questions answered. You have Hazeltine's answers there on the record. It is not fair to ask one expert, do you agree with the other man?

MR. HENDERSON: Do you think not?

HIS LORDSHIP: It helps sometimes, but there is no purpose to be served by asking one expert whether he agrees with the other. You have got the opinion of two experts anyway, and their opinion stands for what it is worth. However, I am not objecting if the witness can answer.

MR. HENDERSON: Can you answer?—A. If Dr. Hazeltine's conclusions are that a chain of tuned circuits is preferable in the design of a receiving set to a chain of circuits coupled with vacuum tubes, I disagree with him.

Q. He says it may be preferable from a selectivity standpoint. He has made a series of very elaborate calculations and tests as between your system and the Marconi system, and he finds that in the second stage the difference is slightly in favour of the Marconi system, but in both cases it is preferable from a selectivity standpoint. What do you say to that?—A. I have investigated the same subject, and I have arrived at the opposite conclusion as a practical matter. I have built a set with one, two, three stages, according to Marconi and Stone, and I have found that although it is possible for that arrangement to get a very good degree of selectivity, you can get the high selectivity only by such a sacrifice of signal strength that its method is inferior to the method that I propose.

Q. As to the selectivity, you do get selectivity with this?—A. Selectivity can be gained only when you sacrifice other very essential features; that is, you must sacrifice signal strength and you must sacrifice——

Q. You get as good selectivity and you may get better selectivity, but you do not get as much signal strength?—A. No better selectivity. I think there is a real distinction there, because the selectivity of the Stone system approaches the selectivity of my system when the signal strength approaches zero. I am talking of the Marconi system.

Q. I am talking of the Marconi system.

HIS LORDSHIP: You mean the Marconi and Stone both?

WITNESS: Marconi and Stone representing the general proper circuits.

MR. HENDERSON: In making that statement have you considered that that would affect the plate circuit?—A. In a properly constructed set the damping of the plate circuit is entirely insignificant. In fact the set can be designed in such a way that the damping of the plate circuit is zero.

Q. You have on more than one occasion spoken of what might happen in a properly constructed set. Do you refer to a set which has proper neutralization ?—A. No, it is not at all necessary to use neutralization in order to design a good set.

Q. Or the equivalent of it ?—A. No. A very good and practical set can be built from the directions in my patent.

Q. Which has no neutralization ?—A. Which has no neutralization.

Q. Do the General Electric Company or any allied company make such a set ? Is there such a set in the market ?—A. There are a number of sets in the market.

Q. Made by any of these allied companies ?—A. The receiving sets used in the trans-oceanic stations of the Radio Corporation use no neutralization.

Q. I was talking about receiving sets on the market ?—A. I am not quite sure of that.

Q. You do not know of any ?—A. Most of the sets that I know of embody some kind of neutralization, but that is simply because the highest degree of amplification can be gained to better advantage if neutralization is used. But it is not at all essential in order to get the benefit of my invention.

Q. No, nobody said it was. But is there a set on the market which simply uses your invention without neutralization or something equivalent thereto ?—A. There are many sets on the market of the character described, but I am thinking of the Splitdorf and several others of that type.

Q. Is there any put out by your Company ? We know the Splitdorf is a poor fatherless thing. I want something fathered either by your organization——A. I believe the sets put out by our Company embody the same kind of neutralization.

Q. You have spoken of these trans-Atlantic sets. One of these is called the Chatham ?—A. Yes.

Q. Is this a diagram of the Chatham set ?—A. Yes.

Q. Is that the same as the other set you referred to as a trans-Atlantic set, I mean substantially ?—A. Yes, sir.

Q. So this illustrates what you mean. This I may say has what appears to have been originally a pencil mark on it, which is photostated into it, I thought at first we had put it on and I was going to rub it off but I found I could not.

EXHIBIT NO. Z-17 :—Filed by Mr. Henderson, Jan. 19, 1927. Diagram of Chatham set.

Q. Is it true that in this system there are only two tuned circuits connected by relays ?—A. Yes, this diagram shows a relay which consists of a composite of three tubes.

Q. And only two tuned circuits connected by relays. Is it not also true that these two tuned circuits are connected by three cascaded relays as you have just said ?—A. Yes.

Q. And it is also true that there is no tuning and therefore no selection interposed between those three individual relays ?—A. Yes.

Q. Then assume several resonant circuits, each of which individually would select against an interfering signal in the ratio of 100 to 1 ; then if these circuits are reactively and loosely coupled in cascades, would the

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Plaintiff's Evidence in Reply.

No. 18. Ernst F. W. Alexanderson. Cross-examination *—continued.*

In the Exchequer Court of Canada.

Plaintiff's Evidence in Reply.

No. 18. Ernst F. W. Alexanderson. Cross-examination —*continued.*

selectivity be in the ratio of 100 times 100 for two such circuits and 100 times 100 times 100 for three such circuits ?—A. Are those inductively coupled or tube coupled ?

Q. I said reactively and loosely coupled in cascades ?—A. The composite effect would be less favorable than 100 times 100 times 100.

Q. Because of what ?—A. Because of the reaction.

Q. Mr. Hazeltine has made a calculation showing that the result would be the same, can you differ from that ? He has so stated in the evidence ?—A. The result, according to my way of looking at it, would be the same, only when the coupling is so loose that the re-action is negligible.

Q. I will leave it at that.

Is there any essential difference from a selectivity standpoint between an inductively coupled Marconi system and a capacity coupled system ?—A. It is immaterial from this point of view whether the energy is transferred magnetically or capacitatively.

Q. I want to ask you if at the time you made your patent application you were familiar with what was called the Marconi multiple tuner, which is illustrated on page 807 of the Fleming book ?—A. No, I was not familiar with it.

Q. I presume you have since become—— ?—A. No, I know about his method of tuning being used by an inductively coupled circuit, but I was not familiar with his particular device.

Q. You know of course that this is the device that we speak about as the Marconi Franklin device, covered by British patent No. 12,960 ?—A. I did not hear that name for it.

Q. Had you not heard of Franklin ?—A. I knew Franklin very well.

Q. Did you know his work ?—A. Yes, and I knew him personally.

Q. At that time were you familiar with the Schloemilch and Leib work, covered by British patent No. 10,210 ?—A. No.

Q. Or were you familiar with the Lorenz covered by German patent No. 258,478 ?—A. No.

RE-EXAMINED BY MR. SMART :

Re-examination.

Q. Dr. Alexanderson my learned friend asked you with respect to certain discussions with Dr. Langmuir as to the sluggishness of these audions, in which Dr. Langmuir said that in any event the sluggishness could be removed. I am not clear as to the date of those conversations. Perhaps you will give them now ?—A. Those conversations took place during January, 1913.

Q. My learned friend also put to you certain evidence in an interference record, being Drs. DeForest and Alexanderson——

MR. HENDERSON : Your Lordship will remember I put it at your Lordship's suggestion to him as my own question, reading from that.

MR. SMART : Can you tell me whether or not the evidence in that interference related to the same invention as covered by the patent in issue here, Exhibit No. 1 ?—A. The testimony read to me related to another invention.

MR. HENDERSON : It was not read to him.

WITNESS: It related to the use of a vacuum tube as a high powered device for transmission of radio telephony. In my earlier testimony I mentioned that I had been working trying to find such a device, and when I became acquainted with the audion it suggested to me that with the development of Dr. Langmuir such a device might be made. It is entirely inconceivable that the audion as then known could be used as this high power device which was the subject of the discussion in that record. That is the reason why my answer was given as it was, stating that the essential thing was to determine whether it would be operative. In that way the consideration of this matter differs from the use of the audion in his receiving circuit, because the audion could as a matter of fact be used in the receiving circuit, and I had a strong belief that it could, although I should see that proved.

MR. SMART: I may wish to refer in my later evidence to this sketch on October 21st, 1921, I will avoid putting it in evidence now on the understanding that my friend and I can identify it later.

MR. HENDERSON: If my friend asks me at any time if this is the sketch referred to earlier I will try and be honest.

MR. SMART: Well I do not want to pass it by without reserving that.

MR. HENDERSON: I merely did not wish to encumber the record with it at the moment.

HIS LORDSHIP: I suppose it is conceded, Mr. Henderson, that the device which we are calling the Alexanderson does accomplish geometric progressive tuning? I mean outside of the question of patent.

MR. HENDERSON: Apart altogether from its patentability.

HIS LORDSHIP: Everyone agrees on that.

MR. HENDERSON: In fact we do not quarrel with the statement made by Mr. Waterman that practically speaking every receiving set in use to-day, every decent receiving set in these days, unless it is tremendously antiquated, uses geometric selectivity with relays, and the relay commonly used to-day is a vacuum tube, and on this continent the great bulk of the vacuum tubes are made and sold by either the General Electric in the States or the Canadian General Electric in Canada. There are others of course.

HIS LORDSHIP: And I understand that geometric progressive tuning and selectivity can be demonstrated mathematically. Both Dr. Hazeltine and the other experts can do that, it is an accomplished fact—not an accomplished fact but a fact demonstrable mathematically.

MR. HENDERSON: I do not know whether your Lordship clearly understands yet, I did not and I let Dr. Alexanderson go, unless your Lordship appreciates that this figure of 10 to 1 that they use is merely a figure which might be 5 to 1 or any other number.

MR. SMART: Oh yes.

MR. HENDERSON: The difference is between arithmetical progression and geometrical.

HIS LORDSHIP: I suppose when he referred to 10 he might have said 9.

MR. HENDERSON: Decimal numbers are easier to think in.

[*This Witness was recalled see p.* 354.]

In the Exchequer Court of Canada.

Plaintiff's Evidence in Reply.

No. 19. Frank N. Waterman (recalled). Examination

No. 19.

Further Evidence of Frank N. Waterman (recalled).

F. N. WATERMAN, recalled. Examined by MR. SMART:

HIS LORDSHIP: There is something left to be said, is there, Mr. Smart?

MR. SMART: Yes, because we have not dealt with the defence. Mr. Waterman has not discussed anything that my friend put in in his defence, the specific evidence.

HIS LORDSHIP: Oh yes, of course you must reply to that.

MR. SMART: Mr. Waterman, you heard Professor Hazeltine's evidence, and also the tests which he performed during the giving of his evidence?—A. I did.

Q. I would ask you to deal generally with those tests and what they purported on his evidence to show?—A. The tests conducted by Professor Hazeltine were conducted with a special apparatus designed and described as showing reactive coupling between a succession of circuits affected in a particular way, and a comparison of the results so obtained with results which he obtained when he introduced tubes into the same apparatus and operated them in a particular way. The apparatus was specially designed to show the effects described, and the impression which it creates or must necessarily create in the mind of one not sufficiently skilled in the art to correctly evaluate the special features of construction and of connection cannot fail to be grossly misleading.

The circuit which he used in making the so-called reactive tests was not, specifically considered, a circuit of the prior art. It was the circuit, diagrammatically considered, which remains when a tube is taken out of one of the figures of the Alexanderson patent, or out of the defendant's apparatus, which is for this purpose the same thing, when the neutralizing condenser is omitted and the circuit that remained was a tuned circuit, a condenser which he inserted into the socket where he took the tube out, connected in series with the coil which on Exhibit 8 is marked 12, which in turn is normally inductively associated with the next tuned circuit tuned by the condenser No. 15.

Specifically therefore he had no circuit described in the prior art as far as I know. He did add a particular way of getting a reactive coupling through the interposed condenser substituted for the tube and the coil. It was in other words a composite electrostatic and electro magnetic coupling. This was made of such an order as to suit his purposes by the special construction of the coil 12. In making this test he applied two signals of excessive loudness.

HIS LORDSHIP: Are you referring to Dr. Hazeltine's demonstration?—A. I am, as made in the other Court Room. I should say that the signal through which, the signal corresponding I think he said to Ottawa, was of excessive loudness, and he obtained a signal through that arrangement which I, being familiar with those circuits, recognized at once as wholly abnormal.

Then he put the tube into the socket but did not light it, and through the capacity which, of course, we all recognize as present in the tube between the grid and the plate, he got a similar signal. Then he lighted the tubes, but he lighted them so feebly that the signal was not, as the Alexanderson patent says, maintained a level signal, but fell off. In other words, the tube, although ostensibly lighted, was not working, it was not functioning as a relay, and naturally he got the same result. There was nothing there to alter it.

When the tubes, at someone's suggestion, Mr. Smart's, I believe, were lighted to a higher degree of brilliance so that a signal approximately constant was obtained from stage to stage, then the difference was at once evident. The selectivity was obviously and noticeably greater. Professor Hazeltine then lighted the filaments more brilliantly, going to a high degree of brilliance, and showed that the tubes oscillated. The same special coils which correspond to 12 and 18 on exhibit 8 function for the same purpose to bring about this ready oscillation. Oscillation even with the special apparatus, was controllable by the control of the battery resistance. The impression necessarily created by this special apparatus was so very far from the facts as we find them in commercial apparatus in every day use of the invention, as not to be readily conveyable to one not familiar with the facts by words or even by figures ; and with your Lordship's permission I would like to illustrate by a demonstration here in the courtroom what I mean by that statement ; and I would like to do it with a regular commercial apparatus purchased in the open market and which has not been altered or modified in any way whatever.

If your Lordship is willing to witness this test I will describe what I propose to do, so that it will be clear when I do it.

His Lordship : Can you do it right away ?

Mr. Smart : Yes, this is the set right here.

Witness : The set is present in court and is connected by a pair of wires leading from the set to a small broadcasting station over in the window.

His Lordship : Mr. Henderson would perhaps like to see it before he proceeds.

Mr. Henderson : I have no objection to the test. I can tell your Lordship now that it will not be comparable with either the Marconi or Alexanderson.

His Lordship : Before Mr. Waterman goes on, would you like Doctor Hazeltine to see the apparatus ?

Mr. Henderson : Doctor Hazeltine says he would prefer to have the demonstration made first, because he would be more or less setting up a straw man otherwise, but we have no objection whatever to a demonstration, my Lord.

His Lordship : Yes. You were interrupted, Mr. Waterman.

Witness (Continuing) : That small broadcasting station will have the high frequency alternations which it generates modulated by an electrical pickup, as we call it, on a phonograph which I will have placed out in the hall in order that we may not be disturbed by hearing anything from the phonograph direct. I take this precaution because in the tests made by Professor Hazeltine all possibility of accurate judgment was vitiated by the fact that the vibrating contact modulating the oscillations, one of the oscillators made so loud a noise that it made the ear continually hear its sound, therefore making accurate judgment difficult.

The oscillations so modulated will be picked up by a small coil of wire lying near the small broadcasting unit and will be taken through a condenser, the purpose of which is not to tune but merely to control the quantity of energy fed to the receiver; and then passed to the regular binding posts in the receiver intended for the connection of antenna and ground wires.

The three dials, which are the tuning elements of the three circuits in this receiver, will be adjusted. The tubes in this receiver are by the manufacturer so arranged that the radio frequency tubes, that is the tubes which are performing the functions of tubes I and II in exhibit 8, are separately controllable. And that incidentally is one reason why I chose this set, because it had this necessary provision without my making any alteration whatever in the circuit.

MR. HENDERSON: It is the Splitdorf set, is it not?—A. It is the set known on the market as the Splitdorf set.

When a signal has been received by the set working normally, I will tune down the filaments of these tubes to so low a point that they are not operating at all. The set not being neutralized in any way, if there is the reactive coupling which Professor Hazeltine has alleged, the signals should continue to be heard. The observation is that the change in signal occurs when the tubes are turned off. The circuit diagram is a matter of schematic illustration, and this Splitdorf set is essentially the same as shown on exhibit 8, with the exception that the neutralizing condensers are not present. It is in other words a set substantially as shown in figures 1 and 2 of the Alexanderson patent.

MR. HENDERSON: With close coupling or with loose coupling?—A. I have not the figures in mind, but the set has manifestly been so designed, following the instructions of the Alexanderson patent and illustration of Fig. 1, that it is an efficiently operative set giving the selectivity in geometrical progression.

MR. HENDERSON: But it is close coupled.

WITNESS (Continuing): Good quality of signals and freedom from oscillation with the tubes at full normal brilliancy, except at the very high frequency end of the scale, when the tubes must be turned down slightly to avoid oscillation, if they happen to be particularly good tubes.

MR. HENDERSON: But it has close coupling, hasn't it,—that is the point? My Lord, Professor Hazeltine pointed out in his evidence that to correspond with Alexanderson's, as Doctor Alexanderson has said to-day, there has to be loose coupling. He pointed out to-day that the one coil was green and the other was a light colour, and he pointed out it was loosely coupled so as to correspond with Alexanderson. This is closely coupled.

HIS LORDSHIP: Is that correct?

WITNESS: I do not think——

MR. HENDERSON: It is, is it not,—yes or no?—A. Your language is not such that I can understand it, even. It is so designed with respect to coupling as to give the Alexanderson result, which is what the Alexanderson patent sets forth. Now I do not know what standard of closeness or looseness Mr. Henderson has in mind, and it is utterly impossible for me to answer that question.

MR. HENDERSON: Your Lordship can look at it and compare it with the Hazeltine coils and see for yourself.

WITNESS: If it is closely coupled in any sense which is objectionable, this set must certainly oscillate when the tubes are below normal brilliance, all over the scale. Now, as a matter of fact, it does not. The coupling is what I, in my own interpretation of those words, call rather unusually loose coupling. Therefore, I have very great difficulty in knowing how to answer an assertion which says it is tight coupling, because Mr. Henderson may have some other standard as to what constitutes tight or loose coupling.

MR. HENDERSON: I am not a dodger.

MR. SMART: I think my friend should not say such a thing.

MR. HENDERSON: I am sorry to provoke my friend, Mr. Smart. If you can show me one time when Mr. Hazeltine evaded a question, I would like to see it.

MR. SMART: Acrimonious comment by counsel will not decide this case.

WITNESS: If I may answer the question categorically my answer is No. To my way of estimating coupling, it is rather unusually loose coupling.

Now may I proceed with the test? I will ask to have the apparatus connected up. I may say that while a phonograph record will be used, I have present a singing relay, a buzzer, which may be employed if it is desired for any reason to have that substituted for the phonograph signal. I use the phonograph signal, first, because the average ear is more accustomed to listening to it, and therefore can detect it more readily when the tubes are turned off, than it can a mere humming sound, particularly as the humming sound is often set up by other causes in a relay.

HIS LORDSHIP: What do you mean by a phonograph signal?

MR. HENDERSON: A phonograph record. Of course this test is taking place in court, where one likes to observe formality. May I ask to forego formality, if Mr. Hazeltine and his associates wish to go forward during the test?

HIS LORDSHIP: Yes.

WITNESS: I will ask Doctor Roberts if he will have the phonograph started and adjust the apparatus and turn it on. I would like to state that in this test I am not demonstrating two stations; nor am I demonstrating interference elimination. The test goes solely to the removal of what I consider to be an entirely erroneous impression necessarily given by the special apparatus used by Professor Hazeltine, which was arranged to the definite end of taking a large amount of energy from the set. And one of the ways in which he illustrated that was to turn the set around and send the energy through it backwards.

The set is now modulating the signal which is being transmitted to the receiver and the sound is coming in. I will now ask Doctor Roberts to turn down the radio frequency filament suddenly. Your Lordship will listen, because the apparatus is now in the condition in which Professor Hazeltine's apparatus was during that test in which he placed the tubes in place of the special condensers, and all the energy which comes in by virtue of that coupling, of which he made so much, is now coming in.

Turn on the tubes, please? Now turn them down again. And this demonstration gives your Lordship the impression of relative values, and illustrates what Doctor Langmuir has said, what Doctor Alexanderson has said, that while these tubes are not ideally perfect devices, such as the mathematician conceives, they are sensibly so. And the effects of which Professor Hazeltine's special apparatus made so much are in an actual apparatus entirely trivial and without substantial effect.

Would your Lordship like to have the test repeated or continued, or a buzzer signal substituted, or any other tests made?

HIS LORDSHIP: Is that all the test you propose?

MR. SMART: Yes.

MR. HENDERSON: All I ask in that connection, then, my Lord, is that we be permitted to examine the apparatus internally, which can not be done at the moment.

MR. SMART: Yes, certainly.

MR. HENDERSON: We will see it in connection with any one my friend may name after the adjournment.

WITNESS: With respect to the matter of relative selectivity, about which I have said little, that could not be judged at the test which Professor Hazeltine made, because of the fact that the signals were very loud. There was no certain way of telling whether the stations as he had them related side by side were acting independently or not. But I am content to rest upon the fact that when the tubes were turned to such a degree of brilliance of illumination of the filaments that it was acting to give the level signal which the Alexanderson patent describes or a more amplified signal than the original signal which the Alexanderson patent also describes, the selectivity was fairly superior even to that of the specially contrived set, which was used to illustrate the so-called reactive coupling.

With respect to orders of magnitude that are involved in that matter I would prefer to deal, when considering the calculated curves which Professor Hazeltine has produced, and which are based upon the contrasting on his part of a certain diagrammatically indicated assumed set of reactively coupled circuits, with another assumed set of uni-directional coupled circuits through the tube.

MR. SMART: *I wish you would refer to the charts which are now Exhibits " I " and " J " and which have been produced by Professor Hazeltine, and let us have your comment on the drawing of those exhibits?*—A. These charts are based first on a deliberate disregarding of the disclosures of the Alexanderson patent, and a violation of the instructions of the patent as to how to proceed in considering the matter. They therefore show nothing of interest and have no real bearing. There are two matters that require to be cleared up before the meaning of the charts or of the statement that I have just made can be understood. First, I will take the matter of the individual efficiency of an individual circuit. I take this because it is one of the fundamental things involved in Professor Hazeltine's calculations. I may say that while I have not seen his figures I do not propose to question their arithmetical accuracy. I only propose to deal with the assumed assumptions upon which he bases them, and the understanding of the Alexanderson patent, or as I would prefer to say, the misunderstanding of the Alexanderson patent upon which he also bases it. I refer to this matter for another reason also, if I may explain to your Lordship.

In the Exchequer Court of Canada.

Plaintiff's Evidence in Reply.

No. 19. Frank N. Waterman (recalled). Examination —*continued.*

The testimony which has been given as to the relative use of receiving signals at sea on an old Marconi tuner known as the jigger, and on a low resistance new tuner known as the Marconi, a multiple tuner, with both of which I am familiar, hangs upon a question which has not been explained, and that is upon the effect, with a given circuit, not multiplied or affected in any way, the effect on its selectivity of merely reducing its resistance. Suppose we imagine a circuit like the circuit constituting the secondary of the transformer and tuned by the condenser 8 in Exhibit 8, or the corresponding parts in Fig. 1 of the Marconi patent. That is a mere diagram. It shows an inductance tuned by a capacity. The losses that may inhere in those two instrumentalities determine to what extent the resonant amplification that that circuit per se effects will take place, and I illustrate that by some resonance curves, the data for which are marked upon the sheet. The curve marked "R" equals 5, "TF" equals 200. We found that this sheet which extends from the top of the curve, and has to be read by the scale on the left, that represents such a circuit as I have just pointed out, so the first tuned circuit to the left in Fig. 1 of the Alexanderson patent in which the losses are low, which is the good circuit, and a resonant current equal to 100 will be developed.

Now without making any change whatever in that circuit I merely assume that those coils are wound on such a spool or with such a wire that the resistance to radio frequency current runs up to 10. Immediately the maximum or resonant current developed in that coil falls to 50, whereas before it was 100. The selectivity against a given signal in other words had fallen approximately to half.

Now, again assume that without making any other change in the coil this resistance is doubled and now equals 20, the current has now fallen to 25 instead of 100. The selectivity has fallen approximately in the same ratio, and if I then figure it at 100 the current has now fallen to 5 instead of 100, and the selectivity has been enormously decreased. Now that change in selectivity, is made without altering the circuit in any way whatever, and unless one has these fundamental facts in mind a calculation such as is made by Professor Hazeltine on these charts means nothing.

It is evident at once that if we are going to compare the performance of two circuits we must compare them on a comparable basis, and if we are going to compare the two receivers such as the Marconi jigger and the multiple tuner we must compare them only after making corrections for the difference in their losses. The resistance which I have here referred to are the causes of the losses and energy which is consumed in resistance, and therefore consumed in heating up the wire, is manifestly not available for transfer to a detector or telephone for useful reception.

The second fundamental matter which is necessary to an understanding of these diagrams is that Professor Hazeltine has definitely ignored the statement in the Alexanderson patent that in his disclosure he disregards the effect of the antenna. That, of course, does not mean that Dr. Alexanderson was throwing away all the good work that had been done by Marconi, Stone and others and starting over again, but it means what it says, that because of this inevitable resistance, a part of which is represented by its radiating ability and the spacial distribution which determines largely its losses, you can not tell what it will be. Now, since he cannot control it, he proposes to disregard it and start with the first tuned circuit which is that tuned by condenser 8. The curves have been made to show that by a calculation based on making arbitrary resistance assumptions, not excluding the antenna (or rather not disregarding it), and on assuming any condition of operation of the tube that may be necessary to bring about such a result, a comparison on which the two methods appear on approximately an equal footing can be made. Of course, to those of us who have been making that type of calculations for many years that is an obvious and well known matter. It is only false in the impression it creates when it is presented to one who does not know the significance of the things chosen, and the expected results from such an association as has been here calculated.

Referring to Exhibit I, and taking the diagram at the left, an antenna circuit whose constants are given is associated in a manner numerically specified with a local circuit. Those two circuits are radically different in their losses, and instead of disregarding the antenna and associating a second circuit, Professor Hazeltine calculates the result of the association of those two circuits. Now those two circuits are the circuits 1 and 2, and with the antenna circuit of Alexanderson Fig. I Exhibit 8, and those are the two things that he calculates. But the instructions of the patent are not to calculate the antenna, but to calculate that circuit i-8 with the circuit associated with the secondary of the transformer 12 and the condenser 15. Whatever benefit accrues from the association shown in Professor Hazeltine's figures, Mr. Alexanderson starts with that. There is nothing there that Alexanderson did. Marconi did that, and it was used for many years, and that is where Alexanderson starts.

Therefore, this figure at the left hand of Exhibit " I " simply develops radio up to the point where Alexanderson started, and has not any bearing on what Alexanderson did. Now in the figure on the right hand side of Exhibit " I " again Professor Hazeltine declines to follow the instructions of the patent and to neglect the antenna. He separates the coil i-8 from the antenna and puts the tube in between. He chooses not a level or declining signal as he showed in the test—that is the latter of which he showed in the test—but he chooses a substantial amplification, and so loads his second circuit with an appreciable plate circuit load. I do not know how he arrived at it and I do not care.

The point is that the thing done is not something which is a normal procedure in accordance with the Alexanderson disclosure to compare the merits of two circuits. It compares the merits of something which Alexanderson said expressly to disregard, with something else.

Q. Now, you have heard Mr. Binns' evidence?—A. Did you want me to consider the other diagram? I had not anywhere nearly finished this answer.

Q. Very well, go on to diagram J.—A. Diagram J does the same as exhibit I, namely it includes the antenna in each case; it disregards the instructions of the patent, and therefore it has no meaning as applied to the comparison of the thing which Alexanderson disclosed with the prior art.

Insofar as there is a transfer from an antenna to a local tuned circuit, that is where Alexanderson started and the benefit which he took from the prior art when he started.

If you compare the effect of the transfer from the intermediate or linking circuit, which is between the antenna and the output circuit in the left hand diagram of exhibit I, it will be found that the output in that last circuit, as compared to that in the intermediate circuit, is a little over one-half. In other words, that is the loss that has been suffered as compared to the level signal with greater selectivity. And in loading the tubes in the right-hand figure, the loading has not been on the basis of a level signal but on the basis of a large amplification, if I correctly apprehend it. But the diagrams, apart from all of these things, are essentially misleading because they ignore the magnitude of the signal. The two curves are drawn on a percentage basis without regard to their actual magnitude.

I have a curve sheet with calculated curves on it, which compare not merely in selectivity but in magnitude, the results of two circuits, the antenna being disregarded, associated on the one hand through uni-directional coupling by the tube, and on the other inductively after the fashion of Marconi and Stone.

On this sheet, the dotted line marked A-1 illustrates the resonance curve of a single such circuit, the characteristics of which are noted upon the sheet for verification.

The curve marked B shows the performance of two such circuits when coupled by the Alexanderson uni-directional coupling method, and shows the enormous increase in selectivity made on the assumption of the levels or unaltered signal which Alexanderson describes. The gain in selectivity is obviously great.

Curve A-11 on this same sheet, which has an altitude of 50 per cent. of the curve B or level signal intensity, shows the same two circuits coupled reactively, after the method of Marconi or Stone, with such an order of coupling that the maximum transfer of energy is accomplished. It is at once apparent that while at some distance each side of resonance the response is greater than that indicated by the curve B or the uni-directional coupling, the response at resonance is only half as great. Consequently the selectivity is less than half as good.

The curve C represents two identical circuits coupled with one half of the coupling which would result in maximum energy transferred. It

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is a sharp curve. The selectivity is somewhat improved; but the maximum amplitude, however, has fallen to only 40 per cent.

Q. See if your legend is marked the same.—A. There is no legend on this. May I explain myself that I find myself in the very embarrassing position of having the very Court exhibit P-22 which was offered in evidence, and which should be in the files of the Court. By some means my copy has been left there and the Court copy has got into my hands. Therefore, I did not dare make any marks on this.

Mr. Henderson: Why not use the photostat, the same as you have given us.

Mr. Smart: I have not an extra one. I will have one made.

Witness: The selectivity is still decidedly inferior to that of the Alexanderson one-way coupling.

Curve D shows the performance of two identical circuits with one-quarter of the coupling, giving a maximum energy transfer; and the energy has here fallen to about 27 per cent. This illustrates what I stated in my former deposition, but what is not shown at all in the curves of exhibits I and J, namely that as we gain selectivity we lose signal, when following the methods of the Marconi and Stone inductive coupling plans. And that same ideal is approached only as we indefinitely diminish the strength of signal.

Now, if we can afford to sacrifice signal strength, of course no one questions the fact that quite good results can be attained in this way. As I understand it, it was quite open to anybody to obtain good selectivity in this way, and they may then amplify as much as they please afterwards.

The reason for the difference is, first, that all of the energy which comes out of the last circuit in the Marconi or Stone arrangements is energy that the system has been compelled to abstract from the air. It acts in the first circuit with all the losses that that circuit imposes. Some of it gets over to the second circuit, where it again suffers all the losses that the circuit imposes; and some gets to the third circuit, and it again suffers the losses. And that same energy thus effectuated must again suffer attenuation, which is not considered in Professor Hazeltine's diagrams to the left, but is at least to an extent considered in those to the right; thereby further attenuating the available energy necessary for a response.

Now in the Alexanderson arrangement the signal energy is conserved in a single circuit and it is associated with a relay that does not take energy appreciably from it. Therefore it is not disturbed in its own selective action, and does not benefit in any selectivity which is attained; and that selectivity will be determined by the characteristics of the circuit in accordance with the sheet which I produce, and which is marked "Resonance curves as affected by resistance."

Q. Just a moment, Mr. Waterman. I want to offer a photostat copy of it, which I will have in the morning, of the first set of curves referred to by Mr. Waterman with his expressed percentages of resonant frequency, which would be exhibit No. 15.

EXHIBIT NO. 15:—Filed by Mr. Smart, Jan. 19, 1927. Photostat of first set of curves produced by Mr. Waterman.

Q. And you now have another curve?—A. That is the first one I produced.

Q. This is not the one which you were just describing?—A. That is the one which I referred to first and also at this last moment.

MR. SMART: I also put in a photostat copy of the curves, Resonance curves as affected by resistance, as exhibit 16. I will make photostat copies of that for my learned friend as well. They are both to be furnished.

EXHIBIT NO. 16:—Filed by Mr. Smart, Jan. 19, 1927. Photostat copy of Resonance curves as affected by resistance, produced by Mr. Waterman.

WITNESS: The other element that accounts for the difference is the fact of reaction, in the one case, and no reaction in the other case. That means this, that if I transfer energy from circuit No. 1 to circuit No. 2, and circuit No. 2 builds up a resonant current, circuit No. 2 at once begins to react back upon No. 1 and to build up therein another current not coincident with the initial current, thereby taking energy back from the second circuit into the first in the reverse of the desired direction of energy transfer.

It is those two factors which must be considered in understanding the difference between what has been broadly called reactive coupling and the one-way coupling of Doctor Alexanderson which gives the true geometric selectivity.

MR. SMART: Q. If the signal went down in the arrangement of Stone or of Marconi, where the circuits are coupled magnetically, can it be brought back by amplification?—A. Oh yes, if it does not go too far. For nearby signals of good volume I have built very effective receivers in that way. They are not much use for distant reception because the signal gets so weak that to bring it back means a very noisy receiver; and even at that one does not get the same selectivity out of the same efficiency of circuits. It is possible to bring back a signal, if you do not let it go too low; and you do not have to let it go too low, if you are satisfied with poor selectivity.

Q. Now you referred to the Marconi circuits and your knowledge of them. Do the present day Marconi circuits use the Alexanderson arrangement?—A. I do not know that I understand what you mean by present day Marconi circuit. I stated it the other way, that some of the present day Alexanderson circuits also used the Marconi, that is to say Alexanderson did not in any way throw away Marconi results.

Q. Do you say that the Alexanderson system of a plurality of tuned circuits coupled by vacuum tuned relay devices was used in the present day Marconi receiving stations?—A. I have only a limited knowledge of the present day trans-Atlantic receiving stations, but in so far as I have knowledge they do.

Q. You have read and studied this Alexanderson letter of February 4th, Exhibit Z-3?—A. Yes, I have read it and I think I understand it.

Q. I would ask you to state generally whether or not in your opinion the disclosures of that letter would be a sufficient communication to a man skilled in the art of the invention described in the plaintiff's patent, Exhibit 1?—A. I have no doubt of it.

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MR. HENDERSON: I object to the form of question. That is for the Court.

(Question read to witness.)

MR. SMART: As of 1913.

HIS LORDSHIP: It would be a little involved.

MR. HENDERSON: I think it is for the Court to decide.

HIS LORDSHIP: It is a very common question, and I have never heard it questioned as a matter of principle. Could a man skilled in the art with that information before him have constructed the patent mentioned?

MR. SMART: Will you answer?—A. I have no doubt of it. It contains sufficient information from which I could construct the patented article, and that information is the same as that which I find in the Alexanderson patent.

Q. And putting yourself in the position of one ordinarily skilled in the art in the year 1913, at the later date, what would your answer be?—A. I intended to have so expressed it. I was at the date of this letter sufficiently skilled in the art so that I am perfectly certain I could have read the letter, and I would have built the same apparatus as had I had the patent in suit before me at that date.

HIS LORDSHIP: Doctor Hazeltine gave the opinion the other way.

MR. HENDERSON: Yes, Dr. Hazeltine said it was a nebulous idea.

MR. SMART: And we have had other evidence.

MR. HENDERSON: With regard to the suggestions and statements which have been made, we will be entirely content if your Lordship sees fit to call in an independent expert in regard to that matter.

HIS LORDSHIP: I am afraid it cannot be done. It is too late now. I do not think I have any authority to do it.

(Court adjourned Wednesday, January 19th, 1927, at 4.30 p.m., to resume on Thursday, January 20th, 1927, at 11 a.m.)

No. 20. Discussion, 20th Jan., 1927.

No. 20.

Discussion.

20th January, 1927.

MR. SMART: My Lord, I have been speaking to my learned friend last evening, after we adjourned, and it seems to me that some matters which I thought were in dispute as to the operation of the Stone and Marconi circuits, are not in dispute. It will save considerable evidence if we can at least clear some of the ground with respect thereto, so there are two statements I would like to make and I will see if my learned friend can agree with me.

The first is that if a plurality of resonant circuits of the type shown in Marconi or Stone, are coupled loosely, electromagnetically, a high degree of selectivity may be obtained, at the expense of the signal strength. That is to say, the signal will be weakened in successive stages of the circuit.

MR. HENDERSON: With my friend's permission; with a very slight qualification, we may perhaps agree to that. Mr. Hazeltine, as you will remember, distinguished between "selectivity" and "sensitivity." He said, in such a case there would be an attenuation of the signal.

HIS LORDSHIP: That is the same as a loss of current?

MR. HENDERSON: Yes. You gain in selectivity. And he pointed out that Marconi was even superior to Alexanderson in the matter of selectivity or what we may call "amplification," broadly, there is a certain loss, as Mr. Hazeltine pointed out. Then my understanding is that Mr. Waterman's time was taken up yesterday afternoon, apart from an experiment, in demonstrating that there was a loss in signal strength. With which we do not differ at all. We so stated affirmatively.

HIS LORDSHIP: Mr. Smart then puts the agreement correctly, does he not?

MR. HENDERSON: It is not as Mr. Smart puts it precisely. We pointed out that the weakening, as Mr. Hazeltine said, is not great.

HIS LORDSHIP: Then you differ as to the degree?

MR. HENDERSON: Only as to the degree.

HIS LORDSHIP: Did Mr. Smart state the general proposition correctly; that attenuation and loss mean the same thing?

MR. HENDERSON: Yes.

HIS LORDSHIP: Loss of strength of the signal?

MR. HENDERSON: Loss of signal strength but not of selectivity.

MR. SMART: I think I can carry it a little further, with additional statements.

HIS LORDSHIP: Listen to this please then, Mr. Henderson, and you can confer afterwards.

MR. SMART: The second is that as the coupling is loosened between the various stages of the Marconi or Stone arrangement, the selectivity is increased, but the loss of signal is also increased; that is the signal loses strength as the coupling is loosened.

MR. HENDERSON: We agree with that proposition, but as to the first, we do not, and before you proceed with the third let me say this.

HIS LORDSHIP: If Mr. Smart has not finished, let him finish.

MR. HENDERSON: I do not want to be taken as agreeing to the first. There is a qualification I have not yet had an opportunity to state before we pass to the third.

HIS LORDSHIP: Let Mr. Smart fully state his propositions first.

MR. SMART: Now that is the second, with which I understand my friend agrees. The third is this:—

That if a number of resonant circuits, as in Marconi or Stone, are closely coupled, then the reaction between the circuits will impair the selectivity of the arrangement.

HIS LORDSHIP: How will it affect the signal?

MR. SMART: The signal will then be strong, but the selectivity will be impaired.

HIS LORDSHIP: The degree of closeness of the coupling causes the variation?

MR. SMART: Yes.

HIS LORDSHIP: In one case it reduces selectivity, and increases the signal; in the other it decreases the signal and improves the selectivity?

MR. SMART: Yes.

HIS LORDSHIP: Now is that all?

MR. SMART: It does not increase the signal.

HIS LORDSHIP: It does not impair the signal?

MR. SMART: It does not impair the signal as much. If it is quite close there will be very little impairment. If it is very loose there will be more impairment, but if you get it close enough to maintain substantially the entire signal strength, then the selectivity is interfered with by the reaction.

MR. HENDERSON: We make no admission as to that, my Lord, but we do say that it does not affect this situation at all. We do not find that in Marconi.

MR. SMART: Then perhaps the discussion will cause my statement to appear more controversial than it is. Let me put it in a simple form in this way:—

That if the Stone and Marconi circuits are closely coupled the reaction between the circuits will impair the selectivity of the signal.

HIS LORDSHIP: Did you follow that, Mr. Henderson?

MR. HENDERSON: I do not follow it as my friend puts it, my Lord.

HIS LORDSHIP: Read that last statement.

(The last statement is read by the reporter.)

MR. HENDERSON: The difficulty is that Stone and Marconi are not closely coupled.

HIS LORDSHIP: He put it hypothetically. He said "if."

MR. HENDERSON: If my friend were more accurate grammatically, we might perhaps be able to agree with him.

MR. SMART: Will my friend state it.

MR. HENDERSON: If the Stone and Marconi were more closely coupled, which they are not, the result might follow.

MR. SMART: The result would follow, would it not?

HIS LORDSHIP: I think you agree.

MR. HENDERSON: In other words, if you were going to use Stone and Marconi in a way in which they were not used.

HIS LORDSHIP: You agree to Mr. Smart's third proposition but you say in actual practice it is not done.

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MR. HENDERSON: It is not done. If you were to do it——?

HIS LORDSHIP: If you were to do it, there would be that result?

MR. SMART: I am not contending that it is done.

HIS LORDSHIP: Does that make the whole matter clear?

MR. HENDERSON: Except as to the first proposition which my friend made. I want to get something on that, which is not clear to me at the moment. My friend spoke of electromagnetic coupling, in his first proposition. If he will extend that to reactive coupling as well as electromagnetic coupling, we will agree. And we also further specify that the signal is not greatly weakened. You will remember that Mr. Hazeltine has illustrated that; that the weakening of the signal was, as he said, really immaterial.

MR. SMART: Then perhaps if I put it in this way: that the weakening depends on the looseness of the coupling.

MR. HENDERSON: Does my friend agree as to the reactive coupling?

MR. SMART: Oh yes. Perhaps as we have had some discussion, I will try to state it again.

The first proposition, as I understand it, or as I remember it, is this:—

That if one used a plurality of resonant circuits, like Stone or Marconi, with loose coupling, reactively coupled, one could obtain a high degree of selectivity, but the signal would be weakened in proportion to the looseness of the coupling.

MR. HENDERSON: You cannot get a proportion there. My learned friend is inaccurate again. It is not proportioned to the looseness of the coupling. Even I know that.

MR. SMART: Leave out the word "proportioned." It would be weakened as the coupling is loosened.

MR. HENDERSON: That depends on what you mean by "as the coupling is loosened."

HIS LORDSHIP: It is either a fact or it is not. You mean you cannot state it in exact proportion.

MR. HENDERSON: It cannot be accurately stated as he states it.

HIS LORDSHIP: Will you state it?

MR. HENDERSON: I do not care to state it in a phrase. I will get it in a moment.

HIS LORDSHIP: I thought you agreed that the degree of coupling has an effect.

MR. HENDERSON: Yes, there is no doubt about that.

HIS LORDSHIP: Mr. Smart does not undertake to indicate the exact proportion.

MR. HENDERSON: He talked about the degree of signal strength decreasing in proportion.

HIS LORDSHIP: He eliminated the word "proportion."

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MR. HENDERSON: I think my learned friend, when he speaks of the plurality of circuits, means two or more circuits.

HIS LORDSHIP: Yes.

MR. HENDERSON: It does not require three.

HIS LORDSHIP: It ought to be easy for the experts to state the propositions if they wanted to, because after all it is a scientific fact. It should be stated with mathematical accuracy and plainly.

MR. HENDERSON: If we get the fourth proposition then I am not particular about the precise phraseology of No. 2, that fourth proposition being that as to the coupled circuit of Marconi selectivity equalled to that of Alexanderson is secured without marked loss of signal strength.

HIS LORDSHIP: You are coming right to the issue.

MR. HENDERSON: That is what Professor Hazeltine has pledged his oath to.

HIS LORDSHIP: And the man on the other side will express his opinion to the very opposite.

MR. HENDERSON: Well, he has not.

HIS LORDSHIP: There is no use putting that proposition because that is obviously the issue before us. Having agreed upon that to-day, you should have agreed upon it a week ago.

MR. HENDERSON: I was not asked to agree.

HIS LORDSHIP: I say you should have.

MR. HENDERSON: I did not know my learned friend was going to make this proposition this morning. It comes like a bolt from the blue. When an agreement is going to be asked, one generally has an opportunity to consider it. It is true that my learned friend, when we were disrobing yesterday afternoon, remarked to me that it was regrettable that so much time should be taken with non-essentials. I quite agreed with him, and also agreed that we did not dispute all that Waterman said yesterday afternoon if we understood it aright. Ordinarily my learned friend would say, "Well, let us agree; here are the propositions," but that was not done. I had not the slightest idea he was going to raise this point.

HIS LORDSHIP: In regard to Waterman, there is not a great deal for you to go over.

MR. SMART: He has not dealt with the specific things set up.

HIS LORDSHIP: We should finish the case to-day easily.

MR. SMART: Yes.

HIS LORDSHIP: I do not see what else there is to say about the case.

MR. SMART: I am quite willing to eliminate the question of proportion entirely in that statement of mine.

HIS LORDSHIP: If you cannot agree better go on.

MR. HENDERSON: The proposition my learned friend asks me to consent to is practically a denial of the proposition I made.

HIS LORDSHIP: I think you agreed upon it, but you are frightened of words.

MR. HENDERSON: I am not frightened of words.

HIS LORDSHIP: Probably you have the same ideas.

MR. HENDERSON: My learned friend has overnight considered what would be an effective trap. That is the situation. I do not say he intended it as such, but I see it myself, and I said without conference with my associates that I could not agree to that proposition.

HIS LORDSHIP: Then proceed.

No. 21.

Further Evidence of Frank N. Waterman (resumed).

RE-EXAMINATION OF F. N. WATERMAN BY MR. SMART RESUMED:

Q. The prior art has been dealt with, and I would like you to refer to Exhibit "K" which shows various forms of mechanical and acoustical relay, and I should like you to compare the devices there shown with the Alexanderson patent.—A. Exhibit "K" shows three schematic diagrams in detail, the Edison, Schloemilch and Leib, and Lorenz respectively. The Edison patent which dates back to 1886, shows an early attempt at telephone relaying; that is, telephone repetition; and the device which is shown is intended to permit two-way speech. The circuit is not at all as shown in this diagram. What the Edison patent shows is a receiving telephone such as we are accustomed to hold here and listen; built into the same box with it is a microphone which is actuated by the sound, and repeats the conversation into another circuit, and does this in either direction in which the message may be going.

I assume that the difference in construction is immaterial, and that it was merely intended to illustrate something in the nature of a telephone repeater, and that neither the circle drawn round it that might suggest a globe, nor the specific arrangement of parts, is intended to have any real significance, and I will so treat the matter. Of course, it is almost self-evident that the device has no bearing, either precisely as Edison showed it in the circuits which he used or as illustrated in Exhibit "K."

MR. HENDERSON: I suggest that the question whether the device has a bearing is a question for your Lordship. He has made a statement of that kind very frequently, and I object to it.

MR. SMART: It has a bearing on the question which is now being asked.

MR. HENDERSON: That is for the Court to decide.

WITNESS: I did not finish my sentence. It almost went without saying that a device which was intended as a telephone repeater had no bearing of any direct sort upon a radio transmission——

MR. HENDERSON: Is that not argument rather than evidence?

HIS LORDSHIP: I do not think so. It is an explanation of a device.

MR. HENDERSON: I object to it.

HIS LORDSHIP: I will receive it subject to your objection.

WITNESS: For the reason that the device is quite incapable of responding at all to radio frequency, and is in construction unsuited to radio circuits. The broadcasting frequencies, for example, that were used are scattered about a frequency, in the neighbourhood of one million cycles per second. The telephone company engineers make their calculations, or did when I worked with them, in the matter, at a maximum voice frequency of two thousand cycles, carrying all the essentials of clear, articulate and natural speech.

The Schloemilch and Leib and Lorenz structures have quite a different nominal purpose. They relate, as I understand, to what are called singing spark systems in the transmission of telegraph messages by radio telegraphy. At the dates when these men were working, the customary way of sending wireless telegraph signals was by what are called damped oscillations produced by the discharge of a condenser across a spark gap. A vast amount of effort was expended to get those sparks to occur at regular intervals, because in that event it became possible to receive in the telephone at the receiver a more or less characteristic note. The difficulty lay in getting such purity of pitch and such constancy of pitch as to make such a result of any real utility.

But on the assumption that it could be done, devices of many sorts were suggested and worked with in the endeavour to help out radio tuning and selectivity with an acoustic tuning.

At one period I myself did a good deal of investigation work of this kind, part of which was in connection with litigation, and part of which was in the early part of the war in connection with hoped for improvements that would be useful in war communication through both the station and static interference. This work was done for the Marconi Company, and it was essentially a total failure, as I believe all of such work has been.

I note that in the Schloemilch and Leib diagram of exhibit "K" the same symbol for a relay has been used for all the figures essentially, and I take it that therefore it is intended merely as a symbol or hieroglyphic.

Of course in the Schloemilch and Leib device, as shown in the United States and British patents referred to, the vibrating member was a tuned reed, suggestive of an organ reed, and the attempt was to get a response by a purely mechanical tuning system, analogous, for example, to other mechanical tuning systems, such as the balance wheel system of a watch. Those also have no application or practical utility at radio frequencies, and the circuits suggested are in no sense radio frequency circuits.

The Lorenz arrangement, which is the third of those on exhibit "K," is of similar nature, save that the vibrator of the repeater is an ordinary telephone diaphragm, as in the Edison device. In other words, the Lorenz repeater is of the same nature as the Edison, and the attempt is made to effect the tuning by electrical means.

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It was this sort of tuning which I personally worked with more than any other and found it entirely ineffective.

In general I think experience has been that the attempt to tune circuits to ordinary acoustic pitches is attended with very great difficulties, and particularly when it is necessary to include, as is always the case, practically speaking, some telephone device which has high losses and high impedance, and also to include some sort of variable resistance mechanism, such as a microphone, which also has a high resistance, and iron cored coils, which also have high resistance. The result is not worth the trouble.

HIS LORDSHIP: How do you tell when a circuit is tuned? In the demonstrations the other day Professor Hazeltine would arbitrarily say the thing was tuned. Is that a matter of judgment of the ear, or would you describe it as when the signals were coming through apparently unaffected by disturbances of any kind? Is that just a matter of judgment?—A. It is a combined matter of judgment and knowledge of the circuit.

Q. Still, judgment has a very large part in the determination, and experience probably,—experience and judgment?—A. Experience and judgment, yes, and knowledge of the circuit and what it will do.

Q. I did not quite follow Professor Hazeltine as to why he said at a given moment that the thing was in tune. I do not doubt that he knew, but to the layman it was not apparently clear at the exact moment. I suppose it does mean when the receiving set is in tune with the incoming waves and there are no disturbances?—A. Yes. What it does mean in such circuits as Professor Hazeltine was using is that the frequency at which each circuit would oscillate if a charge imparted to it is the same as the frequency of the incoming signal.

MR. HENDERSON: If I may say so, the test is as your Lordship thinks, when the ear gets the best signal. That is really the test.

HIS LORDSHIP: Yes, I suppose so.

MR. HENDERSON: I suppose if you have a trick ear you really would not have good tuning.

MR. SMART: There is tuning for a variety of things. There is tuning for getting the best signal, the loudest signal, and so on.

MR. HENDERSON: As I say, some people like noise while others like quality.

MR. SMART: It is rather a relative term. Your Lordship used it in the popular sense.

HIS LORDSHIP: Yes. There is no exact moment when one can say scientifically, There, it is tuned, and in another moment, It is not tuned. There is a zone when nobody but one with the practised ear can determine.

MR. SMART: There is quite a danger in terminology there. One thinks of the signal being acoustically in tune, because one hears it better. The circuits by which it is produced may or may not be exactly in tune. They may be tuned in a given sense, to give selectivity, or regenerative selectivity, and there are other terms. The term is not an exact one as applied to circuits.

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No. 21. Frank N. Waterman. Examination (resumed) *—continued.*

HIS LORDSHIP: But I was right in my characterization of Professor Hazeltine's methods?—A. Oh yes, and I think when Professor Hazeltine said the circuit was in tune, it was in tune with the degree of accuracy that the practised ear is able to attain. But it would not be safe to make such a definition broadly without knowledge of the circuit being used. And therefore I said that it was a matter of the ear in that case, accompanied by knowledge of the circuit and what it would do.

MR. SMART: I think you are on the Lorenz arrangement?—A. The apparatus has no more suitability for radio frequencies than had that of Edison. That is to say it had none at all. And this group of patents indicate rather attempts at solutions of the selectivity problem in entirely different lines from radio frequency selectivity.

The really important statement in the Lorenz patent, as I see it, is the statement which says that the attempt to get selectivity by loose coupling of circuits is futile. That is a statement made in the very first paragraph, where it says:

> "In order to increase the precision of resonance tuning might be performed several times as though several circuits could be provided that are coupled with one another and each one of which is tuned to the sound frequency. The coupling could be effected by transformers, but this arrangement shows the following drawback, if really an increase of the precision of tuning is to be attained, a very loose coupling must be selected in order to avoid mutual interference of the circuit."

I may insert, parenthetically, that means the back reaction which we have been speaking of, which causes the circuit to act at two different frequencies and entirely ruins selectivity. Continuing the quotation:

> "but if the coupling is loose such a noticeable weakening of the sound will take place that the advantage of a more precise resonance obtained will be made ineffective."

This patent shows no device which could be used or have any applicability to radio frequency devices; and in my own opinion distinctly and emphatically leads away from rather than toward the idea of geometric selectivity in radio frequency circuits.

Q. Now will you refer to the Schloemilch and Von Bronk patent and the various patents, and also the evidence with respect thereto, and particularly exhibit "M" which purports to diagrammatically represent that,—chart 4,—and compare the chart and the patents with the disclosures of the Alexanderson patent.

HIS LORDSHIP: Is that the United States Schloemilch and Leib patent?

MR. SMART: The Schloemilch and Von Bronk. This is the diagram put in and the patent itself, my Lord.—A. Do I understand the question you ask me to refer to the Schloemilch and Von Bronk patents?

Q. You might refer to the patents first, and incidentally to a diagram exhibit "M," and perhaps by the way you might either give us your views as to the diagram being a representation of the patents or not?—A. I asked the question because the diagram labelled "Schloemilch and Von

Bronk " on exhibit " M " is not at all like any diagram found in any of the Schloemilch and Von Bronk patents.

MR. HENDERSON : Nor is it so intended, if my friend will look at the evidence.

MR. SMART : My friend states that this diagram on chart 4, labelled Schloemilch and Von Bronk, 1913, does not intend to represent any of the Schloemilch and Von Bronk patents.

MR. HENDERSON : If my friend will look at Mr. Hazeltine's evidence——

MR. SMART : I am taking my friend's statement.

MR. HENDERSON : Does my friend want me to state what it says? Mr. Hazeltine stated that this diagram was intended to indicate what Schloemilch and Von Bronk did, as shown in the evidence taken in this case. That is what was said in substance when this was put in.

MR. SMART : Q. You have read this German evidence have you, Mr. Waterman?—A. Yes, I have read it.

Q. And you have also studied the blue-print diagram, which is the only diagram apart from the patents, which is referred to; and I would ask you to refer to the diagram, Exhibit " P," which is blue-print L-898, and compare that with the diagrammatic representation marked Schloemilch and Von Bronk on Exhibit M.—A. I find that the diagram marked Schloemilch and Von Bronk on Exhibit M is very different indeed from figure 6 of blue-print L-898. The striking things about figure 6 of blue-print L-898 are the use of a crystal detector following a Von Leiben tube, and the use of a peculiar arrangement of transformers which, as I read the drawing, denote what we call a reflex circuit connection. Both of these features are absent from the drawing labelled Schloemilch and Von Bronk on exhibit " M."

In figure 6, under the letter k, will be seen a circuit and adjacent to the letter p and to the left thereof is a symbol which is commonly used to indicate the crystal detector.

Referring to the similar location in the Schloemilch and Von Bronk sketch of exhibit " M," there is no crystal detector, but there is an indication commonly employed to designate an audion connected into the circuit through a grid condenser which is not labelled but which is indicated by two heavy vertical lines just to the left of the circle indicating the tube.

HIS LORDSHIP : The grid condenser, is it the same in construction as the ordinary condenser,—it is not tuned there.—A. No, it is customarily a few little pieces of copper foil or tin foil separated by little sheets of mica; made up of definite size and thickness, constituting a non-variable condenser of a permanent fixed capacity.

HIS LORDSHIP : That is not what you call the grid leak?—A. No, it is the grid condenser.

MR. HENDERSON : My Lord, don't we meet here the difficulty that Mr. Hazeltine was not cross-examined as to this? It is just precisely where the Brown-Dunn rule comes into play. However, I understand your Lordship has ruled on that.—A. It corresponds to the grid condenser, which I

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indicate on Exhibit 8, and which is just above the tube at the right in that Exhibit.

I note also that the circuit from the crystal detector in Figure 6 of L-898 passes thence down through a condenser indicated by two parallel lines and not variable, and thence to the left to an arrow against one of the turns of the associated coil; indicating a variable coupling of the detector to the circuit.

Since my use of that expression in that connection has been criticized, I point out that the purpose of a coupling is to transfer energy or current or voltage from one circuit or element to another, and it is the purpose of this arrow to vary that transfer, and therefore that arrow indicates a variable coupling. Looking at Exhibit M, the drawing labelled Schloemilch and Von Bronk has no such connection. Also it has no such condenser as that just mentioned, which is one just below the crystal in L-898.

Also under the letter D and above the letter L, there is seen an audio frequency transformer. At least, I take that hieroglyphic to so indicate. Shunted by a condenser. There is no such showing in Exhibit M.

HIS LORDSHIP: What do you mean by "shunted."

MR. SMART: It is like "parallel."

HIS LORDSHIP: A condenser in parallel?—A. Yes. Connected across the ends.

MR. SMART: A shunt is something across?—A. Also, above the letter "O" there is another transformer which I interpret to be an audio frequency transformer. There is no such transformer in Exhibit M. What Exhibit M does show is a cascade of two tubes. That is an arrangement of two tubes, the first tube being between two tuned circuits and the second being in the detector relation. Nothing of the sort is shown in Figure 6.

Also I notice that in Figure 6 of L-898, the connection from the transformer which is above the letter "L" at the left of the figure, is connected by an arrow, indicating again a variable coupling to the associated coil, and I find nothing of the sort in the drawing of Exhibit M labelled "Schloemilch and Von Bronk."

MR. SMART: Generally, what to a man skilled in the art would be the effect of the blueprint L-898 as a disclosure without any description as to how the parts were intended to operate?—A. It would not be a definite disclosure. The drawing might be interpreted in a considerable number of ways. Shall I state them?

Q. Are there a number?—A. Yes, the drawing might be interpreted in a number of ways. I think that there is no question about the showing of the drawing in certain respects. I would say that it was intended to indicate a separation of the detection, and the amplification functions. The crystal detector is employed for the function of detection, and the tube—I would assume—was intended for amplification. Now of course, we know that the maximum amplification from such a tube would be attained when the plate circuit were so adjusted as to give the largest regeneration consistent with stability. That would mean that the purpose of the adjustment of the circuit underneath the letter "K" was to obtain a maximum signal, and I would infer that the adjustment was therefore made to that end.

On the other hand, it might indicate a system designed for receiving while in the oscillating state, and the intent might be to operate the circuit under the letter " K " to produce oscillation ; so that that circuit might be called an oscillation control means.

In general, the principal things indicated, as I said at the start, are the desire to obtain the benefits of crystal detector rectification, and of double use of the Von Leiben tube by making it act simultaneously as a radio and audio frequency amplifier.

Q. Now will you take the Schloemilch and Von Bronk disclosure as it is made in the various Schloemilch and Von Bronk patents, particularly the United States, the German, and the French patents.

HIS LORDSHIP : What is this symbol on Alexanderson : the thin black line in the last circuit, and the short heavier one ?

MR. SMART : That is on the Exhibit M. His Lordship is asking what this short line, and heavy line on Exhibit M of Alexanderson, mean ?—A. That is the grid polarizing battery, the purpose of which is to give a condenser detector action to the last tube.

HIS LORDSHIP : These two drawings are exactly the same but for that. They are copies of one another ?—A. Yes your Lordship.

MR. SMART : Does the diagram on Exhibit M entitled Schloemilch and Von Bronk, correctly represent anything disclosed in any of the patents or any of the diagrams already described in evidence by any of the witnesses ?— A. It does not.

MR. HENDERSON : I object to the last portion of that question.

HIS LORDSHIP : Taking the diagrams without that, there is no distinction whatever.

MR. SMART : That is the great danger of diagrams. They should be scrupulously exact.

HIS LORDSHIP : That diagram is true or false. If it is true, there is absolutely no difference between Alexanderson and the German patent.

MR. HENDERSON : My Lord, the diagram was explained very fully by Professor Hazeltine in his evidence, and the differences were pointed out. He went into it very carefully. My friend did not choose to cross-examine him on that, and I repeat once more, my friend must take the consequences of that.

HIS LORDSHIP : We will settle that later on. I am only making the remark that they are exactly the same. They are in evidence, and they are exactly the same. Perhaps Professor Hazeltine's evidence will qualify that.

MR. HENDERSON : Professor Hazeltine says that they are the same, and he gave reasons why they were the same. Now if the witness chooses to criticize that, and your Lordship desires to hear him, I will not press the objection. On the understanding, however, that Professor Hazeltine will have an opportunity of checking the witness' objections.

HIS LORDSHIP : We will come to that later. I am only making the remark that when I find a diagram like that representing two patents, which are in conflict, to be exactly the same, with the exception of the one thing that I have just referred to, it must mean that you say they are the same. I suppose that is your case ?

Mr. Henderson : That is the substance of our position.

His Lordship : But surely the both devices were not exactly like that ? That would be a strange thing.

Mr. Henderson : As a matter of fact, my Lord, you will find if you look at the set which we have here, the Splitdorf set that is in this room, you will find these experts will tell you that is a diagram ; you have here as Exhibit 8 a diagram which has been said to be found in practically every set, but when you look at different sets you find that to the lay-eye they do not look the same at all.

His Lordship : You say that draughtsmen do not differentiate minor details in construction and things like that.

Mr. Henderson : As a matter of fact all these diagrams are made as simple as possible so long as they contain the essentials. Also they are made, if you will, in a proper sense, as alike as possible. That is, they are not intended to mislead the court ; they are intended to assist the court ; for instance, it is a very easy thing to point out that looking at the blueprint there, you do not find this, that and the next thing. Of course you do not, because those things have been eliminated, as Professor Hazeltine explained, left out as non-essentials for our present purpose. That is the point.

Mr. Smart : I might observe, following my learned friend, that the diagrams of the Schloemilch and Von Bronk are particularly simple. They illustrate the circuits very easily. Instead of following those diagrams, if my learned friend re-draws them to look like the Alexanderson patent, it does not seem to me that that is helpful to the court. The question is the fact of whether the devices are or are not the same.

Mr. Henderson : My learned friend is overlooking the fact that we are saying that Alexanderson was anticipated by what Schloemilch and Von Bronk did.

Mr. Smart : I quite agree that that is your contention. But what they did is shown primarily by the diagrams they themselves made. This is an interpretation of an interpretation.

His Lordship : It is confusing to have two things drawn so that they look alike when they are said to be in contest. However, I see Mr. Henderson's differentiation.

Mr. Henderson : There are two diagrams which to the lay eye might look differently, but the expert would say that they are the same.

Mr. Smart : I don't think it needs an expert.

His Lordship : It is the very opposite, is it not ?

Mr. Henderson : I can take one of these wire connections, and carry it out into the hall, as was done yesterday, and it is just the same connection as if I put it right up close. I can move it around the desk so that it will look perfectly different if you had a photograph of it but it is still operating in the same way.

MR. SMART : In those diagrams, for instance, my learned friend has shown two tubes arranged in cascade connected by a tuned circuit. Now Schloemilch and Von Bronk did not use two tubes.

MR. HENDERSON : Yes, they did.

HIS LORDSHIP : That is a matter for argument.

MR. SMART : I mean, they used a tube with a detector. A crystal detector and not a second tube.

HIS LORDSHIP : I see. There is a crystal detector on the German.

MR. HENDERSON : There are four photographs here showing that my learned friend is absolutely incorrect in that last statement. I wish he would not make statements unless he is sure of the fact.

HIS LORDSHIP : The blueprint L-898 does show a crystal detector, and on M it does not.

MR. HENDERSON : Of course it does, and Schloemilch and Von Bronk explained that in evidence.

MR. SMART : They produced photographs but give no circuit diagrams with respect to the photographs. The circuits in the photographs might be any kind of circuit.

HIS LORDSHIP : I am only dealing with a patent, and I am pointing out things as I see them.

MR. HENDERSON : My friend arranged to cross-examine them, and they were his own witnesses.

MR. SMART : Absolutely not my witnesses.

MR. HENDERSON : We called them, as our witnesses ; but they came from the employment of his allied company.

MR. SMART : My learned friend has no right to make a statement of that kind.

MR. HENDERSON : My friend furnished the witnesses to us.

MR. SMART : I did not furnish witnesses.

HIS LORDSHIP : What do you mean by your last statements, Mr. Henderson ?

MR. HENDERSON : I mean the attendance of the witnesses was arranged for. The witnesses came from the Telefunken Company, and the arrangement was made ; if I am wrong, I certainly understood that it was by arrangement with my friend.

MR. SMART : Absolutely not. My friend had a representative in Berlin, who took the matter up with the Telefunken Company, and arranged that these witnesses would be produced at a certain date. I agreed that I would go there on that date without notice, and attend on the examination of the witnesses.

MR. HENDERSON : And the Telefunken Company is not an allied company ?

MR. SMART : I have no knowledge of that. And it is not a matter which concerns us here.

MR. HENDERSON : My friend should not say that.

HIS LORDSHIP : You must take the word of counsel when he says he has no knowledge.

MR. HENDERSON : I take my friend's word when he says he has no knowledge.

HIS LORDSHIP : Then go on, Mr. Smart.

MR. SMART : Q. You were about to deal with the Schloemilch and Von Bronk disclosure, as contained in the patent of Schloemilch and Von Bronk ?—A. The Schloemilch and Von Bronk United States patent Number 1087892 contains the figures of the two German patents 271059 and 293300. It also contains one additional figure, namely figure 2, which is not in the German patents. The purpose is stated in the United States patent :

> " That the oscillations can be perceived more distinctly in the telephone usually employed."

MR. HENDERSON : What page is that ?—A. At page 1, the second paragraph. May I strike that quotation out and begin back further ?

> The purpose is an arrangement " which permits the use of a detector such that the oscillations can be perceived more distinctly in the telephone usually employed for perceiving the oscillations than was the case heretofore."

The tubes of that day, and in the opinion of some people, even of the present day, did not render a signal as distinctly and in as pleasing a quality as did the crystal. And the first purpose set forth in this patent is therefore to separate the two functions of the tube, and use only one of them, a crystal being substituted for the other.

In other words, in a circuit in which the tubes were used at that time, the bulb performed a double function of amplifying and of detecting, and the purpose as expressed is to take away from it the function of detecting, and allow it to operate with its function of amplifying only. While the crystal was used to perform the detecting function, and that for the purpose stated, namely a more distinct repetition of the signals in the telephone.

MR. HENDERSON : I do not want to interrupt, but does the witness take that from the quotation he has given ?

MR. SMART : I was not following it.

MR. HENDERSON : It is difficult to follow. However, perhaps I should not interrupt ?—A. That is what the quotation means, and I was just going on to point out that in the first German patent, 271059, it is pointed out that the purpose of the arrangement is to separate the functions of amplification and detection and to assign the latter to the crystal, which is shown at " L " in the figure of the German patent 271059, and retain for the tube only its amplifying function.

MR. HENDERSON : Where is that found in the German patent ?—A. In the second German patent 293300, figures 1 and 2 thereof, and in the United States patent figures 3 and 4 thereof, there is set forth the idea of double amplification. In figure 1 of the German patent, and figure 3 of the United States patent, we have first the tube performing a radio frequency amplifying function; then a crystal detector " L " giving the more distinct signal; and finally a second tube, marked A-1, giving an audio frequency amplification. In Fig. 2, which is Fig. 4 in the United States patent, we find a single tube used to perform both amplifications. The signal is taken first to the tube as it comes from the antenna, is amplified and taken to the crystal detector " L," by which it is detected. It is taken from the crystal detector " L " back into the same tube and is amplified at audio frequency and is then taken out to the telephone " m " small. These are the essential disclosures and all the essential disclosures, in fact, I think one might say all of the definite disclosures of the patent. While I have not here referred to the British or to the French, or Schloemilch and Von Bronk by number, there are no added disclosures in them, and the figures cover the same ground. There is no mention in any of the Schloemilch and Von Bronk patents, either directly or by implication, of any idea of selectivity. The purposes are fully covered by the statement which I have just made.

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No. 21. Frank N. Waterman Examination (resumed) —*continued.*

Fig. 1 of the United States patent shows a tuned antenna in which there is a transformer, the purpose of which is to pass on the signal to the tube. There is no tuning of the secondary of that transformer. Nothing is said about the tuning, nor of the character of the transformer or the association of the coils. The same is true of Figs. 2 and 4. In Fig. 3 we find this is different; that whereas in the other figures the terminals of the secondary " g " small of the transformer are connected directly to the grid and filament respectively of the tube. In Fig. 3 the grid element of the tube " a " small is connected by an arrow to the secondary coil of the transformer.

Professor Hazeltine has said, as I understand him, that that indicates either one or the other of two things; either that arrow indicates a variability of the secondary of that transformer: that is, the variability of its inductance, and thus a sort of tuning in which case a loose coupling is indicated, and in which case he says that secondary circuit is to be treated as a tuned circuit, so that with the circuit comprising the secondary " k " of the second transformer tuned by the condenser " n ", there are, he says, two tuned circuits with a tube between them; or he says, on the other hand, this figure with the arrow adjacent to the secondary turns of the transformer " g " is to be regarded as a transformer simply of variable ratio, in which case the diagram shows a very tightly coupled transformer, and in that case he says that the tuning of the antenna is effective to tune the whole combination; so that in that case we must regard the combination as tuned in front of the tube and tuned behind the tube.

I know that the only reference to tuning in the United States patent is found at the bottom of column 1, page 2, where it is stated:

> " The increased high frequency oscillations then flow in the circuit closed by the source of the direct current, over the cathode " c " small and anode " g " small, and are supplied from this circuit by means of the transformer " k " small to the detector circuit, comprising the detector " l," and condenser " p " small, an intermediate circuit " n." small, synchronised to the oscillations will preferably be provided."

The word " synchronized " there I think we should take as meaning tuned to resonance, it having the same significance as the word tuned as we have been using it, meaning adjustment to resonance with the signal.

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Plaintiff's Evidence in Reply.

No. 21. Frank N. Waterman Examination (resumed) —*continued.*

The only reference therefore to the tuning is the reference to the optional or preferred method.

Now in the German text this is made still more emphatic. The corresponding passage in the translation furnished of the German text, at the bottom of the first page says:

"The amplified high frequency oscillations then flow into the circuit closed by the source of direct current 'i' over the cathode 'c' and anode 'd,' and thence are passed on to the detector circuit comprising the detector 'l' by means of transformer 'k.' In this case it may be preferable to provide an intermediate circuit 'n' small tuned to the oscillation."

Therefore not even a preference is here expressed for any tuning. It is only stated that it may be preferable. I do not agree with Mr. Hazeltine that the effect of this last alternative would be as he states, nor do I agree that the alternatives that he mentions are the only alternatives.

The tubes of that day——

His Lordship: What do you say the arrow indicates?—A. I say that it has no certain indication.

His Lordship: On my copy of the exhibit the word "tuned" is written in over the Fig. 3 in writing.

(Discussion.)

His Lordship: It is agreed that the word tuned appearing in connection with Fig. 3 on Exhibit G-20 is not part of the exhibit.

Mr. Henderson: Yes. If I did not mention it at the time of putting it in, I intended to?—A. Answering your Lordship's question, I understand the two coupling arrows which Fig. 3 contains have identically the same significance. It will be noted that in the transformer "K" the crystal detector "L" is connected to the winding by a variable connection denoted by an arrow. I think there is no question but that a variable connection is intended. The input of the tube, that is the grid, is connected to the secondary of the transformer "G," in the same manner. That arrow has the same significance in both cases, namely, to vary at will the electrical potential or voltage, the active force which is applied to the device connected. Those tubes were very critical as to the applied voltage. If the voltage was excessive they went into a state known as the blue glow, in which they almost completely lost all sensitiveness or ability to respond. If the voltage was not sufficient then they were also insensitive. It was therefore a matter of great convenience to be able to apply to the grid of the tube such a voltage as gave it a good sensitiveness, without putting it into the blue glow state.

That is, in my judgment, the quite obviously intended convention. It has to be admitted that the drawing is ambiguous.

Now there is another interpretation which is quite a probable one, very much more probable than either of those suggested by Mr. Hazeltine, in my judgment. When a device is to be operated which takes energy, it is important that it should be connected so that the load that it imposes on the device operating it should bear a proper proportion to the impedance or resistance of that device, and so when we put a crystal on to a circuit, as, for example, the secondary circuit "k," to get the best results we should adjust it so as to make the best compromise in the matter of withdrawal of energy from the circuit. That is one of the few all but universal rules of engineering that applies in all sorts of circumstances, and that matter of adjusting the relative loading effect of the tube would, with those tubes, be important, and thus we have a fourth significance of the drawing.

There being nothing whatever about tuning, save the mere possibility of tuning expressed by the possible addition of the condenser "n," showing that when the patentees desired to show tuning they had their definite way of doing it, and knew how to do it, it seems to me the two alternatives suggested by Professor Hazeltine are out of the question, and that choice in determining the meaning of the drawing must be made between those other two which I have suggested.

The best, therefore, that one can say is that the drawing is ambiguous, and the specification makes no disclosure of any matter of selectivity. I think it is also not too much to say that the drawing on any interpretation does not suggest any idea that there was any thought of selectivity. The intent and purpose of the patent is clear, namely to preserve the desired function of that crystal detector, and also to preserve the amplifying function of the tube.

Q. Look at Exhibit "N," chart 4-A, and particularly the figure at the right hand side of that chart, and say whether that diagram in your opinion represents any of the Schloemilch and Von Bronk arrangement referred to in the patent or in the evidence taken in Germany?—A. It does not, as I understand then either the diagram or the evidence——

Q. I refer particularly to the electrical connection?—A. Yes, I so interpret it.

Q. Now regarding the vacuum tube acting as a relay in the circuit, what is the effect of the relay action of the tube itself on the reactance through it?—A. The tube has a very remarkable effect. If the coils associated with it are properly designed, then as the tube filament is turned up and the tube begins to act as a relay, the effect of that relay action of the tube is to completely wipe out the reaction, so that the tube acts as a one-way device in a very rigidly exact sense.

MR. HENDERSON: My recollection is that the witness went into this in his former examination.

HIS LORDSHIP: I cannot recollect it, he may have.

MR. HENDERSON: I am afraid we are going to have the difficulty that we will never end.

MR. SMART: Oh, no.

HIS LORDSHIP: Do you say the filament affects the relay or the tube? —A. I was considering the case in which the tube is not lighted, and there is a small reaction connection through it. Just to recall what I mean, your Lordship will remember the test made in which we had the tube unlighted, the signal came through, and yesterday I made a test with a standard commercial set, showing that while under abnormal circumstances

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the effect of that reaction could be exaggerated, in normal circumstances it did not come through to any extent that could be heard.

Now the present question asked me is, what effect the lighting of the filament has on that reaction. The answer is that with circuits correctly designed the lighting of the filament as it is increased in brilliancy comes to a point where it completely wipes out that reactive effect and the tube acts as a one-way relay. As the tube is brought to a higher degree of brilliance, the effect is not merely to wipe out that small deleterious effect which the cold tube has, but to go in the opposite direction and actively improve the selectivity.

Therefore the relay action of the tube in itself has the effect of overcoming that reaction coupling about which so much has been said.

The attainment of the result of exactly cancelling it out depends upon exact design of the coils; but in all cases that happens substantially so that the reaction effect, which has been so much spoken of, is caused in all essential respects to disappear by the operation of the tube itself as a relay.

Q. I want you to look at exhibit 8 from the standpoint of whether the resonant circuits there shown are arranged in series or parallel, having regard to the way in which those terms are used.

Mr. Henderson: This witness went into that with express reference to exhibit 8.

His Lordship: If he did, we have gone into it with other witnesses, and I do not see how he can add anything. I will hear it if he can do it briefly, as we have had that explained by so many witnesses.

Mr. Smart: Q. I want just a statement as to whether the circuits there shown are regarded as in series or parallel?—A. Both. From the point of selectivity each of these circuits is purely a series circuit. The mathematician understands a small electromotive force put in at some point in this circuit, and the current oscillates back and forth.

As Professor Hazeltine said, when we are calculating that, all distinction betweeen series and parallel disappears. This is a simple series circuit; the second is a simple series circuit, and the third one is a simple series circuit; so that for all purposes of selectivity these are all simple series circuits.

When we stand back and look at them, the grid looks upon the circuit and sees two parallel branches, and therefore it says it is a parallel circuit; the plate, looking through the connection of the transformer, sees a parallel circuit; but the electromotive force which is developed across here is the electromotive force developed in virtue of the series action of the circuit; and it is only a confusing mass of words.

Mr Smart: Q Now in the circuits represented in the curves exhibits I and J, which might they properly be designated as being?—A Both. Where we have to calculate the time period of the circuit and its resonance curve we regard it as though an electromotive force is somewhere inserted in the circuit. We may draw it in forty different ways and it makes no difference. We consider an electromotive force inserted into the circuit, and the purpose of the associated coil 2 in the antenna in the Alexanderson patent is to insert in series in the first circuit an electromotive force; and, the purpose of the transformer of coil 12 with the tuned circuit 15 is similarly to insert such an electromotive force in series. So it is in these diagrams, exhibits I and J; and the point to be borne in mind, the operative distinction for your Lordship to apply in looking at a drawing is this: Is the connected device connected across the inductance and the capacity arranged tandem, or is it connected to one of them or either of them or both of them, connected in parallel. Now whenever the device is connected across the condenser only——

HIS LORDSHIP: Connected in parallel, would that be represented by the condenser immediately to the left?—A. Yes, the fact of it being connected across this condenser shows that the circuit for the purpose of the device is a parallel connected circuit.

If I can have a piece of paper, I would like to show just that difference, because I think that is the one helpful thing that can be given.

I have made a simple diagram in which I show a coil and a condenser supplied with an electromotive force indicated by small e. Now across the condenser is connected some device. That indicates that while we calculate that circuit as what we call a series circuit, that is with the inductance and capacity in series for the purpose of determiniug resonance and selectivity from the point of view of the connected device the two are in parallel.

MR. SMART: Q. Now are the curves as drawn in exhibits I and J curves of series circuits?—A. Yes. Those are calculated taking the devices seriatim.

Q. So that the curves are curves which represent a series connection? —A. Yes.

Q. Now, is there any way of graphically representing the difference between reactively coupled arrangements such as the Stone and Marconi, and the arrangement of Alexanderson in which the circuits are coupled by a vacuum tube repeater?—A. Yes. We have a means of making the currents themselves write their own story, their own autograph, so to speak, known as an oscillograph.

Q. And can you produce a few oscillograms which will illustrate typical circuits with respect to that?—A. Yes, there are some in court.

Q. You might produce them and explain.

MR. HENDERSON: What are these, and by whom were they made, and so on? I am not going to seriously object, but there is always trouble with these things.

MR. SMART: They are made by Dr. Alexanderson and Mr. Oakley, who are in court to-day.

MR. HENDERSON: They really should never be used unless they are made by prior arrangement in the presence of both sides. Your Lordship will see what I mean. They depend upon so many things.

MR. SMART: I do not see that.

HIS LORDSHIP I suppose they are all something which is well known.

MR. SMART: Yes.

MR. HENDERSON : Oscillograms, of course, can be made but the precise way in which they are done may be important. They can be made very misleading.

MR. SMART : I do not think my learned friend will find these in any way misleading. They are typical.

MR. HENDERSON : That has not been by any means the experience with Mr. Waterman's oscillograms before.

MR. SMART : The only case in which Mr. Waterman used oscillograms before, the Splitdorf case, the judge very favourable commented upon them.

HIS LORDSHIP : I should like to see them as I think they may be helpful to me.—A. An oscillograph is an instrument by which a current is made to deflect a beam of light which acting upon a photographic film which is in motion leaves a record of the actual events going on in the circuit, the changes in the current.

HIS LORDSHIP : State that again, will you ?—A. An oscillograph is an instrument by which a current is enabled to act, for example, upon a small mirror, causing it to deflect and cast a beam of light upon a moving photographic film. The movement of the mirror is arranged to be responsive to the action of the current, the changes of the current ; and therefore the current is caused to write its own autograph.

In this particular oscillogram marked CD 127904 the current had a frequency of 1,000,000 cycles per second, and the current was actually oscillating, as shown by the vertical zigzags. The up and down zigzags on this photograph show how such a radio frequency current builds up in a circuit. The horizontal line at the left shows the mirror at rest, the film moving. Your Lordship will see that if I cast a spot of light upon the film and then move the film that spot of light would produce a mark on the film which would be merely a straight line. Now, the current begins to be developed in the circuit and the mirror is deflected to move that beam up and down, and in making that photograph the current was moving the beam of light up and down while the film was travelling. Thus this wave line increasing in the height of the waves above and below the normal rest position of the mirror, which is the position of zero current, indicates the growth of current in the circuit. The current therefore wrote its own autograph. And the time interval between the limits of the motion, as for example between the dots that seem to outline the figure are the one-millionth of a second. The reason that these somewhat indistinct zigzags and in dots is that at that point the mirror comes to rest and reverses, and therefore there is more exposure on the film at that time.

It is a matter of extraordinary difficulty to take these photographs at that speed of a million per second. Hence we customarily work with quite low frequencies, in order that we may be able to control the oscillograph apparatus and to spread out the oscillations so that they are interpretable. Therefore the other oscillograms which I produce are made at a frequency of 60 cycles per second.

MR. HENDERSON : Does this witness know that as a fact ? He did not make these oscillograms, and he is not the one to give evidence concerning them. Even if he were, they would be subject to objection. I am quite satisfied that your Lordship should be told what oscillograms are, and that sort of thing, but when he states this as facts——

MR. SMART: He has stated it and he may know.

HIS LORDSHIP: He may say whether he knows that as a matter of personal knowledge?—A. No, your Lordship, I was not present when these were taken. I have taken large quantities of them and I am very familiar with them, but I was not present when these were taken. They were taken in accordance with instructions that I gave, and they were made by Mr. Alexanderson and Mr. Oakley for me.

MR. SMART: These people are here and will say that they were made at 60 cycles.

MR. HENDERSON: I object to the use of them. I object to the witness giving this evidence.

HIS LORDSHIP: Mr. Smart must call the other people first.

MR. HENDERSON: I do not think that even then he can use them.

HIS LORDSHIP: I would rather have that kind of evidence than a great deal of that which I have had here. There is one thing, that the photographs can not lie. They may be useless or useful. There can be shaving and twisting and sometimes perhaps deception upon things that are obvious to the trained mind and completely demonstrable if both sides to this litigation wanted it done.

MR. HENDERSON: There is a very simple way, if oscillograms are wanted to be used, that the other side should be asked to take part.

HIS LORDSHIP: I do not know that that is a settled rule.

MR. HENDERSON: It is careful practice.

MR. SMART: It has been omitted a number of times.

HIS LORDSHIP: It is not the practice in this Court, because the practice is rather the other way.

MR. SMART: These things only will show graphically the things which my learned friend was ready to admit this morning.

MR. HENDERSON: I do not know even what they are going to show. We have not seen them.

MR. SMART: They were used in the Splitdorf case.

HIS LORDSHIP: There is nothing which you do not know, Mr. Henderson. You can not tell me that you are surprised, and Mr. Smart could not be surprised in this case.

MR. HENDERSON: I must confess, my Lord, that we have made very elaborate preparation for this case and have looked at everything we can think of that might forestall surprise. But I do not know what oscillograms these are. For instance, as my friend has just said, these are oscillograms which were used in the Splitdorf case. If that is so, we would be in a sense forewarned; but I may tell you now that the oscillograms used in the Splitdorf case were of the most objectionable character.

MR. SMART: The judge did not say so.

MR. HENDERSON: The judge in that case did not have information to tell him otherwise. Does your Lordship think you should admit these?

HIS LORDSHIP: Mr. Smart will have to call the witnesses.

MR. SMART: I will undertake to call these witnesses, but I think it would be better to have Mr. Waterman explain the results before the formal proof of the manner of taking them is taken.

HIS LORDSHIP: You will have to produce the witness who took them.

MR. SMART: Yes, I undertake to do that.

MR. HENDERSON: We stipulated in this case matters of various kinds. These were not stipulated.

MR. SMART: I agree that these were not covered.

MR. HENDERSON: My friend can not blame me if I hold him to strict proof or evidence.

MR. SMART: That is why I brought my witnesses here.

WITNESS: In my direct examination I produced two blueprints of sketches which show the similar building up to that shown by the high frequency oscillogram just described.

MR. SMART: That is exhibit 3.—A. (Contd.) If your Lordship will notice, they are the same at 60 cycles as at the higher frequency, except spread out so that they are more easily visible. Those so far dealt with merely illustrate the building up a current in a single circuit. I now produce an oscillogram marked CD-120089. This represents the reaction effects taking place between two circuits magnetically coupled closely.

EXHIBIT No. 19:—Filed by Mr. Smart, Jan. 20, 1927. Oscillogram CD-120089.

A. (Cont'd.) In other words, we have two resonant circuits, such as we have been dealing with, consisting of an inductance and a capacity for each, and the two coils are placed side by side so that they constitute a transformer, and that current in one induces a voltage in the other.

In the upper line, the curves marked A on this sheet, we see the trace made by an alternating current flowing in one of the coils that I will call the primary coil of the transformer. That current was oscillating in that circuit which was tuned to the frequency of the incoming current.

The horizontal line just below and at the left, marked B, shows the mirror governed by the current in the second circuit at rest, meaning that that circuit was still open and therefore no current was being developed. When the switch in the second circuit was closed so that the first circuit containing current A began to develop current in the circuit B, this current starting to flow in circuit B at once began to re-act violently on the current in circuit A, so that we had no smooth development of current in the circuit B but a violently surging (perhaps that is as good a word as any) current, which we know from analysis means that there was no longer a resonant condition of the circuit with ability to oscillate in a single rate, but the circuits were now oscillating at two different frequencies and a very great loss of efficiency and selectivity is suffered.

MR. HENDERSON: During the lunch adjournment, we would like to make tests of the apparatus in court which was used yesterday, and would like my friend to arrange to have somebody to check us.

MR. SMART: Yes, that is all right.

HIS LORDSHIP: That can be arranged between you.

MR. SMART: Will your Lordship now adjourn?

HIS LORDSHIP: Yes.

THE REGISTRAR: Court is adjourned until 2.15 this afternoon.

MR. SMART: If you will proceed with the evidence, Mr. Waterman, in regard to the oscillogram. Perhaps you might first state whether there is any difference between the high frequency and the other features?—A. Yes. It has been called to my attention that I did not discriminate between the instruments with which the high frequency oscillogram was taken and that with which the others are taken.

The ordinary oscillograph which we use for most work is quite incapable of responding at the rate of a million per second, although the moving element is a practically microscopic filament, and the mirror so small that I can see it only when I get a glint of light on it, nevertheless it is incapable of moving at these extreme frequencies.

Therefore the first oscillogram shown, which shows the actual oscillations taking place at the rate of one million per second, was taken with what is known as a cathode ray oscillograph, in which a fine stream of electrons is directed against the film, and that having substantially no mass, is capable of moving at the enormous speed necessary. In that case, of course, the mirror was not used, the stream of electrons impinged directly on the film, and the film itself was not moved but the stream was moved in reference to it, which of course is the same thing.

Q. The next you are producing?—A. The next oscillogram to which I refer is marked CD-120,245.

EXHIBIT 19:—Filed by Mr. Smart, 20 Jan., 1927. Oscillogram Number CD-120,245.

It is produced for comparison with the last one. The one last mentioned showed the autograph of the currents in two circuits, each tuned to resonance with the signal frequency, and inductively, or as it has been called reactively coupled by placing the coils side by side. This oscillogram now referred to, Number CD-120,245 shows the same two circuits performing however, in this instance, by virtue of a one-way relay coupling produced by a vacuum tube.

Referring to Exhibit Number 8 for example for the purpose of diagram, the first circuit, the oscillations of which are indicated by the upper line in this oscillogram, marked "A" corresponds to the circuits in Exhibit 8 tuned by the condenser 8. It was connected to the vacuum tube in the same way as shown in this diagram. The plate element of that tube was connected to a coil corresponding to coil 12, which was identical with the coil of the input circuit tuned by condenser 8. The second tuned circuit was the identical tuned circuit used in the preceding oscillograph. So we have the two tuned circuits coupled by the tube assemblage.

Mr. Henderson : I do not want to be interrupting, but the witness is assuming that this was done. He says " We did " so and so. There is a difficulty.

His Lordship : He is assuming that his instructions were carried out.

Mr. Henderson : Perhaps Mr. Waterman would not mind putting it that way.

The Witness : All right.

Mr. Smart : I do not understand that these oscillograms illustrate anything more than is common ground between us. When they are coupled as stated and the current applied, this is a graphical representation of what both sides agree would occur.

Mr. Henderson : I am not differing from my friend in this sense, there is as your Lordship will see a legend attached to each oscillogram, —I presume the others will be the same ?—A. Yes.

Mr. Henderson : It would be a simple thing if Mr. Waterman would say that the legends are correct. My only objection for the moment is that the witness is saying " We did " so and so.

His Lordship : I understood it because I thought of his statement made previously, that these oscillograms had been made on certain instructions given by him,

Mr. Henderson : I was not rising to obstruct, but another Court reading this might say the witness said so and so and you did not check him.

His Lordship : Well, I think practically your statement was already down. That is correct, is it not Mr. Waterman ?

Witness : Yes, your Lordship.

Mr. Henderson : And so that I will not have to rise again if Mr. Waterman slips into the same error——

His Lordship : It applies to all these oscillograms ?—A. It applies to all the oscillograms, your Lordship.

What happened was that I went to Schenectady and had a consultation with Dr. Alexanderson and Mr. Oakley and arranged that these oscillograms should be taken, drew diagrams explaining what I wanted and how I wanted the coils arranged, and it was provided that they should set up the apparatus and have it ready and I should go to Schenectady and take part in the observations.

Your Lordship will understand that an instrument of this kind is operated by a specialist, there is a specialist assigned to the operation, and none of us interfere with the actual operation of the instrument, but the diagrams and full instructions are turned over to him.

When the time came that I was notified that they were ready it was impossible for me to go to Schenectady, and I wrote or telegraphed asking that they should go ahead in my absence. That I understand was done.

Mr. Smart : I understand Mr. Henderson only refers to the way you expressed it. Take care of that.—A. What I meant to say was that the oscillogram number 120,245 indicates by the legend thereon that it was taken in the way I have just indicated, and I am testifying purely on the assumption that that was done and on the evidence of the oscillogram itself, since I know what the result would be.

MR. HENDERSON : I would not object to Mr. Waterman elaborating the legend if necessary by reference to a diagram.

MR. SMART : I do not think that will be necessary.

WITNESS : As I was saying, the upper line A indicates the oscillations taking place in a first circuit, which might be understood to correspond to the circuit tuned by condenser 8 in Exhibit 8.

Line B indicates the oscillations taking place in the second circuit, corresponding to the circuit tuned by condenser 15 in Exhibit 8. The line B starts with a wavy line but should be straight. The fact that it is not straight indicates either that there was a mechanical vibration of the instrument, or that there was some slight pick-up effected in some wire. Where the switch was closed, that is the moment at which the switch was closed, is indicated by the beginning of building up of larger and larger oscillations in the lower line B.

This oscillogram I requested be made for the purpose of contrast with the last preceding one, which shows the reaction effect taking place when the coupling is of the electromagnetic or reactive type, as contrasted with the absence of any such interaction when the coupling is by the one-way relay.

As the coils are separated this effect, the reaction between the two circuits, becomes materially reduced in magnitude. I show an oscillogram No. C.D. 120,094 which shows, according to the description thereon, the effect occurring between the circuits electromagnetically coupled when the coils have been moved five inches apart, conditions otherwise being the same as in oscillogram C.D. 120,089.

It will be noted that the effect of the interaction is less irregular, less violent than in the first instance.

EXHIBIT No. 20 :—*Filed by Mr. Smart, 20th Jan., 1927. Oscillogram* C.D. 120,094.

I will next refer to an oscillogram intended to illustrate the action when circuits are inductively coupled at what is known as the critical coupling, which is that coupling illustrated in the curve sheet produced yesterday, Exhibit No. 15, by curve " A " in which, while the selectivity is very bad, the energy transfer is a maximum, the violence of the interaction between the circuits is noticeably decreased, as will be seen by the absence of the violent and apparently chaotic oscillations of the needle. The selectivity is still very bad, but the energy transfer is good.

EXHIBIT No. 21 :—Filed by Mr. Smart, 20th Jan., 1927. Oscillogram No. C.D. 120,099.

HIS LORDSHIP : Why do you say the selectivity is very bad on this, what is there on the graph that indicates that ?—A. That is indicated by the other form of illustration contained in Exhibit No. 15. This oscillogram illustrates the graphical representations from which this other curve on Exhibit 15 could be deducted by careful analysis.

MR. SMART: Will you explain as to oscillogram, Exhibit 21, what it indicates as to selectivity?—A. High selectivity is not easily judged from this oscillogram. What we judge by is the magnitude of the reaction of the circuits upon one another, which would indicate that the selectivity was not good. But it would take careful measurement and analysis of the curves to determine just what it was, and that is why we used two types of illustration.

HIS LORDSHIP: That is the resonance curves?—A. Yes. This oscillogram C.D. 120,099 is intended to represent, and evidently does quite closely represent, the condition which is plotted on Exhibit 15 as curve "A." From that curve it is easy to see that the selectivity is very poor as compared with the selectivity obtained with the one-way coupling as indicated by curve B.

MR. SMART: Perhaps you could explain it in this way, I observe that the upper curve A is much wider, has greater amplitude at the left hand end than at the right-hand end. What does that indicate?—A. That indicates that there is still a powerful reactive effect of the associated circuit B upon the circuit A which has forced down the oscillations from the wide amplitude shown at the left of CD. 120,099 to the fluctuating width that is seen further to the right.

HIS LORDSHIP: Does that mean that the curve to the left, figure A, indicates a current which has more amplitude at the beginning than at the end?—A. Yes, at the left it has its full original strength in the oscillatory circuit. When it is associated with the second resonant circuit, energy is transferred over to the other circuit, and those two energies react, so that the coil A now takes much less energy than it did before. This, together with the variations of outline show the marked reactive effect which is in the resonance curve type of illustration shown by the low height and the great broadening of the resonance curve.

MR. SMART: Will you compare that with the effect when there is a tube coupling instead of the reactive coupling?—A. Exhibit 19 shows the complete absence of the effect just noted when there is a one-way coupling.

Q. What is that?—A. CD. 120,245. At the extreme left where it is marked "A" your Lordship will see a signal going into the first circuit. Its magnitude is indicated by the vertical extent of the swings of the curves. After a short time the circuit, whose performance is indicated by the line "B," is closed, and the current builds up in it by virtue of energy transferred through the tube from the first circuit to the second circuit. The point intended to be illustrated is the fact that when we have such association the energy in the second circuit builds up to a very great amplitude, as indicated by the great width of the swings on the right hand end of the lower line "B," and does it without affecting at all the extent of the swings of the line "A," which continues the same clear across the sheet. This is in marked contrast to the others, particularly CD. 120,089, which is intended particularly to illustrate identical conditions, where your Lordship will see at the left that the excursions caused by the beam in tracing curve "A" are very wide, but have fallen to a very small magnitude at the right, and that this very irregular set of disturbances occurs upon the closing of the second circuit, and these changes in CD. 120,089, which is Exhibit 18, illustrate the differences that I have been speaking of without compelling the inductive association of circuits with their association by way of a one-way coupling in the tube.

Now CD. 120,099 illustrates that that effect shown most markedly in CD. 120,089 becomes less as the coils are separated, and when the coils are separated to a distance of ten and three-quarter inches apart, as indicated by the inscription on the sheet, then it is materially less, and this oscillogram corresponds to the condition indicated by the resonant curve on Exhibit 15 which is marked " A " double prime. To illustrate how, by the extreme separation of inductively coupled coils the disturbance created by reaction can be progressively reduced, I requested that oscillogram CD.120,240 should be made. This oscillogram illustrates the same, or was intended to illustrate or supposed to illustrate the same two magnetically coupled resonant circuits when the coils have been moved to 24½ inches apart, the coupling then being very loose.

It shows that the violent reactions occurring in Exhibit 18, CD. 120,089, have been progressively reduced as the coils were separated until they were a little over two feet apart. The violence of that reaction is not at all apparent, and that corresponds to the very loose coupling of the coils at which as I understand it is now agreed that the selectivity has become good, but the signal has become very small.

His Lordship : I am not sure that that was agreed upon.

Witness : It corresponds then to the condition which I stated namely, that the selectivity approaches the selectivity of the one-way coupling when the coupling is loosened as the signal approaches zero.

His Lordship : Q. How is that accomplished as to the inductance? Please go over that again.—A. The inductance is associated with a condenser, and in the instances with which we are dealing the tuning to a definite frequency is accomplished by the varying of the capacity of the condenser.

Q. And that means the tuning of the inductance?—A. Yes.

Q. By the same means?—A. Yes. That mode of expression is sometimes used as a way of designating a tuned oscillatory circuit.

Mr. Smart : My learned friend has kindly consented that I should interpolate Dr. Alexanderson as to these oscillograms before proceeding.

Mr. Henderson : I would require to ask the witness certain questions. I suggest that Professor Waterman step out of the box and that Professor Alexanderson take the stand. I think that would be more convenient.

[*This witness was recalled, see p.* 357.]

In the Exchequer Court of Canada.

Plaintiff's Evidence in Reply.

No. 22. Ernst F. W. Alexanderson (recalled). Examination

No. 22.

Further Evidence of Ernst F. W. Alexanderson (recalled).

E. F. W. ALEXANDERSON, Recalled. Examined by MR. SMART:

Q. I understand that the oscillograms which have been put in, Exhibits 17 to 22, were made under your supervision and that the legend attached to each of the oscillograms is a correct description of the circuit whose action is represented by the curve in the oscillogram?—A. Yes, that is right.

MR. HENDERSON: Has my learned friend a diagram of the circuit used in taking the oscillogram?

MR. SMART: They are put in in the record.

MR. HENDERSON: My learned friend tells me the circuits used were those used in the Splitdorf record, appearing at pages 430 and 431, and I would suggest that we do as we did before, that we use these for the moment, not marking them, and my learned friend will let me have copies.

MR. SMART: Yes.

CROSS-EXAMINED BY MR. HENDERSON:

Cross-examination.

Q. Do I understand that the oscillograms were taken when the switch is suddenly closed in a circuit supposed to represent the radio receiver?—A. I would like to look at that document.

EXHIBIT Z-18:—Filed by Mr. Henderson, 20 Jan., 1927. Record in Splitdorf Case.

MR. HENDERSON: My learned friend tells me the question should be answered in the affirmative, but I want the witness to understand it; that the oscillograms were taken when the switch is suddenly closed in a circuit supposed to represent a radio receiver.—A. Yes.

Q. And does this sudden closing of the switch such as you used in taking the oscillogram occur in a natural receiver?—A. No, the switch is not closed in the actual receiver, but the oscillogram is made to contrast the conditions in the circuit before and after the closing of the switch.

Q. But you do not get that condition in actual practice? I do not mean the practice of taking oscillograms, but I mean that you do not get that condition in the use of an actual receiver.—A. No, we do not close the switches in that way in a receiver.

Q. Do the oscillograms represent actual conditions occurring in a receiver used in broadcast reception?—A. Yes. Before closing the switch the oscillograms represent one typical condition in a receiver, and after closing of the switch it represents another typical condition in the receiver.

Q. Before closing the switch the oscillogram represents a typical condition. Will you describe further that typical condition?—A. Before closing the switch the oscillogram depicts the oscillation in a single oscillating circuit, but after closing the switch it depicts oscillations that take place in two associated circuits and the oscillations that take place due to the reactions between those two circuits.

Q. Are not those reactions due to the sudden closing of the switch? —A. The transition from the one state to the other is due to the closing of the switch, and that transition also represents a typical condition in the operation of a receiver.

Q. You do not get that sudden closing of the switch in an ordinary receiver?—A. No, but we get a sudden impact on the signal which is equivalent to this particular action in closing the switch.

Q. Is that true in broadcast reception?—A. Generally speaking, it is, although it is most specifically true that the signal comes on suddenly in telegraph reception, but the smooth transition from low signal to high signal in broadcasting reception can very well be illustrated or explained by the very sudden transition that would occur in telegraph despatching.

Q. You get it in taking an oscillogram, because you have an apparatus there that closes suddenly so that you get this photograph effect?—A. Yes.

Q. But there is no such photographic effect in an ordinary broadcast receiver?—A. These tests are made to reproduce as closely as possible the practical means, the conditions which we wish to illustrate.

Q. But these photographs are obtained by suddenly closing the switch? —A. Yes.

Q. And there is no corresponding mechanism in the broadcast receiver? —A. I think the sudden change in signal strength that does occur is a very close analogy.

Q. We are not talking for the moment of analogies. In broadcasting do you get that sudden change that you get when you are taking an oscillogram?—A. Usually we do not get it quite as suddenly as we get it with a switch.

Q. Could even an expert operator get it as you get in taking an oscillogram, or anywhere near it—as to the degree of suddenness?—A. I think so. We have shown oscillograms taken at a million cycles.

Q. I am not asking you about oscillograms. I am asking you if you can get that sudden change by doing anything with a broadcast receiver. —A. You can get that sudden change in a broadcast receiver when it corresponds to a signal with the same suddenness as the closing of a switch.

Q. Does that happen in broadcast reception?—A. Usually not, in broadcast reception, but it can happen and does happen in telegraph reception.

Q. We are talking about the broadcast reception of the present day. —A. I think under conditions it might happen, but it is only a bare possibility.

Q. Theoretically it might happen?—A. Yes.

Q. That is as far as you can go?—A. Yes.

Mr. Henderson: There might theoretically be something happen in broadcast reception, but this occurred to me that if you could get the effect of a flash of lightning in a broadcast receiver in some way it might happen, but this is not the kind of thing that one gets in practice.

Witness: Static is something that we are quite used to listening to in broadcast reception, and that happens in broadcast reception.

In the Exchequer Court of Canada.

Plaintiff's Evidence in Reply.

No. 22. Ernst F. W. Alexanderson (recalled). Cross-examination —*continued.*

In the Exchequer Court of Canada.

Plaintiff's Evidence in Reply.

No. 22. Ernst F. W. Alexanderson (recalled). Cross-examination —*continued.*

MR. SMART: With reference to that transient effect due to the throwing on of the switch that my learned friend referred to, can you by referring to Exhibit 18 point out what part might correspond to the transient effect and what part would correspond to the settled effect after the transient effect had passed away?—A. The transient effect is the peculiar irregularity of the curve that occurs after the circuit has been closed.

Q. And then after that, is there still an irregularity in Exhibit 18 between the two circuits?

MR. HENDERSON: Later on it settles down to business.—A. Later on, although it would be further than the oscillogram can reach, it would settle down to certain steady values.

Q. But about where in that oscillogram would you estimate the transient effect ended?—A. It is nearly ended at the end of the oscillogram.

Q. That is to say the effect of the sudden closing of the switch is still in evidence because of the irregularity of movement practically to the end of this oscillogram?—A. Yes, there is some irregularity there.

Q. I was curious, for instance, as to this one little curve about two-thirds of the way down. Is there any way of explaining that?—A. It is the inter-action of the two frequencies. It causes two inter-actions that beat against one another, but at the moment of the sudden closing of the switch there appears to be an entire inconsistency due to inter-action between the two.—A. The inter-action follows a very definite mathematical theory although the mathematics are very complicated.

MR. SMART: Does that inter-action continue in this circuit?—A. The inter-action between the two circuits continues, but the irregularity gradually smooths itself out.

Q. It is an irregular curve that finally results?—A. Well, these two curves will taper off to regular curves of similar amplitude that you see at the end of your oscillogram.

(MR. WATERMAN returns to stand.)

Re-examination.

HIS LORDSHIP: Mr. Smart, is there any way of making the application of those things a little plainer in reference to the Alexanderson patent?

MR. SMART: They illustrate this merely; I do not think it is seriously contested by my friend that if you have two resonant circuits coupled without a tube there will be an inter-action between them, which if they are closely coupled will be pronounced, but which will be diminished as they are loosely coupled, and as they are loosely coupled the signal strength will die down, whereas when they are coupled with tubes they build up uniformly and quickly to the maximum value.

MR. HENDERSON: Professor Hazeltine will speak as to that?

MR. SMART: Yes.

MR. HENDERSON: I would have put the same questions to Mr. Waterman as you put to Dr. Alexanderson, and answered in the same way. That is as to the oscillograms only.

Are you through with him in general?

MR. SMART: Yes.

No. 23.

Further Evidence of Frank N. Waterman (resumed).

F. N. WATERMAN, re-cross-examined by MR. HENDERSON :

Q. Then, Mr. Waterman, dealing with the other evidence which you have given, I understood you to say that you had read the evidence of the witnesses Schloemilch and Von Bronk and had examined the exhibits attached to that evidence ?—A. Yes.

Q. Have you a copy of that evidence before you ?—A. Yes.

Q. Would you be good enough to look at pages 27 and 28 of Schloemilch's evidence with respect to figure 1 of his German patent No. 293,300. You have it before you ?—A. I have.

MR. HENDERSON : I think, in order that his Lordship may follow, I will have to read this now. We did not read it before. Starting at the foot of page 26.

MR. SMART : Might it not be advisable to read it all ?

MR. HENDERSON : I would be quite content to do that.

MR. SMART : The witnesses are to be cross-examined in respect to part of it. It seems to me it would be better to have the whole read.

HIS LORDSHIP : Just put it in.

MR. SMART : It is already in.

MR. HENDERSON : My friend is suggesting, as I understand, that it is fairer to the witnesses and to the Court if we read this evidence now, and then it is as if given in the witness box, a point with which I entirely agree. The first is Otto Von Bronk—

(Mr. Henderson reads evidence taken on Commission in Germany.)

MR. HENDERSON : My friend, Mr. Smart, objected, and I do not know whether he wants to make his objection now.

MR. SMART : Your Lordship will see that finally the blue-print is not proved in any way. Mr. Von Bronk says he only saw the blue-print two weeks before he gave the examination.

MR. HENDERSON : The blue-print was taken from an original in the files of the Telefunken Company. Mr. Von Bronk is now using it to refresh his recollection of what happened at that time. Mr. Schloemilch was the one who actually used and speaks of it more definitely in his testimony.

HIS LORDSHIP : He proves it, does he.

MR. HENDERSON : I submit that he does. Your Lordship will see about that later.

HIS LORDSHIP : I will hear it subject to the objection.

(Reading of Commission evidence continued. In connection with reference to photographs 233 and 2995, Mr. Smart asked to have his objection noted as follows.)

MR. SMART : Will you note my objection, my Lord, to the use of these photographs.

In the Exchequer Court of Canada.

Plaintiff's Evidence in Reply.

No. 23. Frank N. Waterman (resumed). Re-cross-examination —*continued.*

His Lordship: Yes.

(Reading of Commission evidence continued.)

Mr. Henderson: Then the cross-examination proceeds, my Lord, and Mr. Smart will read that, and Mr. Taylor will still represent the witness in the reading.

(Reading of Commission evidence continued.)

His Lordship: Let me understand, before you go on. He could not find the original drawing, and this blue-print has been made by the photostat department of the Telefunken Company.

Mr. Smart: Two or three weeks before.

Mr. Henderson: He did find the original or what purported to be the original, and the blue-print which is before your Lordship is the one which he actually produced, and he had had that made by the photostat department of the Telefunken Company from the original on the files of the Telefunken.

His Lordship: I thought he could not find the original.

Mr. Henderson: Oh yes, this means that he found it, and that this photostat was made from the original on the files of the Telefunken Company. He could not make the photostat without the original. No one ever dreamed it meant anything else. And my friend admits that the blue-print may be used with the full force and effect of the original.

Mr. Smart: No, a copy of the blue-print.

Mr. Henderson: I will not quarrel over that. Of course you cannot photograph a non-existent thing. I was there and never dreamed that that was the point.

His Lordship: I see the inference that you draw, Mr. Henderson.

Mr. Smart: My inference is that this witness never saw the blue-print or the original until two or three weeks before.

(Reading of Commission evidence resumed, at the bottom of Page 20 thereof.)

Mr. Smart: There was an objection of mine as to these being unproved photographs which were being shown by the witness who was being examined as to the date when he made the invention.

Mr. Henderson: I do not understand that my friend Mr. Smart is pressing that now.

Mr. Smart: I am stating it and I do press it.

His Lordship: It may proceed, subject to your objection. It may turn out differently.

(Reading of Commission evidence continued.)

Mr. Henderson: Now it is Mr. Smart's cross-examination.

(Reading continued, by Mr. Smart and then by Mr. Henderson to the close of the Commission evidence.)

Mr. Henderson: That is the evidence, my Lord.

Mr. Smart: My Lord, I think I should move generally against the acceptance of the blue-print, or any of these photographs as not being proved by any witness.

In the Exchequer Court of Canada.

Plaintiff's Evidence in Reply.

No. 23. Frank N. Waterman (resumed). Re-cross-examination —*continued.*

MR. HENDERSON: My Lord, the witness Schloemilch says very, very definitely that he used the apparatus which is illustrated by the blue-print, and he asks for the blue-print; so that it makes no difference whether it is an original or not. He verifies it.

MR. SMART: There is not a witness that has sworn definitely to the dates.

HIS LORDSHIP: I think you should have pressed your objection very much more strenuously.

MR. HENDERSON: I think it only fair to say that neither of us expected the Commissioner to rule affirmatively. On a commission one does not expect a ruling to be made; it would be dangerous. I must confess I have very great confidence in this. It is true that the blue-print was only a blue print of an original which had been produced, but Schloemilch says definitely, I worked with an apparatus of which there is a blue-print available. Von Bronk says he had this blue-print taken from an original drawing in the Patent Office. Schloemilch worked with the apparatus of which this blue-print is a diagram, it was just as good for that purpose; he fathers the blue-print and it is just as good for that purpose as the original.

MR. SMART: That does not prove the date of it.

MR. HENDERSON: Von Bronk speaks of the date, and my recollection is that Schloemilch does also.

MR. SMART: He says that he found two weeks before the examination a tracing with that date on it; he also says that he does not recollect ever seeing the apparatus shown in that tracing: so that obviously he cannot prove that tracing; and he suggests that there are others who might prove it; but they are not called.

HIS LORDSHIP: I will take it subject to your objection, and you can argue that at length in your argument.

MR. HENDERSON: Q. Now, Mr. Waterman, can you perhaps carry back to the lower part of Page 26 of the evidence given by Mr. Schloemilch where he refers to figure I, and is asked what tuning adjustment he made, and he says, Figure I shows a tube connected as high-frequency amplifier, and the second tube connected as the low-frequency amplifier, and tuning of the oscillatory circuits before and after the high-frequency amplification were proceeded with long before April 30th, 1913. Then lower down, on Page 27, when asked whether the apparatus was tuned, he says, Yes, with tuned antenna one would have had a bad reception. And you have heard again in different places he speaks of tuning. Now, having regard to that, do you want to modify anything you have said?—A. Not unless you call my attention to it.

Q. I have called your attention to the fact that both Mr. Von Bronk and Mr. Schloemilch say that tuning was taken as of course; that in practice they did use this tube. Do you still say they did not?—A. Well, if I have given any testimony as to what these gentlemen did, I most certainly want to correct it, because I have no knowledge whatever of what they did.

In the Exchequer Court of Canada.

Plaintiff's Evidence in Reply.

No. 23. Frank N. Waterman (resumed). Re-cross-examination —*continued.*

Q. My friend, Mr. Smart, asked you before you gave your evidence on this point, Mr. Waterman, if you had read this testimony, and I understood you to say you had; and having said that you then went on to express your opinion that this was not a tuned system. Did you mean to convey that impression?—A. I think there is some radical misunderstanding somewhere. I have not been aware of giving any testimony as to what these gentlemen who were examined did or did not do. I would not for a moment undertake that. I have been asked as to what a certain drawing, being Figure 6 of the blue-print, shows, taking it at its face value; and I testified as to what it shows to me as a disclosure by itself. I have also been asked as to what the patents, both drawing and specification, disclose. And I have stated that to the best of my ability; but I certainly have not undertaken to say as to what these gentlemen did.

Q. And did you desire to convey the impression that this system would not be used tuned?—A. I do not know what you mean by "would not be used tuned" I mean to say that the patent does not give one any instruction to tune it. The patent gives one an instruction to make a radio-frequency amplification, and to use a crystal detector. Now it is neither necessary nor desirable for all purposes that they should be tuned; and I have given the various interpretations that the diagram may have.

Q. I grant that you have said a good deal, Mr. Waterman?—A. And it is all true.

Q. Do you desire to give the impression that the Schloemilch and Von Bronk system was not tuned?—A. Yes, so far as shown in the patent.

Q. You did desire to give that impression?—A. That is, there is no certain indication whether it is or is not.

Q. Then, having heard the evidence of Schloemilch and Von Bronk, do you desire to modify that opinion at all?—A. I do not.

Q. You remember the reference to the arrow-head?—A. Yes.

Q. Pointing, as I would say in my layman's way, to a portion of the transformer?—A. Yes.

Q. Do you desire to modify in any way, what you said as to that?—A. Why, certainly not, because the testimony exactly confirms what I said.

Q. I understood you to say that you thought the inventors, Schloemilch and Von Bronk, did not particularly emphasize the tuning of the circuit N. Do you want to give that impression?—A. Am I to assume that you are quoting from anything I have said?

Q. No, I am making a violent effort to condense what you have said, and it is not easy. Did you wish to convey the impression that you thought that Schloemilch and Von Bronk did not emphasize the tuning of the circuit N.?—A. I read the passage from the patent and told the court exactly what it did say.

Q. Do you now express the opinion that Schloemilch and Von Bronk did not emphasize the tuning of the circuit N?—A. In their patents, they certainly did not.

Q. And would one skilled in the art, and knowing these men to be engineers of high standing, assume that they used their circuit without tuning? Recollect that they say it was the obvious thing to do?—A. May I answer that other than categorically?

Q. I would like you to answer it categorically first, and then make a speech about it if you wish ?—A. Yes, I would assume that they intended to show it other than tuned.

Q. I did not say "to show it" but I said, Would you assume that men of their standing would use it tuned or untuned ?—A. I would assume that that is something in which they would undoubtedly be governed by their knowledge, as to which I have no information. What I would like to say is this——

HIS LORDSHIP : Go on, witness.

WITNESS : The early patent showing the DeForest audion shows it, if my memory serves me, in connection with the ordinary Marconi circuit. The grid circuit was tuned. We all tuned our antenna and grid circuits when we wanted to. There is no question about that. Now these patents show the use of a tube as an amplifier with tuning omitted ; and with the tuning omitted ; and with the suggestion that the circuit associated with the output tube and with the detector may be tuned.

The very absence of the illustration of the tuning is almost positive indication that they did not intend it ; because it was practically certain that they were familiar with the prior tuning, which had been a matter going on for years. And when therefore they show what they did show, one must, I think, assume that what they were after was maximum amplification ; and maximum amplification was not necessarily or even possibly occurring with tuning for selectivity. It is practically certain that they were after maximum amplification ; and it is practically certain that they were not in tuning, but that the arrow indicates just what they said it did, namely such a connection to the secondary circuit as would give the loudest signal.

Q. Then you do not agree with what they say in their evidence ?—A On what point, please ?

Q. You still adhere to that after hearing their evidence ?—A. There is nothing inconsistent in their evidence with my statement.

Q. Then you make that statement which you have not * made now, do you, notwithstanding the evidence to which you have just listened ?—A. Certainly. There is nothing inconsistent with what I have just said, in their evidence.

* *sic ?*

Q. You say not, and I am not going to take up time quoting it now, because we have it. I want to make a further reference however, to the variable tap on the secondary transformer of the Schloemilch and Von Bronk patent, 293,300, figure I and figure 3 of the corresponding United States patent Number 1,087,892. In view of what Mr. Von Bronk has stated, will you repeat now what you say about the use of that tap ?—A. Yes. The crystal or other detector, L, is a device which absorbs energy from the circuit. There are two things to be guarded, first, the crystal must not have too high a voltage put upon it ; second, the crystal should not take too much energy from the circuit. There will be in general a certain adjustment of that arrow, at which the best all round compromise will be made in the matter of the voltage applied to the crystal and the energy taken by the crystal from the coil ; and therefore at which the signal will

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be the loudest. And that is what I understand Mr. Schloemilch is saying in the answer that you referred me to, at the bottom of page 32, if I get you correctly.

Q. Will you look at Page 12 of Mr. Von Bronk's evidence, where the question is put to him :

" I notice that in the diagram by means of which you have refreshed your recollection, L-898, and which is dated Feb. 8th, 1913, that figure six shows a variable condenser across the secondary coil, which is not shown in figure I of patent 293,300, in addition to a variable tap on the coil. Will you please explain why the condenser was omitted from figure I of patent 293,300 ? " Now note that, and the answer is :

" A. At that time it was assumed that the tuning by the variable coils was sufficient. In the first patent drawing the variable condenser was included. With a view to simplifying the drawing, it was cancelled, I have the original of the first drawing in my file. It can be seen that the condenser which was originally shown has been eliminated."

In view of that, do you desire to modify your last answer ?—A. As to the showing in the figure I of the patent and the interpretation which it must be given in view of the drawing and the specification, No. As to Mr. Von Bronk's motives for not showing the condenser, I of course have no knowledge other than his evidence.

Q. And do I understand that you still stand by what you have said, and that you are not in any sense influenced by what he did or says he did ?—A. No, I have not been asked to be.

Q. Yes, I have asked you if, having heard——

WITNESS : Will you please allow me to finish my answer, Mr. Henderson ? —A. I would, if you ever finish. I thought you had finished.

HIS LORDSHIP : I thought you had finished. Go on, if you have not finished.

WITNESS : I was asked only to consider the patent and the drawings thereof as shown.

MR. HENDERSON : What I asked you was, having heard and not only having heard, but having before you and having read what Mr. Von Bronk said, do you still adhere to that answer ?—A. Yes, I do. I take Mr. Von Bronk's deposition as a whole. For example, I take this answer in connection with the foundation that he laid for it, on page 11, where he said that the testing was done by means of the telephone. By the loudness of the telephone one could ascertain the most favourable coupling.

Now, for that kind of reception we would make a diagram just such as I have indicated, and it does not indicate tuning at all ; but it indicates exactly those things that I have stated, namely, that he wanted the loudest signal. He was after amplification ; and in order to do that he taps his coil in such a way as, first, to make the best output for his transformer ; second, as not to dampen or injure the sensitiveness of his tube by putting too high a voltage on it.

These statements confirm exactly what I have testified to from the drawing.

Q. And you are still sticking to the drawing, and not to what he said ?—

A. I am sticking to the drawing and say that what he said confirms what I said from the drawing long before I ever saw his testimony.

Q. Is it your contention that a louder signal could be received on a DeForest tube by leaving the grid circuit untuned than by using the variable coil to tune it ?—A. Yes. Give me an option on the coupling as he does here and the arrangements shown in the patent and I think I will unquestionably get a louder signal by using the arrangement as I think he intended to have it used.

Q. Assuming your expression " give me an option in coupling " means to give you a choice as to the type of coupling ?—A. I mean what he says in the middle of Page 11, which I have just read.

Q. What do you mean by the alternative ?—A. Selectivity was not in his mind. Allow me to produce what he says he was after, the loudest signal, and neglect selectivity, and I think I will unquestionably get a much louder signal by the method indicated in the drawing, but I won't have any selectivity to speak of.

MR. HENDERSON : Shall I enter on another question to-night ?

HIS LORDSHIP : Cannot you finish with this witness to-night ?

MR. HENDERSON : I have three or four more questions.

HIS LORDSHIP : Go ahead.

MR. HENDERSON : Referring to Hazeltine's chart number 4. I might be really able to shorten the matter in the morning.

MR. HENDERSON : I will undertake to be very brief in the morning, and probably will be shorter than if we proceeded now.

HIS LORDSHIP : You are going to recall Hazeltine ?

MR. HENDERSON : And one other witness.

HIS LORDSHIP : If you are permitted to do so, what do you propose to go over ?

MR. HENDERSON : A few statements such as the last statement which has been made.

HIS LORDSHIP : There is very little that Professor Hazeltine has not covered.

MR. HENDERSON : Except that Professor Waterman has put things in a new way. I will want to straighten out the oscillograms. It will be just a few general questions.

MR. SMART : Of course, the right of reply is a very special one.

MR. HENDERSON : I have an absolute right of reply on my counterclaim.

HIS LORDSHIP : I am not sure that you have. I do not believe you have any right to counterclaim. However, that is not serious.

MR. HENDERSON : Your Lordship intimated we could recall Hazeltine ?

HIS LORDSHIP : Yes.

MR. HENDERSON : And I intend to keep within your Lordship's understanding of what you said you would permit.

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Mr. Smart: Penn vs Jack, Equity Cases, page 314, covers that point.

His Lordship: Whether I am right or wrong I am going to hear Mr. Henderson in reply, and it is quite a dubious question. I am not so sure that in action where infringement and invalidity are alleged, that the plaintiff should not prove his case with some degree of certainty; at least, he should make out a prima facie case that he was the first to use the device, and indicate when he first used it. For instance, if you had introduced the evidence which came out in cross-examination by Mr. Henderson in regard to these letters——

Mr. Smart: My learned friend opened up that matter and went into it.

His Lordship: I thought that was due to the fact that you had not put them in. I am not quite certain as to whether this Court should not make a rule, either by a formal ruling or in some other way, as to how an action of this kind should be conducted. However, I do not think it is very important.

Mr. Henderson: I understand there is a great deal more ground to cover with Mr. Waterman, and I desire to boil it down as closely as possible, because I think we should be near the end of it.

His Lordship: I am going to allow you sur-rebuttal, if you call it that, just on new matter.

Mr. Henderson: I would not for a moment dream of anything beyond that.

His Lordship: It looks as though you would hardly finish your argument to-morrow.

Mr. Henderson: It looks as though we will not be able to commence our argument to-morrow.

His Lordship: I think you should be able to commence it.

Mr. Henderson: The evidence is going to take some further time.

His Lordship: Surely we will finish the evidence in the forenoon.

Mr. Henderson: I do not know. I cannot predict what is going to happen. I am entirely in accord with your Lordship in hoping that it will not be long. I am as anxious as anyone to get through with it. I understand that one of our witnesses has to be out of town to-morrow. He is unfortunately under orders of the Government. He is Director of Radio Services of the National Defence Department. I cannot ask your Lordship to hear him at this time of day.

Mr. Smart: I cannot see how he will be properly in reply.

Mr. Henderson: As to the criticism of the test made by Mr. Hazeltine.

Mr. Smart: That is going into the thing again. Professor Hazeltine gave his evidence.

His Lordship: I do not think that will help me very much. The probabilities are that I will have to disregard all the evidence on these tests. If I knew as much as the experts I perhaps might make some useful deduction, but I probably will have to discard it altogether.

MR. HENDERSON : The object of the test is to demonstrate.

HIS LORDSHIP : When scientific men on either side will not agree upon the results and method, it is pretty difficult for me to decide.

MR. HENDERSON : I will repeat the test in presence of Mr. Alexanderson, and if Mr. Alexanderson contradicts it I will be glad if your Lordship ignores it.

MR. SMART : We cannot discuss these tests indefinitely.

HIS LORDSHIP : It would be useful to me at any rate to a certain extent.

MR. HENDERSON : I regret that criticisms were presented to your Lordship in that regard, and if Alexanderson will say there was anything wrong with it——

HIS LORDSHIP : He has not said that.

MR. HENDERSON : Waterman has said that and has used some objectionable language. It was intended to be a perfectly simple test, and I am quite willing to repeat it in the presence of Mr. Alexanderson.

MR. SMART : That was with special apparatus, to show things which, viewed in their true light, would not have any bearing on the question.

MR. HENDERSON : There we have the misleading effect of mere words. He says the test was made with special apparatus, in the sense that apparatus had to be specially set up in order that the test should be made, which means that you could not make a test with the ordinary apparatus and that statement is clothed in a smoke cloud of words that mean nothing.

HIS LORDSHIP : I will be glad to hear you when you come to that, and I will do the very best I can. When I said I might have to disregard the evidence of demonstration on both sides, perhaps I went a little bit too far, but if I am left in confusion upon that evidence it will be very difficult for me to do anything else, and I doubt very much if it will help us by bringing in another party.

MR. HENDERSON : I hope to dispel that confusion by a plain statement as to whether the test was conducted with anything such as my learned friend intimates.

HIS LORDSHIP : If it could be made plain to me, I would be glad to hear such evidence. There are several ways of carrying on the test.

MR. HENDERSON : There is no trick about the test. Anybody can do it.

MR. SMART : My learned friend has had his day in court on the matter. Are we to go on indefinitely ? Are we to put in some further expert in reply to him or is he to put in a further expert ?

HIS LORDSHIP : Strictly speaking, I do not suppose he could do that, but notwithstanding that, if I had any hope that the matter could be further elucidated by the production of some independent person I think I should listen to him.

MR. HENDERSON : I intended to bring the best expert from the University of Toronto and the best local expert to speak as to the test.

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MR. SMART: If my learned friend needed that kind of evidence to support his case he should have done it when he was introducing his evidence.

MR. HENDERSON: Now, entirely in a new way they have said the test does not demonstrate anything because the apparatus——

HIS LORDSHIP: You have Professor Hazeltine and you can question him further on that, and I have no doubt he knows as much about the subject as anybody you can bring from the University of Toronto.

MR. HENDERSON: Oh, he does.

HIS LORDSHIP: I think you had better confine it to that, and I will be very glad to hear any explanation.

MR. HENDERSON: I also want to get the Vivian and Thomas notes, and my friend is content that I should borrow the exhibits and take them out over night.

HIS LORDSHIP: Mr. Smart has nothing to do with that. I would rather leave it with the Registrar and he will go as far as he can.

MR. HENDERSON: We unfortunately have no extra copies.

HIS LORDSHIP: Are you calling anybody else, Mr. Smart?

MR. SMART: No, I do not expect to.

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MR. HENDERSON: May I proceed, my Lord?

Q. You have referred, Mr. Waterman, to regeneration and oscillation in connection with Exhibit K. Have you found, in the evidence of Schloemilch and Von Bronk, or in their patents, any reference to regeneration or oscillation?—A. No.

Q. Do you agree with Mr. Hazeltine that the coils of each transformer in Exhibit 8 are tuned as a unit by the condenser in the secondary circuit?—A. No.

Q. What is the distinction you make?—A. The coils which are connected to the condensers are tuned to the frequency of the received oscillations. By virtue of the coupling between those coils and the primary coils associated with them a certain impedance is imported into the plate circuit of the tube.

Q. Does that answer my question as to the distinction between these being tuned as a unit? Is the plate circuit resonant?—A. No.

Q. Then are the circuit elements of your Exhibit B—you remember it? A simplified sketch?—A. No, I don't.

Q. Then may I have Exhibit B. This is a sketch drawn by you, Mr. Waterman. Are the circuit elements of your figure, Exhibit B, contained in figure 6 of the blueprint with the German evidence, in the same relation?—A. I am afraid I do not understand what you mean by "in the same relation."

Q. Are the circuit elements of your sketch which you have before you, contained in figure 6 of the German blueprint?—A. Diagrammatically considered, yes.

Q. Assuming that Schloemilch and Von Bronk had an input circuit and output circuit resonant to the frequency of the received waves, would they not have geometric selectivity ?—A. Yes, to an extent depending upon the intelligence with which the circuits were arranged to that end.

Q. Oh, presumably. Would they not have essentially the same instrumentality as a one-stage Alexanderson system as drawn by your Exhibit B ?—A. I am sorry, I missed one or two words ?

Q. Would they not have essentially the same instrumentality as a one-stage Alexanderson system, as drawn by you in Exhibit B ?—A. Diagrammatically considered, that is so. Whether they would in fact depends upon the interpretation that is to be put upon the diagram ; and the answer might be decidedly, no.

Q. I suppose you can bungle any job, Mr. Waterman ?—A. It is not a matter of bungling. Both might be highly expert jobs, if you use that term ; but intended to quite different ends.

Q. As far as geometric selectivity is concerned, does it make any difference in either Schloemilch and Von Bronk or Alexanderson, whether you use a crystal detector or a vacuum tube detector ?—A. Your question——

Q. Is limited to geometric selectivity ?—A. What I was going to say is that your question does not indicate what you mean by Schloemilch and Von Bronk.

Q. Well now, surely you know that ?—A. The drawings of the patent, and the drawings of Exhibit—I have forgotten the number—the blueprint in connection with their testimony.

Q. Exhibit P is the blueprint connected with their testimony. When I speak of Schloemilch and Von Bronk, I am always speaking with reference to what they did ; and you will remember their evidence about the use of the crystal detector, which at times they preferred to a vacuum tube.

I ask you, as far as selectivity is concerned, and particularly geometric selectivity, does it make any difference whether this man or anyone else uses a crystal detector or a vacuum tube ?—A. Yes, it makes a very great deal of difference.

Q. In what way ?—A. I was confining my answer to the point of view of selectivity, which I understood you requested. Of course, it makes other differences which they were primarily concerned in.

Q. I am confining it to selectivity, and I do not want a lengthy dissertation in answer to a simple question.

HIS LORDSHIP : The question is confined to selectivity ?—A. Yes, it would make a great deal of difference.

MR. HENDERSON : Can you tell me what difference it would make ?—A. Yes, the crystal detector as a circuit element is one which draws heavily on the tuned circuit for energy to operate, and therefore it is impossible to get comparable selectivity from a circuit when it is loaded with a crystal. When you compare the crystal with the tube it makes some difference what tube you are comparing with. In the Schloemilch device——

Q. Nobody disagrees as to that. Schloemilch and Von Bronk said so ?—A. I was going to say that Schloemilch and Von Bronk or Schloemilch said that the tube that they used was the so-called Lieben tube, and such a tube is a very heavy load on a circuit, and I am not prepared to compare those two, but it is certain that either the Lieben tube or a crystal put in the location where they would put a crystal would, to a very large degree, impair the selectivity of the arrangement.

Q. I am not asking as to the impairment of the selectivity. I am asking would it not still be geometric selectivity ?—A. Yes, I should say it would be geometric in a mathematical sense after you had corrected the circuit for the load that is on it. It would not be simply geometric relation indicated by the circuits themselves.

Q. You find it impossible to give a simple answer to that question, do you ? The difficulty is that you answer at such length. Can you not give a simple answer to that question ?—A. I do not see how I could economize words and express the facts.

Q. May I ask you this ; would you not assume from the Schloemilch and Von Bronk United States patent that the antenna is tuned to the frequency of the incoming wave ?—A. Yes.

Q. Would it not be then tuned to the same frequency as the output or intermediary circuit end ?—A. If that circuit is assumed to be so used and tuned, yes.

Q. Do not answer this question please until I see whether Mr. Smart objects to it. I would like to hear what you say as to it ; would it be possible to avoid the geometric selectivity of the Alexanderson patent by substituting a crystal detector for the vacuum tube he speaks of ? Does my learned friend see any objection to that question ?

Mr. Smart : No.

Mr. Henderson : Q. Will you answer it ?—A. May I hear that question again ?

Q. Would it be possible to avoid or could you avoid the geometric selectivity of the Alexanderson patent by substituting a crystal detector for the vacuum tube he uses, meaning as a detector ?

Mr. Smart : My learned friend is not asking the witness to construe the patent, is he ?

Mr. Henderson : The reason I asked the witness not to answer the question until Mr. Smart heard it was that where you ask an expert for an opinion you very frequently come very close to the function of the Court.

His Lordship : I will allow the question.

Mr. Henderson : Q. You have my point ?—A. No, I have not. I am not even sure which patent you are talking about. You say the vacuum tube——

Q. If you use the crystal detector instead of a vacuum tube as a detector, would you by so doing get away from the Alexanderson patent as to geometric selectivity ?—A. I understand the question contemplates that no other alteration is made in the circuit, and so understanding I should say no ; it would be possible to materially impair it, but not, I should think, to avoid it.

Q. If you use the Von Lieben tube would you still have the Alexanderson arrangement ?—A. In the same association—that is, for the purpose of a detector ?

Q. I am speaking generally for relays now ?—A. I have never known of the Von Lieben tube being used in such a relation, and I am not even sure whether they will work or not.

Q. I am not asking whether they are satisfactory or not. If I have what was in all respects the Alexanderson arrangement, subject only to the identity of the tube, instead of the Langmuir tube, let us call them, I use Von Lieben tube, would I come under Alexanderson ?—A. Well, I can tell you such facts as I know, but beyond that it becomes a question of what the Alexanderson patent may include. I have imitated the action of the Von Lieben tube by so connecting the existing tube in the circuit as to cause them to draw heavily on the tuned circuit for energy——

Q. That is not what I ask you ?—A. And the selectivity——

HIS LORDSHIP : Better allow him to answer the question.

MR. HENDERSON : They have a practice in the United States of stopping the witness in the middle of an answer and asking that it be struck out as not being an answer to the question. I have had the same experience again and again with this witness. I ask a question and he goes into a long story that has nothing to do with it.

HIS LORDSHIP : That occurs in all litigation and all evidence, particularly in patent cases, and I think we will get more rapidly to the point if I allow the witness to answer. Of course, your questions are specially prepared, and I cannot always appreciate them at first. Better let the witness have his way.

MR. HENDERSON : They are not specially prepared.

HIS LORDSHIP : I assume they are or otherwise you would not be putting them.

MR. HENDERSON : This question is important, but the reason for it is as plain as the noonday sun. Is Alexanderson a patent on all vacuum tube relays, or is it a patent on any particular type ? I have not been able to find that out yet. I do not know what position the other side is taking ; I am trying to find out now. There are other kinds of devices and I am particularly interested in the Von Lieben tube, and I am going to follow it with a broader question. It is a very plain point and it is a question which can be answered yes or no.

MR. SMART : That was not the question which you put.

MR. HENDERSON : May I put it again ; if the Von Lieben tubes were used would you still have the Alexanderson arrangement ?

MR. SMART : We are in the middle of a question and the question is whether the witness should be permitted to answer, and the witness should be allowed to go back to the previous answer.

MR. HENDERSON : I have a right to say to the witness, " I do not want that answer." And I am claiming that right and your Lordship can rule on it.

HIS LORDSHIP : It is very hard to rule on that.

MR. HENDERSON : I am not obliged to permit an expert witness to answer in any way he pleases a question I put to him. I have a right to keep him to my question.

HIS LORDSHIP: Answer the question if you can, and if you feel you should qualify the answer in order to make it clear, then give the explanation; but if you can, answer the question.

MR. SMART: Will the reporter read the question?

MR. HENDERSON: Your Lordship has ruled that I may carry on.

MR. SMART: But the witness was in the middle of an answer.

MR. HENDERSON: I am asking my learned friend to let me have the witness.

HIS LORDSHIP: Put the question again.

MR. SMART: I am asking that the question be read.

MR. HENDERSON: Will you please allow me?

MR. SMART: My learned friend has been stating all his objections, and when I make an objection he wishes to carry on with his statement. This discussion was started by my learned friend interrupting the witness when he was answering, and we were discussing as to whether the witness should be allowed to answer that question. I understand you have ruled that he should be allowed to answer the question; therefore, the proceedings should be resumed at the point where he was interrupted.

HIS LORDSHIP: I want to have the question put again.

MR. SMART: The same question is on the record.

HIS LORDSHIP: For the information of the witness, I ask that the question be put again. Do you recall the question?—A. I think so, but I cannot answer it categorically.

Q. Do you recall the question?—A. I think so.

Q. Then answer yes or no if you can and if you cannot then give some explanation.

MR. HENDERSON: This is a question which should be answered simply yes or no.

HIS LORDSHIP: I cannot tell that. I am not quite sure about it. I am afraid it is getting very close to the issue.

MR. HENDERSON: I grant you that. I am in accord with your Lordship on that.

HIS LORDSHIP: Mr. Smart did not object to it, and I was going to allow it to be put. You are asking whether Alexanderson——

MR. HENDERSON: It is really asking him what after all is for your Lordship to decide. I clearly appreciate that.

HIS LORDSHIP: Yes. I am a little interested in hearing what the witness has to say about it. I am anxious to get more light upon it.

MR. SMART: May I have the question to which the witness's answer is not completed?

HIS LORDSHIP: I asked that the question be put again, Mr. Smart.

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Mr. Smart: I am not sure that my friend will use the same language as he put it in before.

His Lordship: Instead of asking Mr. Henderson to put the question again, I will ask the reporter to read the question to the witness.

(Question read by the reporter, as follows.)

Q. If you used the Von Lieben tube, would you still have the Alexanderson arrangement?—A. I cannot tell, because I do not know how the patent is to be construed. I can tell you what the facts are as to the effect upon the operation.

Mr. Henderson: Then I will leave that, my Lord. This after all is for your Lordship.

Q. In your evidence relative to the Splitdorf receiver, demonstrated here in court, you referred to certain very loose couplings,—do you remember that?—A. In connection with the Splitdorf set which was tested, do you mean?

Q. Yes?—A. Yes, I was asked whether the couplings were tight, and I said, No, I would consider them loose.

Q. I did not understand whether you had in mind the coupling between the primary and secondary of each transformer, or the coupling between different transformers. Will you state which?—A. I had in mind the coupling between the primary and secondary of each transformer.

Mr. Henderson: That is all.

His Lordship: Mr. Smart, is there anything?

Mr. Smart: I have no questions. That is the Reply.

Mr. Henderson: Then I recall Professor Hazeltine.

[*This witness was recalled, see p.* 387.]

No. 24.

Discussion.

Defendant's Evidence in Rejoinder.

No. 24. Discussion, 21st Jan., 1927.

Mr. Smart: I do not think your Lordship wishes me to repeat my objection to this reply.

His Lordship: No.

Mr. Smart: Of course if a special reply is granted, the Plaintiff has a right, if necessary,—although I think it will hardly be necessary in this case,—of replying to the special reply.

His Lordship: Of course I am going to assume that Mr. Henderson is going to ask this witness to express his opinion about the opinion expressed by another expert, if any new thing came out. Incidentally, I think that question would be quite fair. Mr. Henderson, you are only going to take up new matters which you have not touched?

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Defendant's Evidence in Rejoinder.

No. 24. Discussion, 21st Jan., 1927 —*continued.*

MR. HENDERSON: While I am exceedingly anxious to meet your Lordship's views, my position has been two-fold, that as Plaintiff by counter-claim we have the right of reply. Quite obviously it should not be abused.

HIS LORDSHIP: I said yesterday afternoon that I doubted whether you had the right in the counter-claim. Possibly I was wrong. I think I had in mind Trade-marks.

MR. HENDERSON: I confess that perhaps rather surprised me.

HIS LORDSHIP: Was it a Trade-mark?

MR. SMART: No, it was a patent case.

HIS LORDSHIP: I do not know that it is very important anyway.

MR. HENDERSON: I go further, however, and take this broader proposition, that it has been said again and again that where there is no jury the trial judge can control his own court and hear such evidence as he thinks proper.

HIS LORDSHIP: The court has a very wide discretion about many things, but still we must have some uniform practice about it. However, I have decided to hear this witness. If I am wrong, I am wrong. If not, I do not think it matters a great deal.

MR. SMART: And if he raises any new matters the Plaintiff has his rights?

HIS LORDSHIP: Yes, I would think so. I would ask Mr. Henderson to keep strictly to what is in reply.

MR. HENDERSON: I am going to keep very closely to it, my Lord.

HIS LORDSHIP: There is a tendency in these cases, where there are expert opinions, to ask one expert what he thinks about another expert's opinion. That is not evidence. You must get right down to the specific question of fact upon which you require his opinion.

No. 25. Louis Alan Hazeltine (recalled). Examination

No. 25.

Further Evidence of Louis Alan Hazeltine (recalled).

L. A. HAZELTINE, RE-EXAMINED BY MR. HENDERSON:

Q. Professor Hazeltine, may I ask you to bear in mind what his Lordship has just said, and with your accuracy of mind to keep within the ruling as far as you can.

HIS LORDSHIP: Before you proceed, Mr. Henderson. Yesterday at the closing we had some discussion about the demonstration which Professor Hazeltine gave a few days ago. I do not know whether you are going into that or not. The evidence which Professor Hazeltine gave at that time was largely answers in response to questions. If you want to go into that, I think probably I should like to hear it stated in narrative form what he did.

MR. HENDERSON : That was going to be my first question, my Lord, which I proposed to put to the witness. Please listen, Professor Hazeltine.

Q. Will you refer as concisely as possible to the experiments which you demonstrated to his Lordship, and bearing in mind the criticisms of Mr. Waterman and the experiments made in court under Mr. Waterman's direction, will you recite to his Lordship. the essential matters covered by each demonstration ?

MR. SMART : I think that cannot be in any sense reply.

HIS LORDSHIP : No, but I am asking that question myself. I have to struggle with the conditions in that thing in the best way I possibly can. It is repetition I know.

MR. SMART : But it may be necessary for me to deal with it.

HIS LORDSHIP : I would like to hear Mr. Hazeltine give it a narrative form, to help me. I could not allow another witness to be introduced here as a sort of an arbitrator to tell me which was right and which was wrong ; so I want all the facts I can get, and will have to do the best I possibly can.

MR. SMART : If Professor Hazeltine introduces a different statement, we will have to reply.

MR. HENDERSON : I hope he will not introduce anything different.

Q. Proceed, Professor Hazeltine.—A. The experiments which I demonstrated before your Lordship were intended primarily to show that a reactively coupled cascade system was like the relay coupled cascade system in that both gave geometrical selectivity ; that is, both permitted the reception of a relatively weak distant station through very strong interference ; and that that reception and the separation of the two stations became better as the number of stages was increased.

First, with only one stage, we had practically no selectivity. Under the conditions under which we were operating.

HIS LORDSHIP : That is, the interference was great ?—A. The interference was so great as to drown the signal we wished to hear. Then with the two stages there was still some interference ; and with three stages the interference had entirely disappeared, so far as the ear could judge ; but that same thing was true both with the Marconi system and with the Alexanderson system.

HIS LORDSHIP : Well, that is all there was to it, as I understand it ? —A. That was essentially the experiment. We followed that up by certain special demonstrations on a particular point, the capacity coupling of the vacuum tube. I do not understand that those special demonstrations were criticised and I do not think it is necessary for me to refer further to them. But the main demonstrations were the ones which I have just stated over again to your Lordship.

HIS LORDSHIP : The essential of the demonstration was what I wanted.

MR. HENDERSON : Q. Objection has been taken to the form of re-active coupling which you employed. What do you say about it now ?—A. In arranging for these demonstrations, I had them made with the capacity form of re-active coupling, because I thought it made the fairest comparison. It enabled us to use the same apparatus both for the Marconi system and for the Alexanderson system, and I knew of no way in which I could make such a direct comparison if I used the inductive coupling which was originally used by Marconi.

Q. Will you explain to his Lordship just the difference between the two which he may have forgotten ?—A. The difference between the two I suppose can best be stated by stating what each is. The inductive coupling is the coupling which we have between the two coils of a transformer, which consists in having those coils fairly near one another, so that the magnetic field due to the current in one may link with the other. Capacity coupling is most simply obtained when the two coils are directly connected together at, say, their bottom terminals. That does not happen to be completely shown in this chart, but it is there. The bottom terminal of this coil connected to condenser 15 is actually connected around through the batteries to the bottom terminal of the coil connected to condenser 19. I am referring to Chart Exhibit 8. Then to have capacity coupling we can either have a small capacity directly between the top terminals of the two coils to which I have referred, or we can have capacity between some coil coupled to these coils, which was the case in the experiment. And that was, as I have just stated, because when we put in the vacuum tubes they had naturally such capacity and enabled me to use those both for this capacity coupling and as relays.

The use of such capacity coupling is quite old in the art. I am not able to state when it first came in, but it came into use in early apparatus years ago and is well known in the text books ; and Dr. Alexanderson has quite correctly stated that capacity coupling and inductive coupling are equivalent so far as concerns selectivity ; and I feel that his endorsement is quite sufficient.

His Lordship : You call these primary and secondary coils in Exhibit 8 transformers. Is a transformer ever another means or instrumentality ? —A. A transformer is a combination of two coils which are associated inductively or magnetically.

Q. But is the current stepped down that way ?—A. It may be stepped down or stepped up.

Q. Or elevated ?—A. Yes, your Lordship. In these transformers that we have in this chart it is stepped up, and that is the ordinary thing in a radio receiver.

Q. I was rather under the impression that coils placed in that way were not usually referred to as transformers. I understand what the function of a transformer is.

Mr. Henderson : Each of these that we see in the set, each pair is a transformer.

His Lordship : There is no division of opinion about that ?

Mr. Smart : No.

Mr. Henderson : And your Lordship will remember that in the class of loose coupling in the set it was said they were kept apart, not in immediate juxtaposition, and therefore loosely coupled.

Witness : I might say that the word " transformer " was originally used in power engineering; and the radio engineers largely introduced words of their own; but of recent years the broad art of electrical engineering and radio have come very close together; and now the radio engineer talks their language.

HIS LORDSHIP: That was the real reason I asked you that question, that I had in mind that transformers were largely used in big electric installations?—A. Yes, physically their appearance is entirely different, and they are a piece of apparatus with an iron core, whereas these radio frequency transformers are most commonly without iron cores. But they are quite commonly known as transformers to-day, and the fundamental action is the same.

MR. HENDERSON: Q. When you say that Mr. Alexanderson agrees on this point, when,—are you referring to his evidence to-day?—A. In his evidence a few days ago in this case.

Q. In this case?—A. Yes.

Q. I suppose you do not know whether Mr. Waterman agrees with you or not?

HIS LORDSHIP: You had better not ask that.

MR. HENDERSON: Mr. Waterman, I understood had some criticism of the two-way coupling principles in the Alexanderson arrangement, and self-generated oscillations due to this. Have you any remarks to make on that?

MR. SMART: That is not so. Nothing new arises on that.

MR. HENDERSON: He did give some answers in the other, and I am just refreshing your Lordship's recollection.

HIS LORDSHIP: Q. Did you discuss that question in your previous testimony?—A. I discussed the production of oscillations, but I might say I have not in mind just what Mr. Henderson refers to in that connection, except in so far as it was mentioned in connection with the Splitdorf receiver. I remember that Mr. Waterman made some remarks relating to the production of oscillations in that case; but that is the only reference of his that I remember.

HIS LORDSHIP: You do not imagine that something absolutely new can come out in this?

MR. SMART: No, but I do not want to go over all the ground.

HIS LORDSHIP: Mr. Hazeltine apparently does not quite comprehend your question.

MR. HENDERSON: With reference to Mr. Waterman's own experiment in court, what did you understand it to demonstrate?—A. That experiment showed, as I understand it, only one thing, that when the Splitdorf receiver was first connected normally that the filaments lighted and a rather weak signal was obtained; then if the filaments were turned out the signal became so weak as to be inaudible.

Q. And what bearing has that on your experiment?—A. I showed in my experiments that the lighting of the filaments did not produce any such marked change in the strength of the signal. This was not one of the main points in my experiment, which was to show selectivity, but it was an incidental point to which I believe I called attention. The difference between those experiments is due to the fact that in arranging my apparatus I attempted to follow as closely as possible the disclosure of the Alexanderson patent. Now that is not the practice in present day receivers.

Q. That is the Alexanderson practice ?—A. Those who make receivers using tuned relays, do not closely follow the disclosure of the Alexanderson patent, but they add to it, and this receiver has added to it.

Q. That is the Splitdorf ?—A. The Splitdorf receiver has added to it two things, both of which have the result of lowering the coupling between the stages. One of those things is an arrangement of the primary and secondary coils of each transformer. Now Mr. Waterman stated, and again confirmed it this morning, that he considered that coupling very loose. I do not at all agree with that. The primary and the secondary coils are wound directly adjacent to one another, and in fact are partially interleaved with one another.

Q. Will you show that to his Lordship ?—A. If that is taken apart, yes. In the apparatus which I demonstrated, I followed the disclosure that is specifically brought out in connection with figure 1 of the Alexanderson patent. In figure 1 there is an indication that the coupling is loose, and Dr. Alexanderson has here testified that that was the intention. In the other figures there is no specification as to whether the coupling is loose or not—which Dr. Alexanderson also has confirmed by his testimony—but there is a statement that figure 2, for example, is like figure 1 ; so that I had no option but to use a loose coupling, and the coupling which I used was much looser than the coupling in this Splitdorf receiver, which I hope I can show your Lordship in a moment. That was done by placing the two coils on cylinders and putting them end to end with a space between them. That separation of the coils, in contrast to this partial interleaving gave considerably looser coupling. I then increased the number of primary turns above what is done in such commercial receivers as this, so as to maintain what I suppose was the condition desired in the Alexanderson patent. I did not, however, increase those turns nearly as much as the number of turns in the secondary coil. I did not wish to accentuate in any way the effect that I wished to demonstrate ; and I believe that rather than accentuating it I leaned over backwards in supplying some of the modern knowledge rather than what one might have done merely from the patent alone. That increase in the number of turns was following the practice that Dr. Langmuir explained in his testimony, when he used the apparatus at the home of Mr. Kinney to receive radio signals. He said he tried out the number of turns to get satisfactory operation. Now that is one feature in which the two pieces of apparatus differ. The other feature is that the Splitdorf receiver is partially neutralized. That is a term that your Lordship will hear much more in the subsequent cases in issue here. It means that the natural capacity between the plate and the grid of the vacuum tube is partially neutralized in its coupling effect ; and that has, as its primary purpose, the prevention of locally generated oscillations. That is the prevention of the squeals which were demonstrated in my experiments to your Lordship. And Mr. Waterman has testified that this receiver had very little tendency to squeal; that it only occurred at the higher frequencies.

Now those two things in this receiver—the partial neutralization and the use of very few primary turns closely coupled—are modern developments. In fact they are both included in a patent granted to me in Canada.

MR. SMART: I do not think the witness should say that.

MR. HENDERSON: Why not?

MR. SMART: It depends on the validity of that patent.

MR. HENDERSON: He says merely that they are included in a patent.

HIS LORDSHIP: He simply says they are included in a patent.

MR. HENDERSON: We are not using the Splitdorf here. They are just included and he refers to that as to the date, the patent being of a comparatively recent date.—A. The number is——

HIS LORDSHIP: That does not matter.—A. The two elements I have just mentioned both operate to cause loose coupling between stages, which is for the purpose of preventing oscillations, and that loose coupling also prevents the system from working as effectively as the Marconi system, and that is the reason why the signal was not audible when the filaments were turned out.

MR. HENDERSON: As to audibility of the signal, reminds me of a criticism Mr. Waterman made, of your signal being too loud.—A. My signal was about as loud—that is, I am referring to the interfering signal—as might readily be experienced in the home use of a receiver, due to a local broadcasting station.

Q. Will you now refer to the resonance curves which you prepared and which are marked Exhibits "I" and "J" and to the curves prepared by Mr. Waterman—Exhibits 15 and 16—and state whether your conclusions are modified by Mr. Waterman's evidence?—A. No, my conclusions are not modified at all. I believe that the assumptions which I made, and which of course are necessary for any mathematical calculation, are quite fair and entirely favourable to the Alexanderson arrangement.

HIS LORDSHIP: If you each started with the same assumption, you would reach the same conclusions?—A. I believe so, your Lordship. Mr. Waterman said he would not criticize the mathematical part of the work but only the assumptions.

MR. SMART: The mathematical part is a matter of exact science, of course.

HIS LORDSHIP: Yes.—A. However, I think it will not be necessary for me to refer to my curves, because I can draw and do draw exactly the the same conclusions from Mr. Waterman's own curves, particularly Exhibit 15. It happens that Mr. Waterman shows the same circuit constants; that is, resistance, capacity, and inductance, which I have chosen; so that that made it rather easier for me to make comparisons, and it also prevents any discussion on the fairness of those values.

I will refer them to Mr. Waterman's curves. Perhaps I can point out certain points on these curves to your Lordship directly.

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No. 25. Louis Alan Hazeltine (recalled). Examination —*continued.*

(Indicating) In the Alexanderson arrangement, represented by curve " B," we find that we get a certain peak at the middle of the figure, and at the very top, representing the signal strength at resonance; now if we go to 1½ per cent. above resonance as a convenient point, we can see that the signal strength has dropped off 10.7 per cent. as I read the curve. That is just a little over one tenth of what it was at resonance.

Now if we take curve " C," which represents a Marconi system, we find that it has a resonant peak a little below the centre of the chart. The scale for that point is marked decimal zero four (.04). And for that we do the same thing; look at the curve at 1½ per cent. higher than the resonant frequency; we find that the signal has dropped down to decimal zero zero five (.005). Now the ratio of that to the former is 12½ per cent.; so that the selectivity as represented by that ratio corresponds to 12½ per cent. for Marconi, and to 10.7 per cent. for Alexanderson. Now the difference between those two figures is a difference which is so slight, in my opinion, as not to be material.

I have taken curve " C " in making that comparison. If I took curve " D " we would find that the values were more nearly alike. Curve " C " is one in which the response at resonance is 80 per cent. of the maximum possibly attainable with this Marconi system; that is at the curve marked " A-second." (A-2). And curve " C " gains in selectivity at only 20 per cent. loss in signal strength. Curve " D " gains further in selectivity but at a greater loss. So that we see that there is no great difference—no difference which I would regard as material between Marconi and Alexanderson so far as concerns selectivity.

However, I do not feel that the comparison has been made on entirely a fair basis, although I can see a reason for making it, in this way. I have just said that curve " C " gives 80 per cent. of the maximum signal attainable with the Marconi system; but that is not at all true of curve " B " for Alexanderson. Curve " B " for Alexanderson corresponds as I understand it to a case when there is no amplification of the signal. If there were appreciable amplification of the signal, which is always attained in commercial receivers, then the effect of the plate circuit would be to change the form of this curve and it would change the form in such a way that the selectivity for Alexanderson would be worse than the selectivity for Marconi. So far as I know, no one uses this Alexanderson arrangement in this way without amplification; and it is for that reason that I say that I do not think the comparison is quite fair unless we are to understand that the Alexanderson system is typically a non-amplifying system. If it is, then the superiority of Alexanderson over the prior art, if it occurs at all, will quite disappear, because we have something which gives very little more selectivity and very little more signal strength, in both quite a negligible proportion, and that would never justify the complication of vacuum tubes and batteries and that sort of thing.

Mr. Henderson: Q. Mr. Waterman has repeated again and again that there is no resistance in the tubes. What do you say as to that?

Mr. Smart: May I have the question again, please?

Mr. Henderson: I say, Mr. Waterman, as I understand it, has repeated again and again that the effect of the resistance in the vacuum tube is not of any account when it is being used as a relay. Do I understand that ? —A. I am not sure just what you refer to in Mr. Waterman's testimony.

Q. In the drawing of curve " B," has he taken into account the resistance in the vacuum ? —A. No, that is not taken into account at all. But neglecting that is a legitimate thing to do if the system has no amplification. It would not be a legitimate thing to do for a receiver such as the defendant's receiver, or the Splitdorf receiver, or any other commercial receiver,—when there is amplification.

Q. Does your Lordship follow that ? I do not want to take up time explaining it. And the result of that, Professor, as you have just said, is that unless you look upon this as a system which has nothing to do with amplification, you must take it into account ? —A. Yes.

Q. Will you look at your chart Number 4, marked as Exhibit M, and state the basis for your drawing of this circuit. There was some criticism of it yesterday. State the basis of your drawing of this circuit both as a whole and as to its individual elements.

MR. SMART : He discussed the chart pretty well in his evidence.

MR. HENDERSON : No, you will remember, your lordship seemed to wonder yesterday if his attention was called to the apparent dissimilarity between the Schloemilch and Von Bronk and Chart 4. I want him to refresh your Lordship's recollection as to that and answer the criticisms made yesterday. It will only take about a minute to do it.

MR. SMART : He argued why this was the same in his direct evidence.

MR. HENDERSON : In his direct evidence he explained this diagram.

MR. SMART : And why he had made it.

MR. HENDERSON : Why he had made it that way, quite true. Then there was an entirely new aspect put on it yesterday by Mr. Waterman and I want him simply to explain this chart now.

HIS LORDSHIP : Briefly. Very good.

MR. HENDERSON : Briefly, yes. —A. I do not think, your Lordship, in spite of what Mr. Smart said, that I did explain why I made the chart in this way. I explained that the chart itself showed a figure which was the same as Alexanderson, and I may have stated broadly why I made it that way, and I had definite reasons for the details, as well as for the broad arrangement ; and I think that as your Lordship pointed out, the two are identically the same and that the chart representing Schloemilch and Von Bronk was not the circuit of the patent. I can now refer specifically to the testimony giving the basis for each of these elements. I made this chart in this form to facilitate a comparison with Alexanderson; because I did find on the basis of the testimony, elements identical with Alexanderson and I felt that it was fairer to show that identity rather than to take some other modification which was different, and where the difference might be misleading.

Now the chart illustrates broadly the same thing as is illustrated in the patent. For example figure 3 of the United States patent to Schloemilch and Von Bronk, Number 1087892, which has been very fully discussed by

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Mr. Waterman, and the figure in the corresponding German patent, that is figure 1 of German patent Number 293300; they are substantially identical.

Mr. Smart: This is all argument, of course, my Lord. —A. In each of those figures, there is shown broadly three tuned circuits, as I understand it: a tuned antenna circuit; a tuned grid circuit; and a tuned plate or output circuit. I can refer to the German testimony beginning for example with Mr. Von Bronk's testimony at page 9 of the record. I find a reference to the tuning of the grid circuit and of the antenna circuit.

Mr. Smart: Should this witness argue about the evidence?

Mr. Henderson: This is not an argument. He is pointing out, my Lord, why this diagram accurately illustrates the evidence given by these two witnesses in Germany. The diagram was prepared for that purpose.

His Lordship: There is possibly a reason for that occasioned by my comment. Has not he stated that broadly now? You probably went over all this ground with him in your direct examination in a comparative statement of Von Bronk and Alexanderson.

Mr. Henderson: No, my Lord, I did not ask him about that. He simply stated very broadly that this had been prepared. I forget the exact phraseology. That this had been prepared to illustrate what they did as disclosed by their evidence.

His Lordship: And he incorporated in that drawing all the elements that he believed he found in the Von Bronk.

Mr. Henderson: My Lord, I could in argument give your Lordship the reference to these different portions of the testimony, or the witness can shortly indicate them now as your Lordship pleases.

Mr. Smart: Surely the argument is the place for it.

Mr. Henderson: I am quite content to leave it until the argument, if your Lordship prefers.

His Lordship: Have you pretty well covered it Professor?

The Witness: No, my Lord.

His Lordship: Then I am going to allow the witness to finish it, briefly and very broadly.

Mr. Henderson: Do not quote from the evidence. Give the page and that will be sufficient.—A. On page 9 of Von Bronk's testimony, I find the statement that he tuned the antenna circuit and also tuned the grid circuit.

On pages 27, 28 and 29 of Schloemilch's testimony I find that he tuned all three circuits; the antenna circuit; the grid circuit; and the plate or output circuit.

Mr. Smart: Obviously, the witness is reading an argument written out and in place before him.

His Lordship: I assume there will be a great deal of that by everyone? —A. My Lord, that is incorrect. I have before me the quotations which I have had made from the testimony, to save your Lordship's time, so that I will not have to look it up, and it is that to which I am referring.

Mr. Smart: He has not the right to go on the stand and read a document.

Mr. Henderson: He is not reading. He has extracts from the evidence before him and a reference to the pages.

HIS LORDSHIP: Proceed then please?—A. Now in the United States patent, or the German patent to which I have referred, the output circuit and the antenna circuit are each tuned by a variable condenser, and that I have followed in my chart. But the grid circuit is tuned by a variable inductance, and that I did not follow in my chart; but I chose the variable condenser, also finding reference to that in the testimony. I am stating that the figure in the patents does show a variable inductance; which I think Mr. Waterman has not agreed to. That I am stating because of Mr. Von Bronk's testimony, which appears on page 12. He stated that he had used a tuning condenser and that he realized that it was not necessary to have two tuning elements, and that he erased the showing of the condenser and left the tuning by means of the variable inductance.

MR. HENDERSON: That is it had been shown on this original drawing?—A. Yes.

Q. Then what about this tap that there has been something said about?—A. That is the tap to which I was referring.

MR. SMART: I cannot recollect that in Von Bronk's evidence at all. It shows the undesirability of having the witness state the evidence.

HIS LORDSHIP: I do not see any objection to this question. It is almost necessary for him to refer to it, by reason of my own comments on these two drawings. They left me with the impression that they were mere copies, which possibly might be misleading. I think it is quite fair for him to give any explanation he wants to. It is really not new matter.

MR. HENDERSON: I may remind my friend that the evidence was that at that time it was assumed that the tuning by the variable coil was sufficient. In the first patent drawing that variable condenser was included, but with a view to simplifying the drawing it was cancelled. He said: I have the original of the first drawing in my files. It can be seen that the condenser, which was originally shown, has been eliminated. That is what he said.

MR. SMART: He said he omitted it.

HIS LORDSHIP: These comments are not necessary?—A. I find in Exhibit P—the blueprint marked L-898—the tap to which the question refers—there are two such taps. One of them is to the grid coil and the other is to the output coil. The reason for these taps is explained in the testimony of Schloemilch on pages 32, 33 and 34; and the reason is essentially the same in each case, that he was using first the Von Lieben tube in place of a high vacuum tube as a relay; and second a crystal detector in place of a high vacuum tube detector, and he states that he did not use this tube when he employed a high vacuum tube in each place.

MR. HENDERSON: And you have therefore, omitted the two taps in your sketch?—A. That is correct. I have made connection to the end of the coil but have otherwise used the tuning condenser shown in Exhibit P in each of these places; so that gives just the arrangement of my chart.

Q. And in your chart you show a vacuum tube detector?—A. That is a form of the DeForest type.

Q. The ordinary DeForest connection?—A. Yes. I use the connection taken from the DeForest patent to which I previously referred because I find Von Bronk used the DeForest tube early in his work, and for simplicity and nothing else.

I simply took the circuit of that patent. I do not regard that, however, as being material in any way.

Q. And as far as the antenna circuit is concerned— — ? —A. I have simply followed the arrangement of both patents, and on Exhibit " P," in showing a series condenser in the antenna circuit, that being variable for tune.

Q. In the light of the comments that you have heard, can you now illustrate what was done by Schloemilch and Von Bronk as appears from their evidence better than you did in this chart, Exhibit " L " ? —A. No. I do not believe so. As I have said, they have done things in several different ways, and, of course, I could not show all of them on the one chart, but I think the chart does show in the best way I know how one of the arrangements which they used.

Q. In both halves of your chart, Exhibit " M," representing Schloemilch and Von Bronk and Alexanderson especially, I think you have shown a single relay interposed between two tuned circuits. Am I right ? —A. Yes.

Q. Is there any intentional drawing of distinction between this arrangement and that of employing two or more relays coupled in cascade by tuned circuit ? —A. Not at all. I chose two tuned circuits for simplicity. I find that in certain of the figures of the Alexanderson patent as well as in Exhibit " V," sketched by Mr. Waterman, and stated both by him and Alexanderson to represent a simple Alexanderson arrangement. In the same way I chose a single vacuum tube relay with its associated tuned circuit to represent Schloemilch and Von Bronk. I find that they sometimes use the single relay, and that is shown in the patents to which I have referred.

Q. Is that illustrated by the diagram of the Chatham set Dr. Alexanderson identified ? —A. The Chatham set also has two tuned circuits and a single relay system. It happens that there are several relays that constitute a group, but they are preceded and followed by one tuned circuit in each case and therefore that would come under the same class. The other figures of the Alexanderson patent show a plurality of relays ; that is, two or more, with three or more cascaded circuits ; also in the testimony of Schloemilch and Von Bronk, including two photographs which they submitted, there occurs more than one relay and therefore more than two associated tuned circuits ; so that I do not consider there is any distinction in this regard.

Q. You have covered that question, have you not ? —A. Yes.

Q. Then I think I have only one other matter to ask you ; you heard what Mr. Alexanderson said about the very sudden action of the mechanism used in making the oscillogram. Might I ask my learned friend, before we go into this, to please look at page 871 of the evidence, at the top, where Mr. Alexanderson is made to say, " It would settle down to a certain static values." That should be " steady values."

Then in line 3 he is reported to have said, " It is merely ended at the end of the oscillogram." That should be " Nearly ended."

Then with those two corrections made, you have read what Dr. Alexanderson said about the effect of that sudden movement covering practically the whole of the oscillogram ? —A. Yes.

Q. Do you agree with that statement ? —A. Yes. I think that is generally correct.

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Q. And in view of that statement do you desire to make any comment? Do you think it necessary to make any comment on the oscillogram? —A. My main comment is to agree with Alexanderson that the oscillograms do not represent conditions occurring in radio receiving, particularly broadcast reception. I think Dr. Alexanderson did indicate that something of that sort might occur in abnormal conditions in broadcasting and also might occur in telegraph reception. I cannot quite agree with the latter. The curves showing inter-action between the circuits which I understand to be largely the purpose of these oscillograms correspond to a closely coupled system.

Now, a closely coupled system is not Marconi. The Marconi is essentially a loosely coupled system, and therefore I would have further reason for saying that these oscillograms do not correspond to practical conditions in that they do not correspond to any system used in radio reception. They represent a condition not occurring in practice.

CROSS-EXAMINED BY MR. SMART:

Cross-examination.

Q. On that last point, as to the showing of the oscillograms, you are aware that some of these oscillograms show a coupling where the coils are 24 inches apart? —A. So I understand.

Q. And that would be quite as loose as Marconi? —A. I would not be able to state values; it may be so and it may not.

Q. Would you expect the Marconi circuit to be coupled with coils more than 24 inches apart or less? —A. The coupling might have a degree of looseness corresponding to the separation of more than 24 inches. Of course, the looseness of the coupling would be obtained by placing the coils at an angle to one another.

Q. When you have spoken of the loose coupling of Marconi please state what distance apart in inches of the coupling of the coil you would understand the loose coupling to refer to? —A. It might be any distance. It is not a matter of distance. It might be a fraction of an inch or several inches.

Q. You implied that that coupling—although it might occur through other elements than mere separation in spacial relations—that relative coupling can be expressed in terms of separation or spacial relation. —A. I do not remember saying or implying that, but I think perhaps it is true.

MR. HENDERSON: I forgot to show that coil.

HIS LORDSHIP: You can do that later.

MR. SMART: What I want to get at is, do you think the oscillogram, with the separation of 24 inches between the inductively coupled coil, represents a condition more favourable or less favourable than that in the Marconi circuit to which you have referred? —A. I am really not in a position to tell. It is quite possible that it is favourable, but I have not sufficient information to make a positive statement.

Q. The critical coupling you observe in one of the other oscillograms was $10\frac{1}{2}$ inches? —A. It was so stated.

Q. Assuming that was the critical coupling, what would you say as to the 24-inch coupling ?—A. My impression is, without making any calculation, that under those conditions the coupling would be the Marconi type of coupling in which there was an appreciable sacrifice of signal strength to give a very high degree of selectivity ; in other words, I would say the coupling was probably a little looser than would be the best average practice.

HIS LORDSHIP : Does anything depend upon distance in coupling ?

MR. SMART : No, nothing.

Q. It is true, without disregarding the question of what the proportions are, that in the Marconi arrangement, when one loosens the coupling between the successive resonant circuits, one increases the loss of signal strength ?—A. Yes.

Q. You have referred to the Splitdorf receiver and as to the test which Mr. Waterman performed in Court ; would you say it would be impossible to make that test if the set which Mr. Alexanderson designed on the witness stand were substituted for the Splitdorf set ?—A. That is not the complete design, because there was nothing indicated as to whether the neutralization would be effective or not.

Q. Assuming no neutralization ?—A. If there was any neutralization I would say that the experiment would probably not be quite so striking, but as I remember the figures of Dr. Alexanderson there would be rather a high step-up ratio in his coils, which is one device mentioned as giving the result he demonstrated, but if neutralization is to be absent, which is the other feature, I would suppose the experiment would give results of a rather similar but less striking character.

Q. You do not say generally then that the effect of the experiment would not be observed if there were no neutralization ?—A. No.

Q. Now, close coupling in transformer design, using it in the widest sense in the electrical field, has been a matter of common use for a great many years ?—A. Close coupling in power work is much the most common. In radio work it was the more unusual thing in many of the earlier designs of apparatus, although I find in some of the earliest arrangements of Marconi there was quite close coupling.

Q. No figures of the drawing of the Alexanderson patent, nor any of the circuit designs of Chatham or any other commercial receiver which has been introduced in evidence, show a crystal detector, do they ?—A. Not so far as I remember.

Q. Now, if Mr. Waterman, with respect to the coupling in the Splitdorf receiver, were referring to the primary and secondary coils of circuits, and not to the transformer coupling, then his statement as to looser couplings would be correct ?—A. I did not examine those circuits carefully enough to be sure of that, but I doubt it.

Q. You doubt even that ?—A. Yes.

Q. How does the coupling in the Splitdorf receiver compare with that in the defendant's receiver ?—A. You are referring to the coupling between the primary and secondary as a whole ?

Q. Take it both ways ?—A. I should think the coupling between the primary and secondary as a whole would not be very different in those two receivers. It is a little hard for me to tell, because the calculation is not

In the Exchequer Court of Canada.

Defendant's Evidence in Rejoinder.

No. 25. Louis Alan Hazeltine (recalled). Cross-examination —*continued.*

readily made, and I have, of course, not made measurements, but I think there is no very great difference in that regard.

The coupling between the primary and neutralizing portion of the secondary, to which I assume you refer——

Q. I refer to the coupling of the transformer ?—A. I have answered that.

Q. What do you refer to as the neutralizing portion of the transformer ? —A. The portion indicated on Exhibit 8 between the tap shown by the arrowhead——

Q. In the Splitdorf patent ?—A. Oh, there is none there.

Q. And yet you say it is specially neutralized ?—A. Partially neutralized. I did not mean to say there was no neutralization. There is no tap on the secondary portion that separates one portion from another. There is neutralization, but it is due entirely to the secondary coil and not to the tapped portion.

Q. Is there any capacity neutralization ?—A. Yes.

Q. Is there capacity neutralization in the Splitdorf receiver ?—A. There is capacity neutralization due to natural capacity between condensers and coils in successive stages, and that is made effective by polarity arrangement of the transformer.

Q. I would like you to point out more particularly if you can on the circuit diagram of the Splitdorf receiver.

Mr. Smart : Q. I would like you to show me on that diagram (Exhibit No. 23) the instrumentalities which affect neutralization, in your opinion ?—A. The natural capacities are not shown on this diagram, as it is not the usual custom to show such natural properties unless they are to be emphasized ; but the polarity of the transformer is indicated. The secondary coil of each of the coupling transformers is shown twisted around from the way that it would be most natural to draw it ; and with that twisting around the bottom of the secondary connects to a grid, and the top of the primary to a preceding plate. And that polarity is such as to give the partial neutralization to which I have referred.

EXHIBIT No. 23 :—Filed by Mr. Smart, Jan. 21, 1927. Diagram of Splitdorf type of receiver.

Q. Then, apart from the special arrangement of parts, the only element to which you attribute the neutralization of that circuit is the reversing of the polarity of the transformer by which the circuits are coupled ?—A. That coupled with the magnitude of the ratio of the transformer.

His Lordship : Are you disagreeing with that answer, Mr. Smart ?

Mr. Smart : What is that, my Lord ?

His Lordship : Are you accepting that ?

Mr. Smart : No.

Q. Is it not true that the transformers on the diagram are shown not only reversed in winding but reversed in connection ?—A. You mean the reversal in the curlicues ?

Q. Yes ?—A. I do not consider that that has any significance. I have never understood that it had, and have never used it to have any significance, in my own work.

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Defendant's Evidence in Rejoinder.

No. 25. Louis Alan Hazeltine (recalled). Cross-examination —*continued.*

Q. Supposing it did have.

MR. HENDERSON: Was that drawn by Mr. Waterman,—Is that one of Mr. Waterman's sketches?

MR. SMART: No.

MR. HENDERSON: That is his little things all have significance,—is that not Mr. Waterman's drawing?

MR. SMART: No.

HIS LORDSHIP: I do not understand that there is any substantial disagreement between you on this question. Is there?

MR. SMART: Oh yes. I do not know that it is of any importance.

HIS LORDSHIP: On the assumption on which the witness bases his answer, are his conclusions right?

MR. HENDERSON: Mr. Smart does not know.

MR. SMART: Such differences as there are, are not such differences as I think affect this case.

HIS LORDSHIP: It is difficult to understand how there are differences in this case, dealing with scientific facts; one would think the opinions would be unquestioned.

MR. SMART: There are different circuits.

RE-EXAMINED BY MR. HENDERSON:

Re-examination.

Q. My friend has referred, Professor Hazeltine, to the Chatham circuit again. Do you recollect, while I am looking it up,——

HIS LORDSHIP: I suppose this is something which you have forgotten?

MR. HENDERSON: No, it is something which arises out of what was asked.

Q. Will you tell me what kind of detector it does show? (Referring to Exhibit Z-17)—A. I find a notation, Synchronous detector set. I do not understand just what this apparatus is to which this refers, as I am not personally familiar with this apparatus and have not seen any description of it. I also find a row of vacuum tubes, the last one of which has a telephone in the plate circuit. That might be the true radio detector, although I cannot be positive of that until I know what the rest of the diagram means.

Q. Are the tubes shown there three electrode tubes?—A. Yes, the tubes are three electrode tubes.

Q. However, does it make any difference, as far as geometric selectivity is concerned, what kind of detector is used?—A. No, not so far as the fact of geometric selectivity is concerned.

HIS LORDSHIP: You surely could not have forgotten that question.

MR. HENDERSON: It obviously was intended as repetition, my Lord. That is all, that is our Reply, except that I do not want to show to your Lordship again the transformer in the Splitdorf set which was used in the demonstration by Mr. Waterman.

MR. SMART: I have a question or two, which will take about five minutes, I think, to ask Dr. Waterman.

HIS LORDSHIP: We will not proceed with the argument anyway until the afternoon.

In the Exchequer Court of Canada.

Plaintiff's further Evidence.

No. 26. Frank N. Waterman (recalled). Examination

No. 26.

Further Evidence of Frank N. Waterman (recalled).

FRANK N. WATERMAN, Recalled. Examined by MR. SMART:

Q. Professor Hazeltine in his evidence was unable to say whether the set which Dr. Alexanderson designed on the stand would make the same demonstration as the Splitdorf set with which you demonstrated in your evidence, and I would ask you whether you can give any evidence which would throw light on that question ?

MR. HENDERSON : I do not quite follow how that is.—A. Yes, I had the set built and made the test upon it, and it gave the same results ; and I have the set in court.

Q. That is the set shown in the design which Dr. Alexanderson made in the stand ?—A. Yes.

Q. You have made a set according to that ?—A. Yes.

Q. And you have tested that set ?—A. I have made some tests and with the same results ; and I have the set here in court and would be glad to show it, if his Lordship would like to see it.

HIS LORDSHIP : No.

WITNESS : The set is here for Professor Hazeltine and others to look at, if they desire to see it.

MR. SMART : I am through.

MR. HENDERSON : Your Lordship might take a minute to indicate what your Lordship's idea is as to the order of argument.

HIS LORDSHIP : We will adopt the usual course. Mr. Smart will open and sketch out his case as fully as possible, so as not to surprise you in any way.

MR. HENDERSON : My friend and I had a somewhat informal conversation, and that is the order which I would have preferred in the interest of saving time. My friend will open as fully as he thinks proper.

HIS LORDSHIP : And open fully. But there are some legal points in this case ; there is that about the affidavit, and there may be others. Will we deal with those first ?

MR. SMART : I think I would rather have my learned friend's attack on the legal point, than to anticipate.

MR. HENDERSON : If my friend could indicate his position, it might perhaps narrow even this. My friend did indicate that he was relying on the Treaty of Peace.

MR. SMART : Yes, there is no doubt about that.

MR. HENDERSON : If one has to enter into dissertation upon the effect of the Treaty of Peace, it might take considerable time.

HIS LORDSHIP : From Mr. Smart's standpoint, the Treaty of Peace is important. His patent falls, unless there is something there to save it.

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Plaintiff's further Evidence.

No. 26. Frank N. Waterman (recalled). Examination —*continued.*

Mr. Henderson : If my friend will indicate in his opening what he hopes from it, I would be quite content that he should have elasticity of reply. If he makes his point in opening, it will narrow down my argument.

His Lordship : The point about the Treaty of Peace should be a very simple affair. We will adjourn until 2.30.

The Registrar : Court will resume at 2.30 this afternoon.

No. 27. Formal Judgment, 14th April, 1927.

No. 27.

Formal Judgment.

IN THE EXCHEQUER COURT OF CANADA.

Thursday, the 14th day of April, A.D. 1927.

PRESENT :—

THE HONOURABLE THE PRESIDENT.

Between :

CANADIAN GENERAL ELECTRIC COMPANY, LIMITED,
Plaintiff ;

and

FADA RADIO LIMITED,
Defendant.

THIS ACTION coming on for trial before this Court at the City of Ottawa on the 10th, 11th, 12th, 13th, 14th, 17th, 18th, 19th, 20th, 21st, 24th, 25th and 26th days of January, A.D. 1927, in the presence of counsel both for the Plaintiff and the Defendant ; upon hearing the evidence adduced at the trial by both Plaintiff and Defendant ; THIS COURT WAS PLEASED TO DIRECT that the said action should stand over for judgment, and the same coming on this day for judgment ;

THIS COURT DOTH DECLARE AND ADJUDGE that the Letters Patent of the Plaintiff, No. 208,583, granted on the 15th day of February, 1921, for improvements in Selective Tuning Systems, is valid as between the parties hereto, and infringed as to the claims thereof numbered 1, 2, 3 and 7 by the Defendant as alleged in the pleadings ;

THIS COURT DOTH ORDER AND ADJUDGE that the Defendant, its officers, workmen, servants and agents be, and they are hereby perpetually restrained from infringing claims 1, 2, 3 and 7 of the Plaintiff's said Patent, No. 208,583, and from making, constructing, using and vending to others to be used, in the Dominion of Canada, the said invention as described in that part of the Specification relating to the said claims 1, 2, 3 and 7 attached to the said Patent ;

THIS COURT DOTH FURTHER ORDER AND ADJUDGE that the Defendant do forthwith deliver up to the Plaintiff, all products or articles in its possession or under the control of the Defendant which infringe the said Claims 1, 2, 3 and 7 of the said Letters Patent;

THIS COURT DOTH FURTHER ORDER AND ADJUDGE that the Defendant pay to the Plaintiff such damages or profits as the Registrar of this Court shall determine to be due to the Plaintiff after making proper enquiry and account, together with the costs of such enquiry and account;

THIS COURT DOTH FURTHER ORDER AND ADJUDGE that the counter-claim of the Defendant be and the same is hereby dismissed;

AND THIS COURT DOTH FURTHER ORDER AND ADJUDGE that the Defendant pay to the Plaintiff its costs of this action forthwith after taxation thereof.

By the Court,
(Sgd.) CHAS. MORSE,
Registrar.

No. 28.

No. 28. Reasons for Judgment, 14th April, 1927.

Reasons for Judgment.

Judgment rendered 14th April, 1927.

MACLEAN J.

This is an action for infringement of Canadian Patent No. 208,583 issued to the plaintiff in February, 1921, the plaintiff's inventor being one Alexanderson, a consulting engineer of the General Electric Company of the United States. The principal defences are lack of invention and anticipation; but the validity of the issue of the patent is attacked upon the ground that the application for patent was made subsequent to the expiration of the period fixed therefor by the Patent Act.

Alexanderson describes his invention as relating to the selection of oscillations of a given wave length from mixed oscillations, and comprises systems suitable for tuning out interferences in radio telegraphy. Interference describes what occurs when one at the radio telephone receiver hears signals from stations other than that desired. Signals arriving at any receiving antenna have an intensity which depends upon two things: the original intensity with which they were emitted, and the distance that the receiving station is from the sending station. One station wishing to hear another station must be able to pick out of the confusion of currents in the receiving antenna, the particular one desired. It may perhaps come from a somewhat distant station and be relatively feeble, while an undesired signal may come from a nearby and more powerful station, producing much greater current in the receiving antenna. The problem therefore is one of selection, and one of the most difficult problems is to select a feeble signal

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No. 28. Reasons for Judgment, 14th April, 1927 —*continued.*

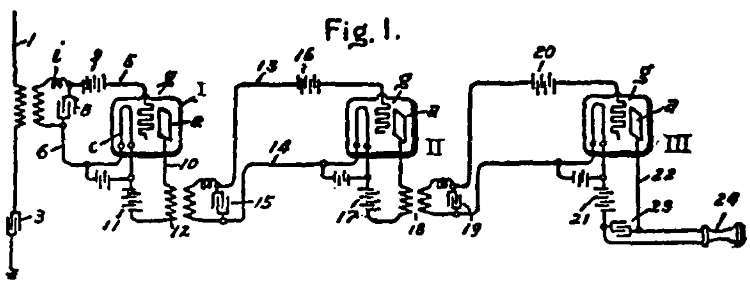
from a more powerful signal particularly when the separation in wave length is slight. In practice the preliminary precaution in abating interference, is the use of different frequencies or wave lengths, by the different transmitting stations.

A few words might appropriately be said here as to the chief elements in a radio receiving outfit, their functions and their operation. An electric circuit is a conducting path through which a battery or generator may send an electric current. There are two kinds of electric currents, direct and alternating currents. A direct current is that which flows in a coil of wire when a battery is connected to the terminals of the coil, and flows in one direction only. An alternating current is one which reverses, or flows first in one direction and then in the other. The number of pulsations of the current in one direction in a second of time is called the frequency of the current, and in the case of radio currents this frequency is very high as compared with the currents used in power or lighting circuits. The function of a radio transmitter is to create a high frequency alternating current in the transmitting antenna. This in turn produces a wave which travels in space and cutting across the receiving antenna sets up in it a high frequency alternating current, corresponding to that created by the transmitter and of identical frequency. In radio telephony the voice is impressed upon the transmitted wave, which carries it to the receiving apparatus which in turn transforms it back into audible sound. At the receiving station it is necessary to be able to eliminate all waves other than the desired wave. To achieve this, use is made of what is known as a tuned circuit, and the method of selecting electric currents of any one frequency is based upon electrical resonance or tuning. A tuned circuit consists of a coil of wire across the ends of which is connected a condenser, consisting of two sets of plates. Such a combination of coil and condenser possesses the inherent property of responding strongly to impulses of one particular frequency. This frequency is known as the resonant frequency of the system or circuit. If this resonant frequency of the receiving circuit is made to harmonize with the frequency of the incoming wave which it is desired to receive, the receiving apparatus is made less receptive to interfering waves of other frequencies. If one set of plates is now made movable or variable with respect to the other, which means altering the capacity of the condenser, the resonant frequency may be adjusted so as to correspond to the frequency of the desired wave, and thereby that wave will be received with the maximum of effect. The resonant frequency of a circuit may also be varied by changing the number of the turns of the coil, thus regulating the inductance, and from this we have the expression, variable inductance, which one frequently encounters. In general practice the coil of the tuned circuit is one of two coils or inductances, constituting what is known as a transformer, the coils being associated closely together so that if an alternating current is set up in the first, or primary coil, it will induce a corresponding current in the second, or secondary coil of the transformer. A vacuum tube or audion consists essentially of an evacuated envelope or tube containing three elements : first, a filament which is heated by a low voltage battery and which emits electrons or minute charges of electricity ; second, a metal plate or anode ; and last, a grid so arranged that the electrons emitted from the filament must pass through the grid in order to reach the plate. Connected between the filament and the plate is a high voltage battery which charges the plate or anode, thereby attracting to it the electrons emitted by the filament, and thus setting up a current in the tube and the associated plate circuit. The grid acts as a valve to control the flow of electrons in the tube, and is usually connected to one side of a receiving circuit, the other side being connected to the filament. The variations of voltage due to the received wave are thereby impressed upon the grid, and cause corresponding variations in the flow of electrons through the tube to the plate, and in the current through the associated plate circuit. These variations of current are identical in character to the current in the antenna, but are very much stronger, and the result is that the antenna current is reproduced in the plate circuit in a magnified or amplified form. The human ear cannot respond to the higher or radio frequencies, and in order to render the signals carried by the radio wave audible to the ear, it is necessary to separate the low frequency of the voice or signal from the high frequency of the radio wave, and the change is one from radio frequency to audio frequency. This is the function of a detector or rectifier, and the device usually employed for the purpose is a crystal or vacuum tube. It should be observed however that when a vacuum tube is used as a detector, the manner in which the tube is operated is different from that when the tube is used as an amplifier.

Having generally described, no doubt with some inaccuracies, the principal elements of a tuned circuit, its purpose and operation in radio reception, I shall now turn to portions of the specifications and claims of Alexanderson, and allow the inventor to describe with greater accuracy and in greater detail his invention, the problem he claims to have solved, and his particular method of selective tuning, which he claims to be secured by the plurality of resonant circuits, arranged in cascade or series, and in such a manner that the selectivity of the system, that is the ability of the system to select the desired radio signals, increases in geometric ratio with the number of circuits employed.

Fig. 1 of the plaintiff's patent here shown, will illustrate the circuits of Alexanderson's invention.

Fig. I.



The problem which claimed the inventor's attention is described as follows: —

One of the chief problems encountered in radio-telegraphy is the suppression of waves of various wave lengths interfering with the

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> waves constituting the signal to be received. The method now commonly employed for this purpose consists in using an electric circuit in which a train of waves of a given frequency acts cumulatively so that each successive impulse adds its energy to the previous impulse, while disturbing impulses of a different frequency have little effect. However, to screen out strong disturbing impulses effectively when weak signals are to be received, requires an accuracy of adjustment which imposes a definite limit upon the possible selectivity of the system.

He then proceeds to describe how he secures an improved method of selective tuning:—

> In accordance with the present invention, selective tuning is secured by the use of a plurality of resonant circuits arranged in cascade in such a manner that the selectivity of the system increases in geometric ratio with the number of circuits employed. The selective circuits are respectively interlinked by a relay controlling a separate source of energy to initiate oscillations corresponding to potential oscillations impressed upon the relay. As each tuned circuit is more or less opaque to disturbing oscillations differing in frequency from the oscillations to be selected, a certain percentage of the disturbances is eliminated in each circuit of the series, so that the purity of the incoming train of oscillations progressively increases as it is successively relayed. The relay preferably used for this purpose is an electron discharge tube having an incandescent cathode, an anode and a grid.

After describing the drawings illustrative of his circuits, he gives a description of the operation of the first circuit, which will sufficiently describe for the present purposes his drawings illustrating that circuit, in fig. 1. That is as follows:—

> " As the incoming oscillations are received by a resonant circuit tuned to the particular frequency of the signals which are to be received, the effect of disturbing waves having a different frequency is suppressed to an extent dependant upon the tuning of the circuit. Because of its resistance and special distribution the antenna circuit cannot be closely tuned, so that the suppression of interference in this circuit may be disregarded in the present case. However, the waves of various frequencies picked up by the antenna are transferred by the transformer 2 to a resonant circuit 5, 6, the inductance and capacity of which may be closely adjusted so that the oscillations having the desired frequency have a maximum effect whereas the effect of wave impulses having a different frequency is suppressed to say, for example, one tenth their original value. The resulting voltage oscillations are superimposed upon the definite negative potential maintained upon the grid of the electron discharge tube by the battery 9, and this varies the conductivity between the cathode *c* and the anode *a* in accordance with the variations of voltage. Preferably the negative terminal of the battery 9 is connected to the grid. The battery 11 sends through the plate circuit 10 a variable current, the oscillations of which are in step with the oscillations in the resonant circuit 5, 6."

Alexanderson then proceeds to state that the oscillations are transferred by a transformer 12 to the second resonant circuit 13, 14, tuned to the desired frequency, and he states that if the disturbing oscillations are here suppressed one tenth, they will have been reduced to one hundredth of their original effect when received by the antenna circuit. For the third tuned circuit he claims the same beneficial results, the disturbances being reduced to one thousandth of their original value. He states that if desired the size of the battery in this circuit may be so arranged as to magnify the effect of the oscillations, now practically free from disturbances, and so may be readily distinguished by the telephone receiver. In the same manner other tuned circuits may be added, and the disturbing impulses suppressed in the same degree.

Claims 3 and 7 are typical of the others :

> 3. A tuned circuit receiving system for detecting sustained oscillations of a given frequency comprising a plurality of circuits resonant to the frequency of the oscillations to be detected and arranged in cascade, relay devices joining each of said circuits to another comprising an evacuated envelope, an electron-emitting cathode, a co-operating anode, and a grid, said devices being connected to one of said circuits at the cathode and grid and to another circuit at the cathode and anode and a local source of energy in the second circuit.
>
> 7. The combination of a resonant circuit containing, an inductance and a condenser, an incandescent cathode relay having its grid circuit connected to the terminals of said condenser, a source of energy connected to the electrode circuit of said relay, and a second circuit resonant to the same frequency as the first resonant circuit supplied with current from the relay electrode circuit.

The defendant contends that Alexanderson is void for want of invention and that it has been anticipated. It might be convenient and appropriate at this stage to consider what principles are applicable, in reaching a determination upon these two defences. As to the first point, it is necessary to consider what is required in the way of invention to sustain the patent. Broadly stated the alleged invention must be new and useful, that is the statutory requirement, and it is always a question of fact if any patent fulfils those requirements. There must be a substantial exercise of the inventive power or inventive genius, though it may in cases be very slight. Slight alterations or improvements may produce important results, and may disclose great ingenuity. Sometimes it is a combination that is the invention; if the invention requires independent thought, ingenuity and skill, producing in a distinctive form a more efficient result, converting a comparatively defective apparatus into a useful and efficient one, rejecting what is bad and useless in former attempts and retaining what is useful, and uniting them all into an apparatus which taken as a whole is novel, there is subject matter. A new combination of well known devices, and the application thereof to a new and useful purpose may require invention to produce it, and may be good subject matter for a patent.

Then as to the question of anticipation. Any information as to the alleged invention given by any prior publication, must be for the purpose of practical utility, equal to that given by the subsequent patent. The latter invention must be described in the earlier publication that is held to anticipate it, in order to sustain the defences of anticipation. Where

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the question is solely one of prior publication, it is not enough to prove that an apparatus described in an earlier specification, could have been used to produce this or that result. It must also be shown that the specifications contain clear and unmistakable directions so to use it. It must be shown that the public have been so presented with the invention, that it is out of the power of any subsequent person to claim the invention as his own. Hills vs. Evans (1862) 31 L.J.Ch. 457. Otto v. Linford (1881) 46 L.T. 35. Flour Oxidizing Co. v. Carr (1908) 25 R.P.C. 428, at p. 457. Armstrong Whitworth Co. Ltd. v. Hardcastle 42 R.P.C. 543, at p. 555. It then is to be considered if the cited prior art, considered in the light of such principles, anticipated Alexanderson, and if not, whether Alexanderson itself discloses that degree of invention necessary to sustain a patent.

Several prior patents were cited by the defendant in support of its plea of anticipation. I shall first refer to the group of Marconi patents, and Stone, because they are similar in that they introduce a plurality of circuits inductively coupled. By means of a plurality of resonant circuits, inductively coupled, Marconi and Stone it is conceded may obtain a high degree of selectivity, but in practice it is said that this degree of selectivity, owing to the reaction of the circuits on one another or the transference of energy from the second circuit to the first, is obtained only at the expense of signal strength, and which signal strength diminishes from circuit to circuit. This reactive effect of Marconi and Stone may be reduced in magnitude, by loosening the coupling between the coils, but as the coupling is loosened the electrical oscillations diminish in strength, in which case one may have a high degree of selectivity but with a considerable loss of signal strength ; if close coupling is employed, increased signal strength is obtained, but the reaction between the circuits is increased and this impairs the degree of selectivity of the arrangement. With such circuits as Marconi and Stone, a high degree of selectivity is therefore only attained at the expense of signal strength. The evidence abundantly supports that proposition, in fact I think it is admitted. In the Marconi and Franklin multiple tuner, British Patent No. 12,960 (1907) a compromise is attempted between these neutralizing factors with a view of maintaining a fair degree of selectivity, whilst retaining a workable signal strength, by taking the same cascade of resonant circuits and coupling them inductively. It might be worth while to quote from the specifications of this patent, as it will probably make more intelligible what I have just been attempting to state :

> " It is well known that if an instrument sensitive to the electric oscillations used in wireless telegraphy (hereinafter called a " receiver ") be placed in a close circuit inductively coupled to an aerial circuit and if both circuits be put in resonance with (that is to say be adjusted to have the same natural frequency of oscillation as) the received wave, the looser the coupling between the circuits the freer is the receiver from interference by waves of other lengths. Similarly if an aerial circuit be inductively coupled with a closed intermediate circuit and this intermediate circuit be inductively coupled with a closed circuit containing a receiver, and all three circuits be put in resonance with the received wave, the receiver is still more free from interference by waves of other lengths and this freedom is further increased by

decreasing either of the couplings between the circuits. Increasing the number of circuits and decreasing the couplings between the circuits increases the freedom of the receiver from interference, but at the same time decreases the strength of the signals in the receiver; it is however found that in an instrument containing an aerial circuit, an intermediate circuit and a receiver circuit such as described above, great freedom from interference without great loss in the strength of the signal is obtained by making the two couplings simultaneously and equally variable, etc."

This portion of the specifications seems to admit that even with the suggested circuit arrangement, there is still a loss of signal strength, and I think there is also the general implication therefrom, that for the purposes of obtaining freedom from interference, the circuit proposed had inherent limitations, and that only a limited improvement in selectivity was expected from such circuit arrangement. Alexanderson, by means of a high frequency one way relay, a vacuum tube, which due to its amplifying properties not only prevents any loss of strength in the oscillations from circuit to circuit, but permits of an amplification of the same, obtains a high degree of selectivity without any appreciable loss of signal strength. Alexanderson is not limited to two or three circuits, as are Marconi and Stone by reason of the progressive loss in strength of oscillations, but he may use any number of circuits with corresponding improvement in selectivity, as the number of circuits is increased, and without loss of signal strength. It seems therefore to me that in substituting the vacuum tube as a high frequency one way relay coupling, for the inductive coupling of Marconi and Stone, Alexanderson found means of transferring energy from one circuit to the next circuit, without any reactive effects between the circuits. In other words he found means of obtaining the highest degree of selectivity that Marconi or Stone could theoretically obtain, but without losing signal strength. It has been contended that the selectivity obtained by Marconi or Stone, approached the selectivity of Alexanderson only when the signal strength of the former approached zero, and that may be so, but it is not necessary that I should express an opinion upon a point so technical. Alexanderson I think disclosed an arrangement that neither Marconi or Stone had suggested, and therefore it is my opinion that Marconi and Stone are not at all anticipations of Alexanderson.

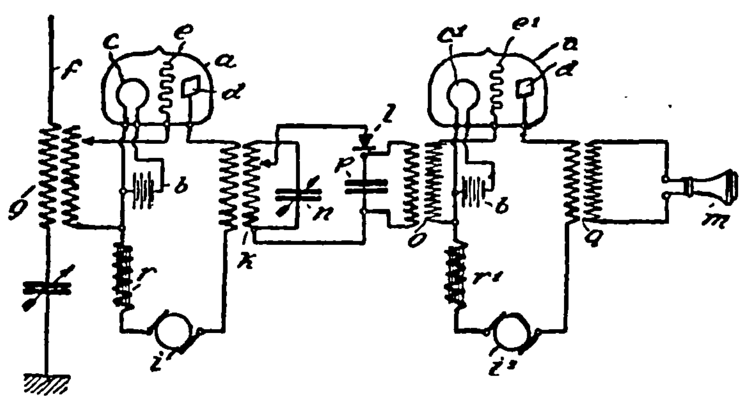
The next prior art to be considered are three patents granted to the joint inventors, Schloemilch and Von Bronk, being German patents Nos. 271,059 and 299,300, issued in 1911, and 1913 respectively, and United States patent No. 1,087,892 issued in Feb. 1914. These patents are much relied upon by the defendant, and I think are the most important of any of the suggested anticipations, and I understand them to be treated on that footing by Mr. Henderson, defendant's counsel. They therefore demand a careful consideration. If anticipation of Alexanderson is not found in this series of patents, I do not think it can be found in any other of the prior art cited by the defendant.

First, a broad and general consideration of those patents. The chief purpose of Schloemilch and Von Bronk throughout is amplification of electrical oscillations. The inventors perceived the amplifying properties of the vacuum tube, which they say had previously been used only as a detector. They contemplate the use of the vacuum tube as an amplifier, both before and after detection, or in other words at radio frequency and at audio frequency. The first mentioned patent refers to radio amplification, the second to audio amplification, and the last one, the United States patent, to both radio and audio amplification. In fig. 3 of the drawings of the United States patent, there is shown a vacuum tube to amplify the received oscillations, a detector to rectify them, and following this a second vacuum tube to amplify the resulting audio frequency oscillations or signals. Tuning is specifically shown only in the antenna circuit and in the intermediate circuit, or the circuit *n* inductively coupled with the output of the first tube. In none of the drawings of all these patents is more tuning shown than this, in some of them less, in one of them none at all. This, however, is subject to the qualification that the antenna is in all cases shown as tuned. And it is to be observed that in neither the specifications or claims of these three patents do the inventors make any reference whatever to tuned circuits for the purpose of attaining selectivity. If selectivity was the end to be achieved it is remarkable that it was not mentioned. Their minds were not evidently directed to this problem, and as a natural consequence they are silent upon it. They were apparently thinking in terms of amplification and not selectivity. In referring to the arrangements shown in Fig. 3 (U.S.A.) Schloemilch and Von Bronk express a preference that the intermediate circuit *n* between the radio frequency amplifying vacuum tube and the detector, be tuned or " syntonised " as they say, and that circuit is shown in that figure as tuned by means of a variable condenser. The antenna circuit is shown in the drawings as tuned though no reference to this is made in the specifications or claims, but no suggestion is made as to tuning the secondary of the transformer *g* which couples the antenna with the first tube. The other drawings of this patent do not suggest any tuning at this stage. It may be that the effect of the tuning of the intermediate circuit, would result in an improvement in signal strength, and a gain or improvement in selectivity, but this is not mentioned in the specifications or claims. The dominant idea heralded throughout the specifications and claims is amplification; they claim the use of the vacuum tube as an amplifying relay but they are entirely silent as to selectivity. At all times of course, in the radio art, any means of receiving electrical oscillations would in some degree be selective means, or the receiving apparatus would be of little value or perhaps none. Upon a broad construction of these patents alone, there would not appear sound reasons for concluding that the inventors intended to refer to the same subject matter as Alexanderson, or that any one of the same was an anticipation of the latter.

Now for a more critical and detailed examination of these patents. Evidence was taken in this cause under commission in Germany, where the joint inventors Schloemilch and Von Bronk each gave evidence, and this evidence in relation to the question of anticipation must be considered with some care. As I have already indicated, the substantial controversy upon the defence of anticipation relates I think to the question as to whether or not Alexanderson was anticipated by the Schloemilch and Von Bronk patents, and that in turn largely revolves around the point as to whether the circuits disclosed in Schloemilch and Von Bronk were tuned or intended to be tuned as in Alexanderson, and for the purpose of selectivity. The importance of that point will perhaps appear more clearly when I say that it is contended by the plaintiff, that it is not possible to obtain geometric selectivity unless all circuits are tuned to the same frequency, and so far as I can see that is a correct statement of fact.

In respect of German patent No. 271,059 where the antenna only is tuned, and which was common practice, Von Bronk states definitely that this patent was developed by himself alone, and that no tuning of the grid circuit of the tube was contemplated, and the drawings themselves are conclusive upon the point. This patent may therefore be put aside as not being in anticipation of Alexanderson. Remembering now that no tuning is shown in the input circuit of the first tube of the German patent No. 293,300 which is declared to be an improvement of German patent No. 271,059, or in the same circuit of the United States patent, and remembering that it is contended by the defendant that tuning of this input circuit was common knowledge at the time and should be considered as expressed in the specifications of this patent, the plaintiff contesting this contention, I now proceed to a consideration of the evidence of the German inventors upon this point. It might be useful to insert here fig. 3 of the United States patent granted to Schloemilch and Von Bronk.

Fig. 3.



In respect of German patent No. 293,300 Schloemilch states that tuning of the antenna circuit, the grid circuit, and the output circuit, was practised by him and was obvious but he is indefinite as to time, and he only affirms that it was prior to Feb. 9th, 1913. In support of Schloemilch's evidence, a blue print was introduced in evidence bearing the date of Feb. 8th, 1913, which turns out to be the day prior to the filing of the application for this German patent. There is nothing upon the blue print particularly associating it with the patent in question. Fig. 6 shows a tuned antenna circuit and also the grid circuit tuned by a variable condenser, and it is

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because of this latter fact that the blue print is said to be of importance. Von Bronk's evidence as to the blue print and to the arrangement of circuits there disclosed is indefinite, altogether negative, and consequently of no assistance upon the point. Schloemilch seems to have done all the work on this patent and it is not strange that the evidence of Von Bronk in determining what Schloemilch had in mind in respect of tuned circuits, is of little or no assistance here. Schloemilch states that he communicated his experiments in connection with this patent to one Graf Arco, but there is no precise evidence as to when this was done, and Graf Arco was not called to corroborate this testimony. Fig. 1 of the drawings accompanying German patent No 293,300 indicate circuits giving both radio and audio amplification, although the claims of the patent only refer to audio amplification. Radio amplification having already been claimed in German patent No. 271,059, the principal patent as it is called in the later German patent, it is clear why radio amplification was not claimed in the latter. When they both are put together in the American patent, they do bear a physical resemblance to Alexanderson, except that the grid circuit of the first tube is not tuned. Now Schloemilch states that he always tuned the grid circuit, and that it was obvious and known to the art at the time. In the evidence, there is only his own testimony in support of this contention. Let me now refer to the documentary evidence, the patents and drawings, in order to see whether evidence may be found there in support of this contention. In fig. 3 of the United States patent, the secondary of the transformer *k* forming part of the intermediate circuit *n*, which the specifications say it is preferable to have tuned, is shown with a variable condenser across its terminals for tuning purposes. In fig. 6 of the blue print the secondary of the antenna transformer is tuned by means of a variable condenser. The condenser was therefore known to Schloemilch, and he makes use of it for some purpose or other. Now it is suggested that certain arrows shown in certain of the drawings indicate their use for tuning purposes. The arrows shown in the connection of the secondary of the transformer *k* to the detector 1, in fig. 3 of the United States patent, and in fig. 1 of the later German patent, is obviously a tap to control the voltage communicated to the detecting device, there being a variable condenser shown in that circuit, and both would not be required for tuning purposes. It is reasonable to assume that the arrows shown on the secondary of the transformer *g* of the United States patent and of the German patent, fulfil the same function, that of providing means for the control of the voltage impressed on the grid element *e* of the vacuum tube *a*, and has nothing to do with tuning. Von Bronk said timidly that the variable coil, controlled by the tap, was used for coupling or tuning purposes, but he did not profess to know what Schloemilch had in mind in regard to it. Schloemilch referring to the circuit *k.n.* stated, as I understand it, that the arrow indicated a coupling between the detector and the secondary of the transformer *k.* to obtain loose coupling and thus prevent excessive damping of the circuit, which would happen he said if the detector were coupled parallel to the entire circuit. Nowhere in the specifications of any of these three mentioned patents, is there to be found any suggestion that the arrows are used to indicate tuning ; in fact, their presence or purpose in the drawings is not explained in the specifications. It appears therefore that the inventors when wishing to show a tuned circuit, show a variable condenser, and when they wished to show a voltage tap they do so by means of an arrow. It would seem quite clear therefore that the arrows shown in the drawings of the German patent No. 293,300, in fig. 3 of the United States patent, and in fig. 6 of the blue print, were intended to indicate voltage taps and not means of tuning. If it had been intended to tune the secondary circuit of the transformer *g* for the purposes of selectivity, I have no doubt they would have shown a variable condenser connected across it.

In respect of the evidence taken in Germany I am of the opinion that it does not support the contention that tuning of the first grid circuit of patent No. 293,300 was contemplated. If the blue print were clearly shown to be made contemporaneous with the drawings of the patent under discussion, intended to be associated with them, and evidence of the inventors' minds, omission to show tuning of the grid circuit of the first tube in the drawings of the patents themselves as already mentioned, seems to me convincing evidence that the inventors had not in mind selectivity at all, at least not of the order Alexanderson had in mind, and to attain which the tuning of every circuit was essential. It is as reasonable to say that the condenser shown on the blue print across the secondary of the transformer in the antenna circuit, was discarded in the patent drawings because found unnecessary or useless in the arrangement or apparatus the inventors had in mind, as it is to say, that being shown on the blue print it should be assumed to be shown in the patent drawings. I am not impressed with the evidence of Schloemilch that it was omitted in order to simplify the patent drawings, if selectivity was what the inventors had in mind. I am satisfied that Schloemilch and Von Bronk were after signal strength rather than improved selectivity, and accordingly they accentuated amplification, while on the other hand Alexanderson, seeking selectivity of a high order accentuated tuning and the one way relay, the vacuum tube. Evidence given for the purpose of supporting the plea of anticipation of Alexanderson by Schloemilch and Von Bronk should not receive much encouragement as against the former patent which has gone into general and successful use, unless it be of a much more convincing character than that presently under review. I do not think it can be successfully or reasonably urged, that Schloemilch and Von Bronk describe Alexanderson, or that the former gave the latter to the public. There can be no doubt that early in 1913, Alexanderson had a clear scientific comprehension of the theory of selectivity in geometrical progression, and he then had in his mind means or instrumentalities by which he believed he could accomplish that end, and all this he communicated to others. In time and in collaboration with others, he worked out a practical realization of his theoretical selectivity in geometrical ratio, in the production of a commercial apparatus, capable of producing the results he earlier predicted. There can be no doubt as to what he had hoped to accomplish, the means he had in mind for doing so, and that he did accomplish that end and by that means. If Schloemilch and Von Bronk had in mind an improved selectivity and the means of bringing this about, then their specifications did not communicate the idea, nor did they describe, as they were bound to do, how their arrangement could be operated for purposes of selectivity if that was in their minds, and their evidence

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singularly lacks clarity in showing all this. Upon that evidence and the patents themselves, I feel warranted in resolving every doubt against Schloemilch and Von Bronk. I am of the opinion that the Schloemilch and Von Bronk patents are not anticipations of Alexanderson. That being so it is unnecessary for me to deal with the precise dates of invention alleged by the respective inventors of these several patents, that is Alexanderson, and the three mentioned pâtents of Schloemilch and Von Bronk.

It now remains to consider whether Alexanderson possesses subject matter, and falls within any of the principles I have elsewhere mentioned as requisite to sustain a patent. I do not understand it to be seriously contested that Alexanderson does not possess utility, and it has not at least in my opinion been successfully attacked upon that ground. Alexanderson obtained radio frequency selectivity in geometric progression without loss of signal strength, and this was at that time I think a very substantial improvement over anything previously known. The system or arrangement of circuits there disclosed is capable of selecting a weak signal of one frequency from stronger signals of another frequency and at the same time amplify it. Upon the lowest ground it is a new and useful improvement over what was previously known to the art, and that is sufficient to support a patent. He disclosed a workable arrangement, and as Dr. Langmuir, one of the plaintiff's witnesses put it, Alexanderson's proposal gave a new order of magnitude of selectivity, while in the prior art there was selectivity only in the sense that simple tuned circuits were used. I cannot escape the force of the fact that the general acceptance and adoption in the art of the Alexanderson system is evidence confirmatory of novelty and utility although of course it is not conclusive. Prof. Hazeltine in his evidence discussing one of the Schloemilch and Von Bronk patents, stated that it was "the first embodiment of the arrangement which Alexanderson believed that he invented," and he stated, that was a radio frequency system having a vacuum tube type of relay, and attaining geometric selectivity by having a tuned input circuit and a tuned output circuit. If then Schloemilch and Von Bronk had not a tuned input circuit, and I think it had not, then Alexanderson, on Prof. Hazeltine's own statement was the first inventor of the system which Prof. Hazeltine described. Further Prof. Hazeltine admitted that the conditions of selectivity disclosed in the Alexanderson patent could be obtained by the circuit there shown, but he said, if one in addition wanted amplification and the full advantage of amplification, one would need to add something to it. It is not I think necessary to enquire what was in the mind of Prof. Hazeltine as the requirement for a more complete amplification, for if the result claimed by Alexanderson may be obtained, then the utility claimed is admitted, and there is only the claim of novelty to be established, to sustain the patent. Having reached the conclusion that this result was not disclosed in or recoverable from any of the prior art, then I am of the opinion that Alexanderson was the first to achieve the result he claims, and that his patent possesses novelty. Alexanderson claimed radio frequency selectivity in geometric progression without loss of signal strength, and he also states in his specifications that if it was desired to magnify the oscillations the battery might be so chosen so as to obtain greater amplification. It is admitted that the prior art

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disclosed devices by which selectivity in radio frequency could be obtained, and other devices disclosed methods for obtaining amplification of radio frequency currents, but it is claimed and correctly I think, that Alexanderson was the first to assemble the instrumentalities which furnished means for providing both selectivity, which progressively improved from circuit to circuit, and amplification at radio frequencies, in one device. As I pointed out in my discussion of the defence of anticipation, one may have a succession of tuned circuits inductively coupled giving progressive selectivity, but at such a loss of signal strength that it would not be practical for the purpose of obtaining the maximum of selectivity. It is quite true that up to a certain stage, the reduction of the signal strength may be prevented from falling below the range where it may be elevated by audio frequency amplification. It is claimed by the plaintiff however, and so far as I can see with force, that when one must stop short in obtaining selectivity to avoid loss of signal strength, the selectivity obtained is of a different magnitude from that obtainable from the Alexanderson arrangement where one may proceed from two tuned circuits to any number, without loss of signal strength, because the vacuum tube relay coupling the circuits together at each stage, brings the signal up to its original strength. It is particularly the vacuum tube element which prevents the signal strength from falling and which also admits of amplification, and it is this which gives what is described as geometric selectivity by Alexanderson, and it is the feature distinguishing it from the prior art. The patent in suit is a particular arrangement of essential parts of a radio reception apparatus, which arrangement has advantage, and has been found practicable when carried out in the manner described in the specifications. Alexanderson may represent but a short forward step in the progressive radio art, but I conclude that what he did do was new and useful, produced new and important results and consequences, and required that substantial degree of inventive power, and skill in the art, which warrants me in holding that his patent possesses subject matter and should be upheld.

Granting that Alexanderson has subject matter and has not been anticipated, there is no doubt I think but that the defendant has infringed Alexanderson. In fact I do not understand that to have been seriously contested.

There now remains but one more point for consideration. Alexanderson applied for a patent in the United States on October 29th, 1913, and a patent issued to him in that country, on February 22nd, 1916. According to the provision of the Patent Act, Alexanderson therefore should have filed his application for patent in Canada on or before February 22nd, 1917, or within one year after the date of the issue of his patent in the United States. It was not, however, until September 17th, 1920, that he filed his application in Canada, and a patent issued on January 15th of the following year. It is therefore contended by the defendant, that the patent issued to Alexanderson in Canada is void by reason of the fact that the application for the same was not made in Canada on or before February 22nd, 1917, as required by the Patent Act. If this view is well founded, it is of course the end of Alexanderson so far as his Canadian patent is concerned. The plaintiff on the other hand contends that the application filed in Canada was within the period fixed by Chapter 44, sec. 7 (1) of the Statutes of Canada, 1921, post war legislation regarding patents, and which enacts as follows :

> 7 (1) A patent shall not be refused on an application filed between the first day of August, 1914, and the expiration of a period of six months from the coming into force of this Act, nor shall a patent granted on such application be held invalid by reason of the invention having been patented in any other country or in any other of His Majesty's Dominions or Possessions or described in any printed publication or because it was in public use or on sale prior to the filing of the application, unless such patent or publication or such public use or sale was issued or made prior to the first day of August, 1913.

The same point, in analogous circumstances, was raised in a cause tried before me between the parties herein, immediately following the trial of the cause now under consideration, and I there held, that the application and the patent issued thereon was valid by virtue of the provisions of the statute to which I have just referred. I do not think therefore that it is necessary for me to engage in a prolonged discussion of this point in this cause, and I would refer to my reasons for judgment given in the other cause mentioned, and which is numbered 7244 in the records of this Court. I am therefore of the opinion that this defence fails, and that the plaintiff's application for patent and the patent granted thereon, is in this respect, within the provisions of the statute.

The plaintiff succeeds therefore in its action for infringement, and is entitled to the usual relief, and also its costs of action. The counterclaim is dismissed.

No. 29. Agreement as to Contents of Case for Supreme Court, 3rd Aug., 1927.

No. 29.

Agreement as to Contents of Case for Supreme Court.

The parties agree that the Case on Appeal to the Supreme Court of Canada shall consist of the following :

1. Pleadings ;
2. Evidence at trial ;
3. Formal Judgment ;
4. Reasons for Judgment ;
5. Exhibits produced and filed at the trial ;
6. Order dispensing with printing of Exhibits ;
7. Agreement as to Case.

DATED at Ottawa this 3rd day of August, A.D. 1927.

(Sgd.) RUSSEL S. SMART,
Solicitor for Plaintiff ;

HENDERSON & HERRIDGE,
Solicitors for Defendant.

No. 30.

In the Exchequer Court of Canada.

No. 30.

Registrar's Certificate, 3rd August, 1927

(not printed).

No. 31.

In the Supreme Court of Canada.

No. 31. Statement of Case.

Statement of Case.

IN THE SUPREME COURT OF CANADA

BETWEEN :

FADA RADIO LIMITED,

Defendant (*Appellant*),

and

CANADIAN GENERAL ELECTRIC COMPANY, LIMITED,

Plaintiff (*Respondent*).

This is an appeal from the judgment of the Honourable the President of the Exchequer Court of Canada, rendered on the 14th day of April, A.D. 1927, declaring that Canadian Letters Patent No. 208,583 was valid as between the parties hereto, and was infringed as to the claims thereof numbered 1, 2, 3 and 7.

From this judgment the Appellant now appeals to the Supreme Court of Canada.

In the Supreme Court of Canada.

No. 32.
Order dispensing with printing of certain exhibits, 1st Sept., 1927.

No. 32.

Order dispensing with printing of certain exhibits.

IN THE SUPREME COURT OF CANADA

BETWEEN :

FADA RADIO LIMITED

Defendant (Appellant),

and

CANADIAN GENERAL ELECTRIC COMPANY,

Plaintiff (Respondent).

Before the Registrar in Chambers

Thursday, the 1st day of September, A.D. 1927

UPON application of the Appellant and upon hearing read the consent of the Respondent, filed, and upon counsel for the Appellant undertaking to file ten bound copies of all Exhibits, excepting Exhibit 5, 12 and Z12 (of which separate copies will be filed) and upon hearing what was further alleged by counsel for the Appellant.

IT IS ORDERED that the printing of all Exhibits be dispensed with as part of the printed case upon complying with the undertaking above.

IT IS FURTHER ORDERED that the printing of the German Transcript of the evidence of Otto Vonbronck and Wilhelm Schloemilch taken on commission be dispensed with.

IT IS FURTHER ORDERED that the printing of the foreign Transcript in Exhibit G be dispensed with.

E. R. CAMERON,
Registrar.

No. 33.
Factum of Fada Radio Limited.

No. 33.

Factum of Fada Radio Limited.

PART I.

STATEMENT OF FACTS.

This is an appeal from the judgment of the Honourable the President of the Exchequer Court of Canada, rendered on the 14th of April, 1927, holding Claims 1, 2, 3 and 7 of Canadian Letters Patent Number 208,583, issued to The Canadian General Electric Company, Limited as assignee of Ernst F. W. Alexanderson, valid and infringed.

The Alexanderson Patent has to do with the radio art and claims an improvement in securing selectivity : i.e., in selecting the signals sent from one radio station from those sent from other radio stations.

The defences are: that there was no invention in view of what was known to those skilled in the radio art; that the work of Schloemilch and Von Bronk anticipated the invention, if there was any invention; that the patent was void from its inception because the oath in support of the patent was untrue in a material respect; that, because of a previous grant to the same company on the same disclosure, there was no consideration given to the public in exchange for the patent granted.

Radio Principles.

The principles of radio may now be briefly discussed. Radio is an electrical process and depends on *alternating currents* as distinguished from *direct currents*. The direct current of electricity is one such as comes from an ordinary battery: it flows always in one direction. An alternating current is one which, beginning at zero, increases in one direction up to a maximum, and then decreases to zero, and immediately increases to a second maximum but in the reverse direction, returning again to zero as before. The number of times the current goes through this complete process in one second is called the *frequency*. The violin string, which moves first one way, then the other, has a frequency of vibration.

The radio sending station sends out alternating current waves from its antenna or aerial system. The frequency of the alternating waves sent by one station may be different from those sent by another. The frequency is usually so high that it is beyond the range of the human ear. If a violin string vibrated so rapidly, the sound produced would not be audible. Such waves are generally referred to as radio frequency waves.

These alternating current waves spread out through space with the speed of light. Their presence may be detected by a *receiving apparatus*. The receiving apparatus consists of an antenna or elevated conductor which intercepts the alternating waves and conducts the alternating currents to a *detector*. The detector reduces the frequency of the alternating currents to a point where they are audible to the human ear. This wave is made to carry a message by *modulation*, i.e., impressing on it the interruptions of dots and dashes, as in ordinary telegraphy, or impressing on it the vibrations of the voice as in ordinary telephony. In a simple system such as this, the signals from all stations would be heard at the same time.

The receiving set must be able to *select* one wave from another. Since the different waves have different frequencies of vibration, this *selection* is accomplished by tuning. The receiving set is tuned to the same frequency as the wave which it is desired to receive, and then this wave has more effect on the receiving set than any other. The more nearly perfectly the undesired waves are excluded, the better is the selectivity of the receiving set.

This *tuning* is accomplished electrically by the combination of *inductance* and *capacity*. A wire possesses the electrical properties of self-inductance and capacity. If the wire is coiled, it has more inductance than if it is straight; therefore coils are used. A coil also has more capacity than a straight wire, but the inductance is usually greater than the self-capacity. Because it has a certain inductance and a certain capacity, the coil is said to be tuned to a certain frequency, i.e., an alternating current of that certain frequency producing much greater effect than one of any other frequency. A change in either inductance or capacity or both, will change the tuning and therefore change the frequency to which the coil best responds. This change may be accomplished by using a greater or a smaller number of turns of the coil, in which case both inductance and capacity are changed. By so changing the number of turns in the coil, it is possible to vary its fundamental frequency, and in this way cause it to respond more readily to the wave from one particular station among all the stations that may be transmitting at the time. In other words, selection is accomplished.

It is sometimes more convenient to change the tuning by varying only the capacity, so a *condenser* (concentrated capacity) is connected to the coil and this condenser is varied instead of the coil. This condenser usually consists of two sets of metal plates with air space between them. The larger the plate surfaces opposite one another, the greater the capacity. The capacity, and therefore the tuning, is varied by moving one set of plates with respect to the other.

When the undesired signals are very strong, the desired signal may still be too weak for practical use even when selected in the manner described above. The strong undesired signal seems to drown the desired one unless the receiving set is highly selective.

Only a minute portion of the energy sent out from a station is intercepted by any one receiving aerial. The current, in flowing through the coils and condensers of the receiving set, loses some of its energy. Therefore it is important that the receiving set be very sensitive, so that even very weak signals can be made audible; i.e., the set must be *sensitive* as well as selective.

Sensitivity is secured by making the receiving set efficient (i.e., making the loss small) and by employing *amplification.* Amplification consists in adding new energy. It is accomplished by means of a *relay*. The relay is a device controlled by the received energy, and which releases energy from a new source in such a way that the new energy varies or alternates in the same way as the received energy which controls the relay. These relays may be used before detection or after detection. In other words, they may be used to amplify the radio frequency wave before it is reduced to an audible frequency, or the amplification may be carried out after the wave has been reduced to an audible frequency. It is customary to employ them in both ways in the same receiver.

The *vacuum tube* is the special relay usually employed in radio to secure amplification. It may also be used as a detector. Whether its action is as a relay or as a detector is determined by the circuits with which it is used. It is used as a relay in preference to any other relay because it works well at any frequency and releases from its output circuit energy at the same frequency or frequencies as are found in the energy delivered to its input circuit from the receiving aerial. It does not distinguish between frequencies; it is not selective. The vacuum tube looks like an electric light bulb. It has a lighted *filament*, a *grid* and a *plate*. The filament is also termed the cathode; it is like the filament in an electric light and serves as the source of a cloud of electrons. The plate is of metal and is called the anode. A battery or other source of electrical pressure is connected between the anode and cathode. This battery, together with the anode and cathode, and any included coil, constitute the *anode* or *plate circuit.* The electrons, because of this pressure, flow in a stream across the vacuum between the anode and the cathode. This electron stream is really an electrical current which flows not only through the vacuum tube but through the wires of the plate circuit as well. This current is very sensitive and can be easily controlled. It is controlled by means of the grid. The grid is a wire coil or screen usually placed between anode (plate) and cathode (filament) and in the electron stream. The grid acts as a sensitive valve controlling the output of the relay, and for this reason the vacuum tube is sometimes referred to as a valve. The grid and filament are usually connected together outside the tube and this circuit is called the grid circuit. A very small electrical charge on the grid produces a large charge in the electron stream, and this change is proportional to the value of the charge on the grid. Therefore the received wave, which only possesses a small amount of energy, is impressed on the grid. This causes large variations in the electron stream, the variations being exactly similar in form and frequency to those of the incoming wave. Thus the signal has been amplified, i.e., its energy has been increased, and it can then be passed on from the plate circuit of the vacuum tube to another part of the receiving circuit.

If this amplified energy of the plate circuit of the vacuum tube, or any portion of it, gets back to the grid (either through the tube or around the tube through the grid and plate circuits), the grid will be affected by it and will cause still more energy to be released. Some of this energy will again come back to the grid circuit and cause still more energy to be released. This action goes on and on until the vacuum tube *oscillates* by itself and is no longer controlled by the incoming signal.

The patent in suit brings up the problem of securing both selectivity and sensitivity. It proposes selection in one tuned circuit and then transfer by means of a relay to another circuit where further selection occurs.

PART II.

The appellant submits that the learned trial Judge erred in the following respects :—

(1) In holding that, in view of what was known in the radio art prior to Alexanderson, it required an exercise of the inventive faculties to devise the system of the patent.

(2) In holding that Schloemilch and Von Bronk did not do the same thing as Alexanderson.

(3) In not holding that Schloemilch and Von Bronk did this prior to Alexanderson.

(4) In holding that a prior use or a prior publication is not an anticipation of the patent unless in the prior use or prior publication there was a statement that the same results would be obtained as those aimed at by the patent.

(5) In holding that the Alexanderson system had come into general

and successful use, and on that basis, resolving every doubt in favour of the patent.

(6) In not holding that the patent is void in law because a material allegation of the supporting oath was untrue.

(7) In not holding that the patent is void in law because, a patent having issued to the same Company (Canadian General Electric Company, Limited) on the same disclosure, no consideration to the public was given in exchange for the monopoly granted.

PART III.

ARGUMENT.

The Radio Art Prior to Alexanderson.

The appellant wishes at the outset to emphasize the fact that Alexanderson, although familiar with the use of electricity in engineering, knew practically nothing of radio reception until the late autumn of 1912. He then did not know of the work of the leaders in the art, to which reference will now be made.

Naturally, one of the first problems met by the early workers in radio, was that of selectivity. And it was solved by them by the use of tuning. One of the earliest solutions was in 1899 when Marconi tuned the antenna of the receiving set and secured *simple selectivity*, i.e., the selectivity of a single tuned circuit. He tuned by means of an adjustable coil (Marconi Patent Number 627,650, Ex. G-1, page 1, lines 31-37): "It is desirable that the induction-coil should be in tune or syntony with the electrical oscillation transmitted, the most appropriate number of turns and most appropriate thickness of wire varying with the length of wave of the oscillations transmitted."

Fig. 1.

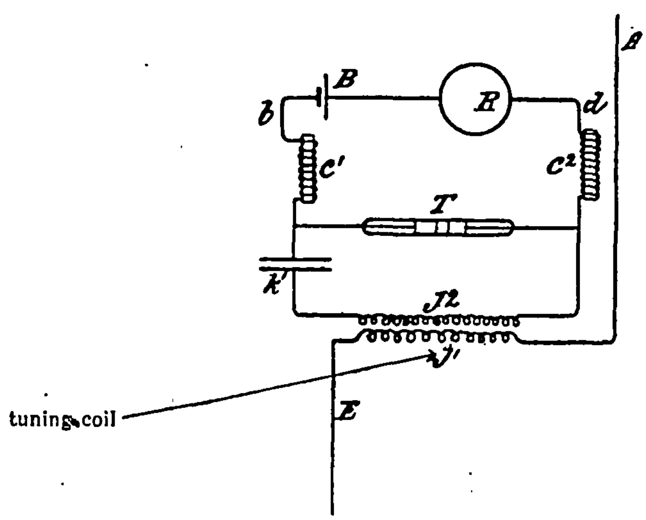


Figure 1, Patent Number 627,650—Simple Selectivity.

Shortly afterward (in 1900) Marconi added another tuned circuit and secured "*geometric selectivity,*" i.e., the selectivity of a series of tuned circuits (cascaded circuits). The incoming waves were successively filtered, first in one circuit and then in the next, to select the desired wave. The result was not merely twice as good (as one might at first expect), but was many times as good; and was in fact the product of the selection obtained in each of the individual circuits. Therefore the name "geometric selectivity" has been given to it, probably by Alexanderson. If in the first tuned circuit the undesired signals were filtered out so that they had only one-fifth their normal effect, and then their resultant waves impressed on the next tuned circuit which filtered them in the same proportion, then the undesired wave would be only one-fifth of one-fifth, or one-twenty-fifth, of its normal strength. If the first tuned circuit merely reduced the undesired waves to one-half and the second tuned circuit reduced the undesired waves that reached it to one-sixth then the total reduction would be one-sixth of one-half, or one-twelfth; but it would of course still be geometric selectivity. In this system, Marconi used adjustable coils for tuning (Marconi Patent Number 763,772, Ex. G-2, page 2, lines 86-98): "An inductance coil *g'* of variable inductance is interposed in the primary circuit of the transformer, being preferably located between the cylinder *f'* and the coil *j'*, and the inductance of the said coil may be adjusted in accordance with the methods described by me in my Letters Patent of the United States Number 676,332, to harmonize with the inductance of coil *g* at the transmitting station, Figure 1 of the accompanying drawings, or with that of the coil or coils at one or more of the transmitting stations included in the communicating system."

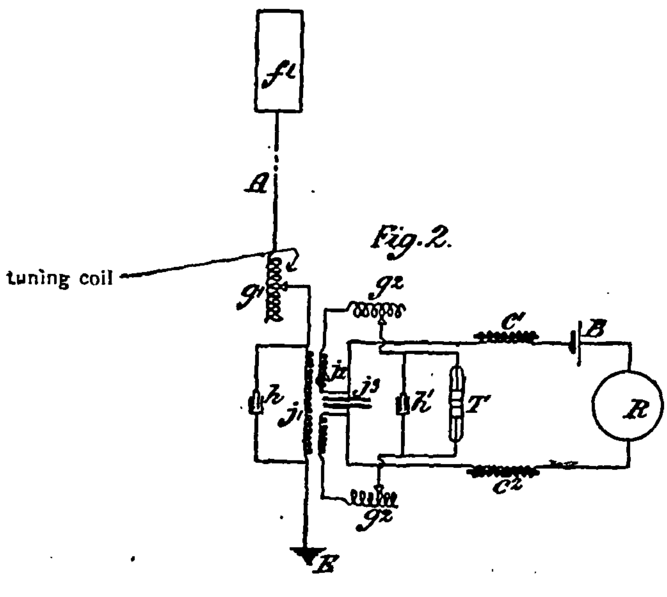
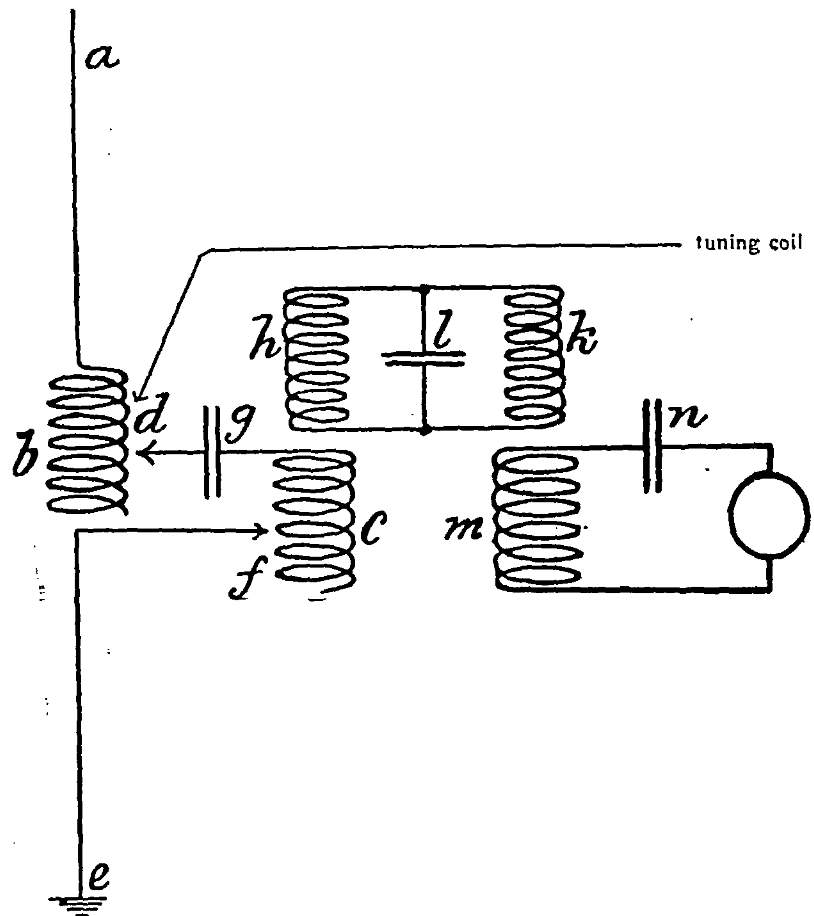


Figure 2—Patent No. 763,772—Geometric Selectivity.

In 1907, a third tuned circuit was added by the Marconi Company which gave still greater geometric selectivity. In this system also, tuning was secured by adjustable coils as well as coils and condensers (Marconi Patent Number 12,960, Ex. G-3, page 1, lines 33-36): "The natural frequency of these circuits may be adjusted by varying their capacities or inductances or both, but the method we find most convenient for adjusting the frequencies of the intermediate circuit and the receiver circuit is to vary their capacities only while keeping their inductances constant."



British Patent Number 12,960—Geometric Selectivity.

All of these were practical, much-used devices. The device of 1907 was called the "Franklin Multiple Tuner," and was used by one of the appellant's witnesses, John R. Binns, on board the SS. "Republic." The story of this, the first time radio was responsible for saving life in a disaster at sea, was modestly told by Binns at the trial. He used this type of tuner for some time and was able to select weak distant signals from strong local ones.

The respondent very properly points out, and the appellant has from the beginning conceded the fact, that this system without relays is not so sensitive (i.e., has not as much sensitivity) as it would have if relays were used. The reason for this is that the signal, in passing through each tuned circuit, and more particularly in passing from one tuned circuit to the other, loses energy. Therefore the signal becomes weaker, i.e., the sensitivity becomes less. Practically speaking, the loss of signal strength was not a serious matter since the remaining desired signal, while weak, had been made many times stronger than the remaining undesired signal, by the process of selection. The Marconi multiple tuner was therefore a good receiver and was much used in commercial radio communication. As was demonstrated at the trial, the *selectivity* of this tuner without relays was exactly the same as one with relays (Exs. I and J).

The use of a relay as an electrical device to secure amplification, is very old, and was known as far back as the year 1886 (United States Patent Number 340,707, Ex. G-7). In 1910, or earlier, Schloemilch and Lieb applied the relay to a radio receiving circuit to secure sensitivity. The circuits were cascaded, i.e., there were a series of circuits with relays between each two circuits. This device went into wide use and is referred to in several publications in existence.

Ex. G-10—The Electrician, London, November 24, 1911, pp. 249-252;
Ex. G-11—Manual of Wireless Telegraphy for the Use of Naval Electricians, S. S. Robison, published by United States Naval Institute, p. 136;
Ex. G-12—Jahrbuch der Drahtlosen Telegraphie und Telephonie, 1912, pp. 309-310;
Ex. G-23—Electrical Review, Vol. 46, No. 12, 1925, pp. 502-507.

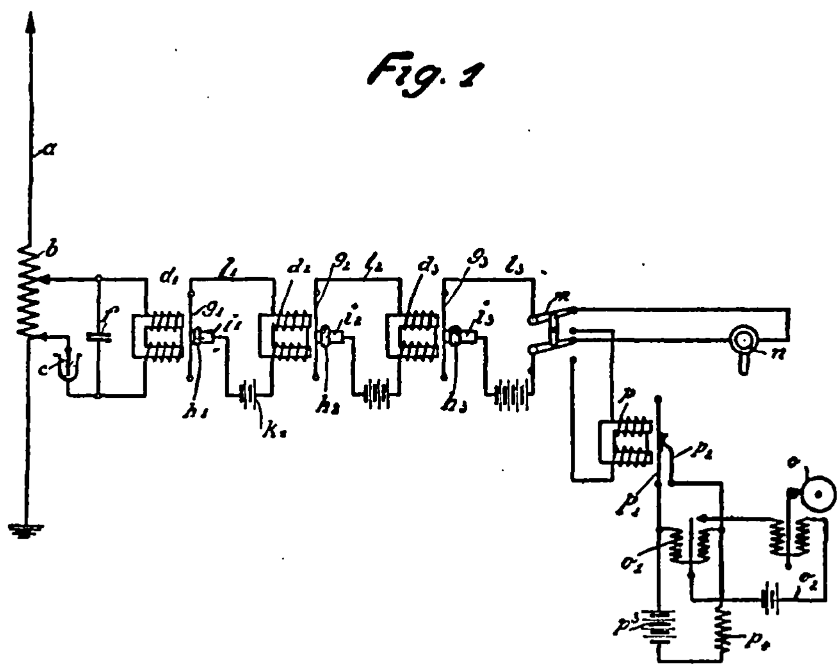
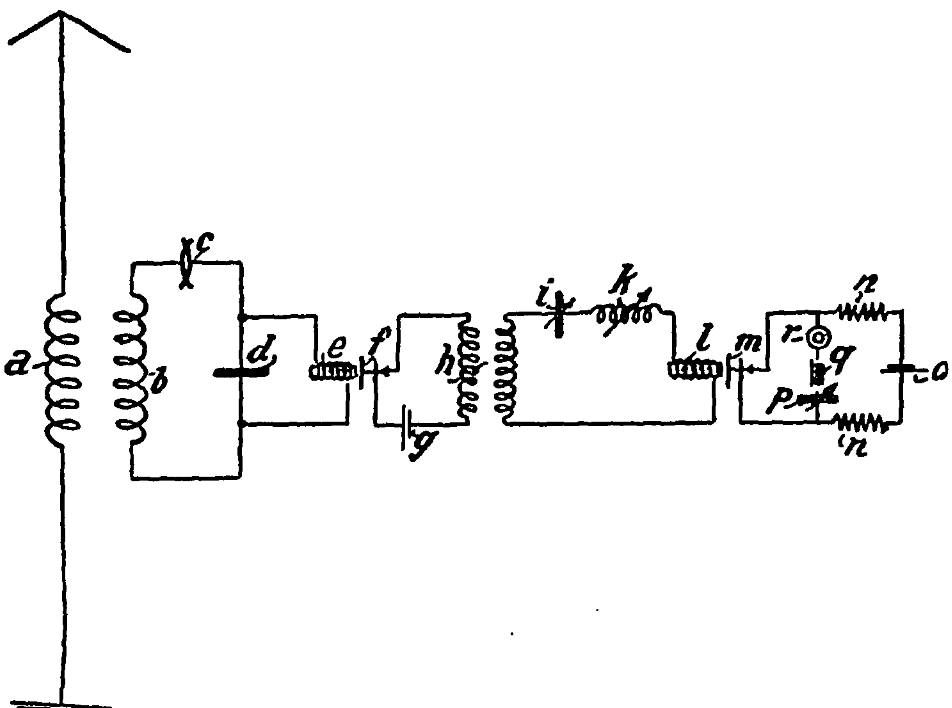


Figure 1—United States Patent Number 1,163,180—British Patent Number 10,210—Geometric Selectivity and Sensitivity by Relays.

In " The Electrician " of November, 1911, it is described (p. 249): " *Sound Intensifier*—An instrument that has been developed by the Telefunken Company, and which adds greatly to the simplicity of receiving with a singing spark, is the sound intensifier. It consists practically of three tuned microphones and it acts in two ways: firstly, by selecting the sound to which it is tuned and, secondly, by magnifying this sound "; (p. 250): " The sensitiveness is high. . . ."

In 1912, the Lorenz Company devised a system in which selectivity was secured in the long and well-known manner by inductance and capacity, and sensitivity was secured by the relay. The Lorenz patent Number 258,478 (Ex. G-14) issued on April 3, 1913. The system was of course invented prior to October, 1912, when the application was filed. (Alexander Milburn Co. v. Davis-Bournonville Co., 270 U.S. 390, 70 L. Ed. 651). This was before Alexanderson came into the field.



German Patent Number 258,478—Geometric Selectivity, and Sensitivity by Relays.

In the patent the same advantages for this system, over a system not having relays, were stressed, as were stressed in the Alexanderson patent. The description says: " In order to increase the precision of the resonance, tuning might be performed several times, thus, several circuits could be provided that are coupled with one another, and each one of which is tuned to the sound frequency. The coupling could be effected by transformers. But this arrangement shows the following drawback. If really an increase of the precision of tuning is to be attained, a very loose coupling must be selected in order to avoid mutual interference of the circuits; but if the coupling is loose, such a noticeable weakening of the sound will take place that the advantage of a more precise resonance obtained will be made ineffective.

"According to the present invention this drawback is fully removed by using for the coupling of the circuits an acoustic instead of an electric one, and by making the circuits among each other fully independent of each other."

Claim 1 of this Lorenz patent reads:

1. "A process and arrangement for the selective sound reception in the wireless news transmission, characterized by the feature that several circuits are used which are tuned to sound frequency, but are electrically independent among one another, the oscillations being transmitted from one circuit to the next circuit by connecting a telephone with a microphone" [a relay].

There is no difference between these selective and sensitive systems of Schloemilch and Leib and the Lorenz Company, and Alexanderson's system, as claimed in Claims 1 and 2 of the patent in suit, which read:

"1. The method of selecting sustained oscillations of a given frequency from disturbing oscillations differing therefrom in frequency which consists in impressing all the oscillations upon a circuit resonant to the frequency of the oscillations to be selected, thereby reducing the effect of disturbing oscillations in accordance with the degree of tuning of the resonant circuit, and controlling by means of the oscillations in said circuit an independent source of energy to initiate oscillations in step therewith, and impressing the second set of oscillations upon a second circuit resonant to the frequency of the oscillations to be selected.

"2. A receiving apparatus for electromagnetic waves comprising a plurality of tuned circuits largely opaque to oscillations of other than a given frequency, means linking adjoining circuits said means comprising a source of energy and an energy transmitting apparatus varying in conductivity with impressed oscillations for initiating oscillations in step with received oscillations and means associated with the last circuit of the series for detecting the oscillations."

The remaining claims in suit (3 and 7) refer to the same system as do claims 1 and 2, but specify a particular kind of relay: the vacuum tube relay.

The practical limitation on these devices of Schloemilch and Lieb and the Lorenz Company was that they could not work at very high frequency, although they could work at the lower radio frequencies. This was because the relay was a mechanical device and could not be made to vibrate at excessively high frequencies. The vacuum tube, which was invented by DeForest, was a relay which did not have any frequency limitation, and it was used for that purpose by Schloemilch and Von Bronk, to whose work reference will now be made.

It is submitted, therefore, that the learned trial Judge erred in holding that Alexanderson's system amounts to invention over this prior art.

The Work of Schloemilch and Von Bronk.

The evidence of Schloemilch and his co-worker, Von Bronk, was taken in Germany by commission.

Schloemilch had been connected with the Wireless Telegraph Company (Telefunken Company) of Germany for over twenty years, as an expert on receiving sets. Von Bronk was head of the Patent Department of that Company and had a laboratory at his home, where he experimented with and developed receiving apparatus. Schloemilch is the same person who developed with Lieb, the receiving system to which reference has already been made, in which a series of mechanical relays between circuits were used to improve the sensitivity.

As early as January, 1913—the significance of this date will be discussed hereafter—Schloemilch and Von Bronk developed for commercial purposes a selective receiving system in which vacuum tube relays were used to improve the sensitivity. Von Bronk had previously (in 1911) developed a system in which a vacuum tube relay was used to improve the sensitivity. This system had a selective circuit before but not after, the relay. It was used in 1913 by Schloemilch and Von Bronk with selectivity both before and after the relay. In a modification of this system, one vacuum tube relay served to amplify before detection and then amplify after detection, but although this formed a basis for their patent claims (Patent Number 293,300: Ex. G-19) further consideration of it is unnecessary, as the appellant is concerned with what they did, and not what they patented.

The system which was built and used by Schloemilch and Von Bronk is illustrated by a drawing made on February 8, 1913, which is here reproduced.

Fig 6

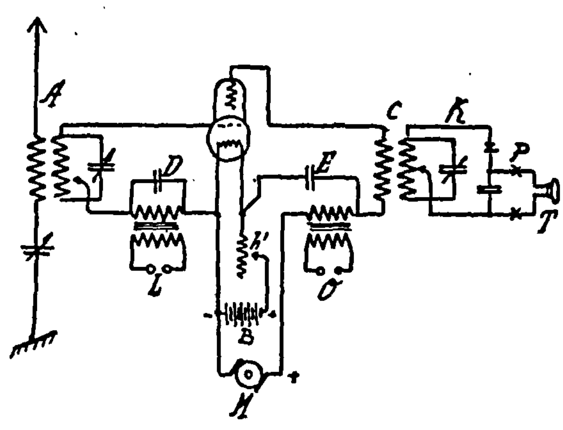


Figure 6, Ex. P—Schloemilch and Von Bronk Work.

Geometric selectivity, i.e., selectivity by two or more tuned circuits, was used, and in addition, vacuum tube relays were employed in order to take advantage of the gain in sensitivity. The method used for obtaining selectivity was well-known at that time, but not under the name of geometric selectivity.

Schloemilch said:

"The antenna circuit, the grid circuit and the anode circuit were always tuned to the same wave."

To secure geometric selectivity it would not have been necessary to tune the grid circuit, because the antenna circuit and the plate circuit, being tuned to the same frequency, would give geometric selectivity. However, the grid circuit *was* tuned. In this drawing it is shown tuned by means of a condenser. In the patent (Number 293,300, Ex. G-19) it was shown tuned by means of a coil. The sensitivity was secured by placing the vacuum tube relay between two tuned circuits to amplify the signal and thus make up for whatever loss there was in signal strength due to passage from one circuit to another.

In short, it was exactly the system of the Alexanderson patent. The two are compared by the illustration of Exhibit M.

The respondent attempts to escape this manifest similarity in several ways; first, it says the Schloemilch and Von Bronk work was not early enough; secondly, it says that the testimony of Schloemilch is not corroborated; thirdly, it says that selectivity was not patented by Schloemilch and Von Bronk: that only sensitivity was patented; fourthly, it says that the patent to Schloemilch and Von Bronk on this work says nothing about selectivity, and does not show a system which had selectivity.

The first contention involves a consideration of Alexanderson's date. This is dealt with in the later discussion (p. 25) of Alexanderson's work. Suffice it to say for the moment, that the earliest date which might be even argued for Alexanderson, is February 4, 1913, the date of a letter written before he had built or attempted to build, his system. This was at a time when he did not believe it would work (Exhibit Z-4).

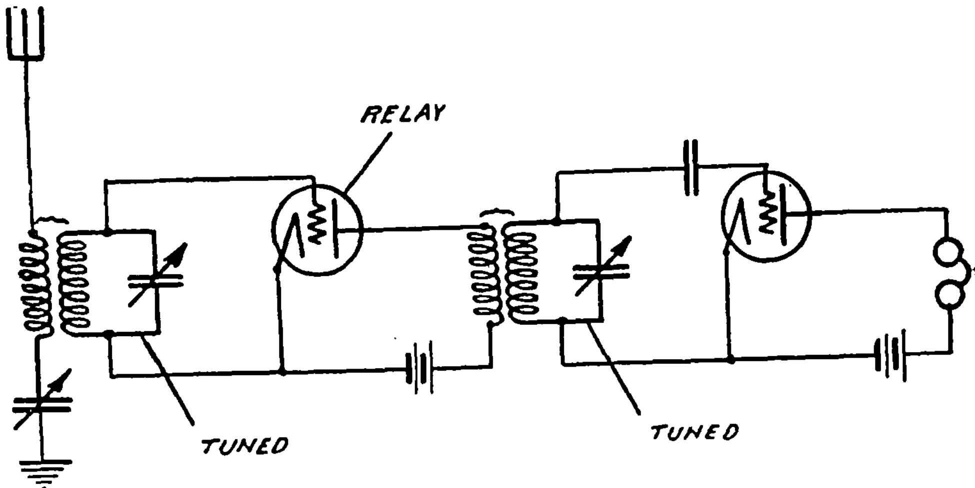
Schloemilch and Von Bronk's date is established with an exactness and accuracy of statement characteristic of trained and honest minds. The patent drawing, which has been reproduced above, was made on February 8, 1913. This was made from actual apparatus which had been used. The procedure was to make the experiments first, then draw the connection diagrams, and then prepare formal drawings for the patent application. The application for patent based on another drawing was made February 9, 1913. It took ten to fourteen days to prepare the application after the experiments were made. Photographs of actual production apparatus intended for commercial use were made on April 30, 1913.

Schloemilch says:

"Q. And can you tell me approximately the date at what time the apparatus was first built after the system shown in the photograph?—A. That I cannot state definitely, because the apparatus were first set up by me in the laboratory, then the drawings thereof were made and then only constructed in the shop, therefore the laboratory type of the apparatus dates much farther back than the date shown on the photograph. It may be a matter of several months. . . . .

"Q. At about what time did you disclose your experiments with reference to the filing day of the application, namely, February 8, 1913?—

SCHLOEMILCH AND VON BRONK



ALEXANDERSON

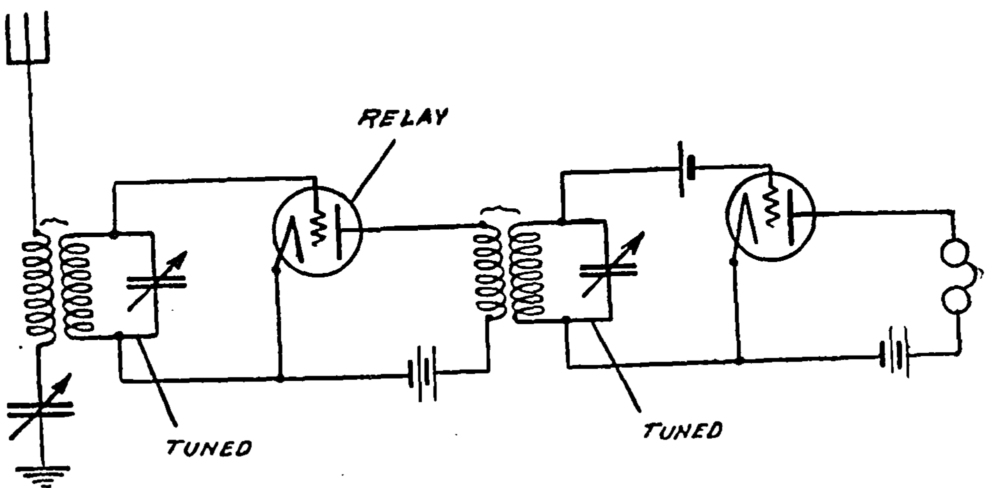


Exhibit M—Comparison of Alexanderson, and Schloemilch and Von Bronk.

A. Quite accurate details it is impossible to state. As a rule improvements in connection diagrams were communicated at once to Mr. Von Bronk, provided they were of value from the patent point of view. To give an accurate date is impossible for me.

" Q. Can you tell me whether you knew of the existence of any drawings, sketches, blue prints, photographs and the like by means of which you could refresh your recollection with particular reference to the preceding question ?—A. As documentary proof, that about that time, that is to say, ten years ago, I did work with these connection diagrams, the photograph No. 233 of April 30, 1913, serves, likewise also a blue print must be available somewhere here.

" Q. Can you tell me whether or not the blue print I now hand you is the blue print in your mind ?—A. Yes.

" Q. And if you will look at the date in the lower left-hand corner and say whether or not that refreshes your recollection as to the date when you told Mr. Von Bronk of the results of your experiments ?—A. I have myself carried out and tested out the connection diagrams shown here on the blue print L. 898. As to when I spoke to Mr. Von Bronk concerning them, I am unable to state. The date shown in the left-hand corner is going back thirteen years and it is impossible to recollect verbal communications made so many years ago."

Von Bronk says :

" Q. And at about what date did you so operate the arrangement you have referred to by reference to Fig. 1 of patent No. 293,300 ?—A. I cannot say that today any more, at any rate prior to the date of the patent application.

" Q. And would you say that that would have occurred prior to the day of the beginning of the preparation of the application ?—A. First the experiments were made and then on the basis of the experiments the connection diagrams were drawn.

" Q. And can you say definitely whether or not the experiments which preceded the drawing of the diagrams were before the time at which the preparation of the application was begun ?—A. Yes, I can say that definitely. I can say that definitely because it requires a certain time before the drawings I ordered have been prepared.

" Q. Have you any papers with you that might refresh your recollection and if so, please produce them ?—A. Yes, I have a drawing of February 8, 1913. In this drawing is shown the connection diagram which was used together and before. In Fig. 6 of the drawing which I have here is shown a connection diagram which has been used by Schloemilch before the filing of patent No. 293,300 in the laboratory of the Telefunken Company. Of course, we have discussed together the connection diagrams. . . . .

" Q. I notice that in the diagram by means of which you have refreshed your recollection, No. L. 898, and which is dated February 8, 1913, that Fig. 6 thereof shows a variable condenser across the secondary coil which is not shown in Fig. 1 of patent No. 293,300 in addition to a variable tap on the coil. Will you please explain why the condenser was omitted from Fig. 1 of patent No. 293,300 ?—A. At that time it was assumed that the tuning by the variable coil was sufficient. In the first patent drawing the variable condenser was included, but with a view to simplify the drawing it was cancelled. I have the original of the first drawing in my file. It can be seen that the condenser which was originally shown, has been eliminated.

" Q. Can you tell me the date of the sketch that you are now referring to ?—A. Unfortunately not, I can only say that the preparation of the application papers requires 10-14 days."

This definitely places the completion of the experiments at January 27 to 31, 1913, and disposes of the first of the plaintiff's contentions.

As to the second : that the evidence of Schloemilch is not corroborated : the appellant submits that there is no rule of law which requires corroboration of evidence of the truth of which the court is satisfied. And there is nothing in the case on appeal on which any doubt as to the accuracy of the evidence of Schloemilch and Von Bronk can be based.

The evidence is, however, as a matter of fact, fully corroborated. Schloemilch and Von Bronk, testifying separately, corroborate each other. With no interest in the controversy, it is manifest that they made not the slightest effort to recall dim pictures of past events. Their evidence is unusually accurate in that they were careful not to testify to anything they do not know. As illustrative of their attitude, the following statement of Von Bronk may be quoted :

" Q. May I take it with respect to your answers on direct examination as to the apparatus shown in Fig. 1, that you have no direct knowledge of the operation itself but only by what Mr. Schloemilch said ?—A. The question must be replied to in this way : Schloemilch has made the experiments and has incidentally shown to me the connections and let me hear the effects. The purposes he had in mind with the various tuning circuits I am not in a position to state today. If I were asked in the quality of an expert, I would, of course, say that the tuning means served for the tuning."

They are corroborated by the patent application contemporaneously filed. They are corroborated by sketches, drawings and photographs. For example, Schloemilch says :

" A. I have developed the apparatus in the laboratory and for all I know Graf Arco has also seen it. Moreover the apparatus is shown on the photograph.

" Q. When you say ' photograph ' have you particular reference to something which you have recently seen ?—A. No, that is a photograph, which must also be available here, of 1913.

" Q. Do you refer to the photographs Nos. 233 and 2995 dated April 30, 1913 ?—A. Yes, the two apparatus have been developed by me and tested by me. . . . .

" Q. Can you tell me whether you knew of the existence of any drawings, sketches, blue prints, photographs and the like by means of which you could refresh your recollection with particular reference to the preceding question ?—A. As documentary proof, that about that time, that is to say, ten years ago, I did work with these connection diagrams the photograph No. 233, of April 30, 1913, serves likewise also a blue print must be available somewhere here.

" Q. Can you tell me whether or not the blue print I now hand you is the blue print in your mind ?—A. Yes."

To the third of the respondent's contentions, namely that Schloemilch and Von Bronk did not patent geometric selectivity, the appellant gives unqualified assent. Schloemilch and Von Bronk did not patent geometric selectivity, and did not claim to patent geometric selectivity for the simple and sufficient reason that geometric selectivity was old in the art as they who were practical men with experience in that art, very well knew. All that was to be known about geometric selectivity was known long before, and in the year 1913 there remained nothing new about geometric selectivity which could conceivably form subject matter for new patent.

"Q. Can you tell me whether the antenna circuit of your commercial apparatus was tuned and which system corresponded to the system *f* including the coil *g* and the variable condenser shown in Fig. 1 of the patent? —A. Yes, without a tuned antenna one would have had a bad reception.

"Q. You may answer with respect to what you did?—A. The tuning of the grid circuits in cathode tubes was something obvious, because we were used to that already from earlier receiving even with the detector. I have always tuned the grid circuit in cathode tubes."

What Schloemilch and Von Bronk did was to patent a system for increasing sensitivity by vacuum tube amplifiers. They were improving the sensitivity of a geometrically selective system. That is all that can be claimed for Alexanderson, and it has been most insistently claimed by the respondent in order to distinguish this patent from the geometrically selective system of Marconi's multiple tuner.

The respondent misses the point. The work of Schloemilch and Von Bronk is the anticipation, and their patent is corroborative evidence of their work. The appellant does not claim that the Schloemilch and Von Bronk *patent* was a patent for the invention of geometric selectivity. Obviously it could not have been, as geometric selectivity was known in the prior art. Schloemilch and Von Bronk devised a means for making a geometrically selective system more sensitive, just as Alexanderson claims to have done. It is abundantly clear from the exhibits and evidence, that the work of Schloemilch and Von Bronk was with geometrically selective systems.

The fourth contention of the respondent: that the patent does not teach geometric selectivity: is again illustrative of the fact that the respondent has missed the point. It is not necessary that the patent teach geometric selectivity; that was well known. The patent does teach the only step which was necessary—sensitivity by vacuum tube relays. The patent being for those skilled in the art, it would seem unnecessary to say that a coil possessed the characteristics of inductance and capacity, or that a coil might be used for tuning. A patent is not supposed to be a compendium of the prior art for a *novice*. As Von Bronk said:

"If I were asked in the quality of an expert, I would, of course, say that the tuning means served for the tuning."

The patent does, in fact, show a geometrically selective system in which vacuum tubes were used to improve sensitivity. The apparatus which was constructed and which formed the basis of the patent was a geometrically selective system in which vacuum tubes were used to increase sensitiv ty. Any worker in the art who built and used the apparatus described in the patent would get that result: geometric selectivity and sensitivity. It

In the Supreme Court of Canada.

No. 33. Factum of Fada Radio Limited —*continued.*

is not necessary that he know that Alexanderson chose to call it *geometric selectivity*, nor is it necessary that an infringer call his system geometric selectivity in order to infringe. The useful arts are advanced by physical accomplishment, not by phrase-making.

What did Schloemilch and Von Bronk do? Schloemilch was the expert on receiving sets and Von Bronk was the head of the Patent Department of the Telefunken Company. Schloemilch built a receiving set. Its arrangement, parts and connections are illustrated in Fig. 6 of Exhibit P reproduced above.—It is common ground that the vacuum tube shown, gave sensitivity by repeating the signal from one circuit to another. The only question which can remain is as to whether geometric selectivity was secured by tuning two circuits to the wave desired: one circuit before the vacuum tube amplifier, and one circuit after. It must be admitted, and it is not understood that the respondent denies, that there is a tuned circuit before the vacuum tube relay and a tuned circuit after it. Were they tuned to the same frequency? The only reasonable interpretation of the diagram is that they were.

But that there may be no shadow of doubt on this point the evidence of Schloemilch is again referred to:

" Q. Can you tell me whether the antenna circuit of your commercial apparatus was tuned and which system corresponded to the system *f* including the coil *g* and variable condenser shown in Fig. 1 of the patent?—A. Yes, without a tuned antenna one would have had a bad reception. . . .

" Q. Now, again referring to Fig. 1 of patent No. 293,300, can you tell me whether or not the circuit referred to in the patent by the letter *n* was tuned?—A. Yes, the circuit was tuned because it would have been impossible to otherwise obtain the optimum of efficiency of the tube. . . .

" Q. But you have not told me, when you were for example receiving a 500 mtrs. wave signal, by what frequency the antenna system, the tuned grid system and the tuned circuit *n* were tuned?—A. The antenna circuit, the grid circuit and the anode circuit were always tuned to the same wave.

" Q. And the antenna circuit too?—A Also, I said already, that the antenna circuit, the grid circuit and the circuit *n* were tuned to the same wave length."

Von Bronk said, referring to his early work (which resulted in German Patent Number 271,059):

" Q. Will you tell me in the apparatus that you used whether or not the antenna was tuned and if so, will you indicate by reference to the drawings of patent No. 293,300 what variable electrical unit was controlled to produce the desired tuning?—A. A rotary condenser and exchangeable coils together.

" Q. In the apparatus that you used, will you tell me whether or not the circuit connected to the cathode and grid was tuned?—A. No, at that time it was not tuned. Only later on, until Schloemilch came into the matter.

" Q. And when you say, when Schloemilch came into the matter, do you refer to the joint work with him as described in Patent No. 293,300?—A. Yes.

" Q. Will you kindly indicate by reference to the drawings of patent No. 293,300 the tuning you referred to?—A. The tuning of the grid circuit.

"Q. And was that tuning independent of the tuning of the antenna system?—A. It could be modified independently of the tuning of the antenna circuit.

"Q. Did you operate an apparatus in which you used the circuit arrangement you have just referred to and in which the antenna tuning was independent of the grid circuit tuning?—A. Yes, it could be modified independently of the tuning of the antenna circuit."

and on cross-examination:

"Q. Referring to Fig. 1 of patent No. 293,300, what was the purpose of the variable connection to the coil of the transformer *K*?—A. Concerning this point only Mr. Schloemilch can give information on his account because, as already stated, the practical work was done by Mr. Schloemilch. To me Mr. Schloemilch stated that both the variable coils and the variable condensers were used for tuning purposes. I can only add that these two variable elements fulfil two purposes, that is to say, for coupling purposes and for tuning purposes. But this, of course, is only an expert's opinion.

"Q. May I take it with respect to your answers on direct examination as to the apparatus shown in Fig. 1 that you have no direct knowledge of the operation itself but only by what Mr. Schloemilch said?—A. The question must be replied to in this way: Schloemilch has made the experiments and has incidently shown to me the connections and let me hear the effects. The purposes he had in mind with the various tuning circuits I am not in a position to state to-day. If I were asked, in the quality of an expert, I would, of course, say that the tuning means served for the tuning."

The respondent triumphantly points to the fact that in the patent drawing there is no *condenser* in the grid circuit; and therefore there is no tuning. This view it is submitted, is basically incorrect, but it was accepted by the learned trial Judge and so expressed by him:

"A tuned circuit consists of a coil of wire across the ends of which is connected a condenser, consisting of two sets of plates."

The fact is that a condenser is not necessary for tuning, and there is not a word in the record to show that it is. Only a fundamental misconception of fact could lead one to say that a condenser is essential. As has been explained and conceded, tuning may be accomplished by a coil alone, because it has both inductance and capacity. The appellant's position is, that it is a necessary inference from the showing of the variable coil in the patent, without anything additional, that the grid circuit is tuned. But the appellant is not dependent upon this inference, for two reasons: first, the work of Schloemilch and Von Bronk clearly shows that in the actual apparatus the grid circuit was tuned and that the variable coil was intended to show tuning; and secondly, even if they were not, there would still be geometric selectivity, because the antenna circuit ahead of the tube and the circuit after the tube, were admittedly tuned to the same frequency. And the tuning of these two circuits gave geometric selectivity.

But the respondent says that the omission of the condenser shows a certain state of mind; on the theory that anyone who omitted a condenser could not have been thinking of selectivity. On this point the following evidence of Von Bronk is submitted:

In the Supreme Court of Canada.

No. 33. Factum of Fada Radio Limited *—continued.*

" Q. I notice that in the diagram by means of which you have refreshed your recollection, No. L. 898, and which is dated February 8, 1913, that Fig. 6 thereof shows a variable condenser across the secondary coil which is not shown in Fig. 1 of patent No. 293,300 in addition to a variable tap on the coil. Will you please explain why the condenser was omitted from Fig. 1 of patent No. 293,300 ?—A. At that time it was assumed that the tuning by the variable coil was sufficient. In the first patent drawing the variable condenser was included, but with a view to simplify the drawing it was cancelled. I have the original of the first drawing in my file. It can be seen that the condenser which was originally shown, has been eliminated."

The respondent's point, however, loses all pertinency when it is realized that whether the added capacity of the condenser were there or not, there would still be tuning because of the capacity and inductance inherent in the coil. A coil cannot be built without these two properties.

The respondent has taken an unnatural and strained position with respect to what the patent shows, and then maintains that this unnatural position is the one which would be taken by anyone ; and, neglecting the evidence of Schloemilch and Von Bronk, maintains that the patent shows what Schloemilch and Von Bronk *did.*

The respondent's argument proceeds thus : an arrow pointed at the representation of a coil indicates that that is a variable coil ; this is a recognized symbol to show tuning or coupling ; the best adjustment for coupling is not the best for tuning, therefore it is not known whether this arrow in the grid circuit of Figure 1 of the patent means tuning or coupling ; another arrow is found in the plate circuit pointing at a coil which has a tuning condenser across it ; the patent *says* this arrow means coupling, therefore it is concluded that the other arrow means coupling.

The fallacy in this attempted syllogism is that the coil in the grid circuit has not a condenser across it, whereas that in the plate circuit has. In other words, where the arrow is said to indicate coupling and not tuning, a condenser is added for tuning, whereas where it does not say that the arrow is for coupling, there is no condenser, thus permitting the conclusion that the arrow indicates tuning.

So, by a more complete understanding, the respondent's argument is wholly destroyed.

The chief witness for the appellant, Professor Hazeltine, describes very fully the technical aspects of the Schloemilch and Von Bronk patent and supports in every particular the foregoing argument on the question of tuning. The appellant submits with great confidence that in Professor Hazeltine's evidence will be found complete justification for the claim, that the position of the respondent is basically unsound, and that its contentions are definitely refuted by the disclosures of the prior art, and by the patent and evidence of Schloemilch and Von Bronk.

It is the appellant's respectful submission that the learned trial Judge was not in a position to appreciate and classify the work done by Schloemilch because he had been led into a grave misconception of the fundamental principles of radio reception. It would appear from his above quoted opinion that the learned trial Judge did not understand that a coil has capacity as well as inductance, and that it is not necessary to add a condenser in order to get capacity.

It is further submitted with respect, that the learned trial Judge failed to grasp the fact of controlling importance, that when Schloemilch and Von Bronk were working in 1913, the problem of selectivity had been solved. The remaining problem was that of sensitivity. This they solved by using vacuum tube relays, to make up for the loss of signal, or to amplify the signal. It is noteworthy that their patent claims only sensitivity or amplification; there was nothing new about selectivity which could be claimed.

The Work of Alexanderson.

Alexanderson was not familiar with the prior art of selective receiving systems. He expressed his theory of "geometric selectivity" in a letter of February 4, 1913 (Exhibit Z-3). On March 8, 1913, he thought the vacuum tube would not work (Exhibit Z-4). In May, 1913, he learned how it worked. On May 17, 1913, his system was operated experimentally in the laboratory. In 1920 there was a limited commercial use.

Prior to the autumn of 1913, Alexanderson, who was in the employ of the General Electric Company, knew little or nothing of radio receiving and had not worked at the problem, although he had been working extensively with electrical machinery and had done some work with radio transmitters (sending apparatus). He did not know of the selective system of the Marconi Multiple Tuner; he did not know of the Schloemilch and Lieb selective system with cascaded relays; he did not know of the selective system of the Lorenz Company with tuned circuits and relays; and, of course, he did not know of the work of Schloemilch and Von Bronk.

Having regard to his almost absolute ignorance of the prior art, it is not difficult to understand why Alexanderson thought he had made an invention.

This ignorance of the prior art is also apparent from the patent specification of the patent itself (Exhibit 1):

"One of the chief problems encountered in radio-telegraphy is the suppression of waves of various wave lengths interfering with the waves constituting the signal to be received. The method now commonly employed for this purpose consists in using an electric circuit in which a train of waves of a given frequency acts cumulatively so that each successive impulse adds its energy to the previous impulse, while disturbing impulses of a different frequency have little effect. However, to screen out strong disturbing impulses effectively when weak signals are to be received requires an accuracy of adjustment which imposes a definite limit upon the possible selectivity of the system.

"In accordance with the present invention, selective tuning is secured by the use of a plurality of resonant circuits arranged in cascade in such a manner that the selectivity of the system increases in geometric ratio with the number of circuits employed."

As appears from the work of Marconi and others which has been discussed, this of course was not so, and led to the erroneous belief that Alexanderson had invented "geometric selectivity."

In the latter part of 1912, Alexanderson visited the laboratory of

John Hays Hammond, Jr., who had ordered two sending alternators which Alexanderson had developed. While Alexanderson was there, Hammond discussed with him problems of selectivity and showed him a vacuum tube (audion). Alexanderson says that it then "occurred to me that the DeForest audion might be improved and used as a high frequency relay which I had been looking for for some time. When I thus realized that it would be possible to relay high frequency currents I conceived the idea of using a high frequency relay in a high selectivity system which I called tuning in geometric progression, which is the subject matter of this patent."

He wished to investigate the system further, and asked one of his assistants to make some calculations. These are in evidence as the Vivian Notes (Exhibit Z-1). This was followed by more calculations by Mr. Thomas (Exhibit Z-2). These notes are not dated but formed the basis of a report (Exhibit Z-5) dated February 27, 1913.

The Vivian Notes say:

"There is a relay now built which will give the above results," but it is not identified nor is there any instructions how to connect it in the circuit. In the Vivian Notes there is a circuit diagram which could have shown how, if they had had any idea as to a practical, useful system. Alexanderson says a vacuum tube might be connected in there if a proper transformer were added; Hazeltine says the circuit is not adapted for a vacuum tube at all. The Thomas notes add nothing. Hazeltine testified that the notes did not show how to construct the system and that they affirmatively showed that whoever made the notes did not know how a vacuum tube operated. Alexanderson thought it was a high current device, whereas it was in fact, a high voltage device.

Langmuir said: "The actual method of operation of the audion was not generally understood in 1913."

The best discussion of what Alexanderson supposed to be his invention is in his letter of February 4, 1913* (Exhibit Z-3), which Alexanderson sent to several other people in The General Electric Company as a matter of record.

This letter also shows that Alexanderson did not understand the vacuum tube relay and thought that it was a high current device instead of a high voltage device. The letter does not include a sketch showing how to connect up the system or build it.

Also on February 4, 1913, Alexanderson wrote another letter (Exhibit Z-8) saying he would like to *try* the vacuum tube as a relay.

On March 8, 1913,† Alexanderson wrote another letter (Exhibit Z-4) to one of his co-workers saying that the vacuum tube was too sluggish to work and would have to be developed and improved so that it would. He says that it "is expected" that this difficulty will be overcome. Langmuir overcame it later, and at the trial said that he knew all the time that he could do it. Perhaps it would be more accurate to have said that he *thought* he could do it.

* Prior to this Schloemilch and Von Bronk had actually built the same system.

† Prior to this Schloemilch and Von Bronk had not only built the system but had made application for patent.

On May 9, 1913, there is an entry in Dr. Langmuir's notebook (Exhibit Z-10):

"This morning Alexanderson and Day came over. I showed them several audions that White has made up. It was arranged that White and I should test them out with Alexanderson's alternator to see if there is any sluggishness, i.e., whether they will give a frequency in the relayed current equal to that in the primary and of *increased* energy."

So far Alexanderson had merely an idea which he thought might be realized if certain difficulties were overcome.

The first appreciation by Alexanderson that the vacuum tube was a high voltage device is shown by his letter of May 14, 1913 (Exhibit Z-6).* In this letter he says:

"With the present development of the incandescent vacuum relay, as perfected by Dr. Langmuir, it seems that its capacity for handling considerable amounts of energy can be easier increased by employing high voltages than by attempting to handle large currents."

And in this letter, when he understands how the vacuum tube works, Alexanderson includes a sketch of connections. (These show it in a sending system, not the kind of system of the patent, nor in a receiving system at all).

On May 18, 1913, in Langmuir's laboratory notebook (Exhibit Z-10) recording a series of experiments, there is an entry which says:

"Tuning by geometrical progression according to Alexanderson's system is an accomplished fact."

The conclusion from these facts may be drawn without argument. Although Alexanderson's *theory* of geometric selectivity may have been nicely expressed in his letter of February 4, 1913, he did not carry it into practice or tell anyone enough to enable it to be put into practice at that time. Misunderstanding the nature of the vacuum tube, he doubtless did not know how to carry out his theory; at any rate, he believed it could not be done until someone developed a tube which would work. He could not have made the invention until he knew how to make it work and thought it would work. This was not until May 14, 1913. The first time it did work was May 17, 1913; and this, it is submitted, is the date of Alexanderson's invention.

Queen v. Laforce (1894) 4 Ex. C.R. 14, at pp. 44, 61;
Wright and Corson v. Brake Service (1926) S.C.R. 434;
Permutit vs. Borrowman (1924) Ex. C.R. 6; (1925) S.C.R. 685; 43 R.P.C. 357;
Gerrard v. Cary (1926) Ex. C.R. 170.

The trial Judge attributed to Alexanderson's system great commercial success, and on that basis favoured the Patent. The Patent cannot summon to its support that great commercial success which turns the scale when there is grave doubt as to sufficiency of invention.

After the laboratory work recorded in the notebook, some further experiments were made at Mr. Kinney's house in the Summer of 1913,

* Prior to this date Schloemilch and Von Bronk had photographed apparatus produced for commercial use.

and again in January, 1914. Nothing was done after that until a receiving set alleged to embody the system, was used by the Radio Corporation of America in 1920. A glance at the circuit of that receiving set (Exhibit Z-17) will show how different it was from what Alexanderson shows in his Patent.

The value of this invention apparently did not greatly impress the Canadian General Electric Company Limited, the assignee of Alexanderson of the Canadian rights under the Patent, since it was not until September 17, 1920, that any step was taken to file a Canadian application for Patent.

Although many tried to use the Alexanderson system, they were unsuccessful. The difficulty was that the vacuum tube was not a one-way device, as Alexanderson thought it was. Whenever it was attempted to obtain the advantages of sensitivity (i.e., amplification) this defect caused the set to feed back and oscillate by itself so it was no longer controlled by the receiving signal. It was not until the invention of the "neutralization system" by Hazeltine, which the Defendant uses, that Alexanderson's system came into general use. That was in 1923. Alexanderson said that most of the sets now on the market enjoy some form of neutralization. He also said his system *could* be built and used without neutralization. This merely means that it was operative. It certainly was not a commercial success as he left it. He did not revolutionize the art.

In passing on the corresponding United States Patent to Alexanderson, Judge Thacher* said, in *Radio Corporation of America v. E. D. Edmonds*, (not reported):

> "Modern methods for the control of regeneration and the undesirable self-oscillations which result therefrom were unknown in the art when the Patent in suit issued. These improved methods have perfected Alexanderson's system of geometric tuning, and are employed by the Defendant. Their importation cannot be denied (see *Hazeltine Corporation v. Electric Service Eng. Corp'n*, 18 Fed. 2d 662), and it may be conceded that the Alexanderson device, without some such improvement, would be of little commercial use to-day."

The Appellant now summarizes its submissions on the question of Alexanderson's contribution to the art:

1. The only contribution which Alexanderson made to the art of selectivity was in calling the old system of Marconi by a new name.
2. Alexanderson contributed nothing to the art of securing sensitivity in the selective system. Schloemilch first used the relay as a sensitivity device. All that Alexanderson did was to use as a relay device the vacuum tube which admittedly was in some respects an improvement over the relays used by Schloemilch and Leib and Lorenz.
3. Alexanderson was not early enough to claim invention of the vacuum tube relay in a selective system for improving sensitivity. Schloemilch and Von Bronk built such a system in January, 1913, made drawings and filed application for Patent before February 9, 1913, and had commercial apparatus in April, 1913. Alexanderson, on March 8, 1913, thought the

* Judge Thacher did not have before him any evidence of the Schloemilch and Von Bronk work, and under the United States law could not have considered it.

vacuum tube relay would not work without development; and not until May 14, 1913, did he understand how it worked; and not until May 18, 1913, was the system made to work.

The Appellant submits that the case is clear and free from doubt. If there were doubt, it would be resolved against the Patent because of its comparative failure in the commercial field, and in favour of the Appellant which operates under the system which has been proved to be a great commercial success.

The disclosure having been given to the public in a previous Patent, there was no consideration for the Patent grant.

The fundamental basis of the Patent system is the benefit to the public which flows from the publication of something which is new and useful. The public welfare is promoted by placing in the hands of the public a new and useful process, system or device. Since it is a natural right to use whatever is attained by honest means, it was in times past (and still in some cases, is) also natural that inventors should keep their invention secret. When they were made public, and in exchange for making them public, a limited monopoly was given, called a Patent grant.

Terrell on Patents, 7th Ed. pp. 6-7. *Fisher & Smart on Patents* 1914, p.36.
But to grant a monopoly in exchange for what is already known would secure no benefit to the public. There would be no consideration for the Grant. Therefore, the disclosure must be new. The Statutes of different countries have from time to time defined what tests may be used to determine what is new. For example, prior use, prior publication, prior patenting, etc., negative novelty (Patent Act 1906, Sections 7 and 8). Where the disclosure in exchange for which a Patent is sought, has already been used to secure another Patent, that disclosure is not consideration for another and second Patent.

In re Leonard Ex. C.R. Vol. 14, p. 351.

Otherwise one could, by repeatedly disclosing the same thing, secure a series of patent grants and indefinitely extend the period of monopoly. In this way, the law which proposed that a monopoly should be strictly limited in point of time, would be defeated. Thus the later Patent, if accidentally granted, is void for lack of consideration.

What may seem to be an exception to this basic rule occurs when the Patents are granted to different persons. But in that case, when the first inventor is ascertained, the same controlling principle is manifested by the invalidating of the Patent covering the later invention.

It may be suggested that another exception is in the case where two Patents are granted to the same person in exchange for the same disclosure, but where both applications were made within the time allowed by the law and before the first Patent had been granted. Then the question is whether the monopolies are co-extensive. If they are, only the earlier one granted, is valid.

Miller v. Eagle Mfg. Co., 151, U.S. 186.

" The result of the foregoing and other authorities is that no Patent can issue for an invention actually covered by a former Patent, especially to the same Patentee, although the terms of the claims may differ; that the second Patent, although containing a broader claim, more generical in its character than the specific claims contained in the prior Patent, is also void; but that where the second Patent covers matter described in the prior patent essentially distinct and separable from the invention covered thereby, and claims made thereunder, its validity may be sustained.

" In the last class of cases, it must distinctly appear that the invention covered by the latter Patent was a separate invention, distinctly different and independent from that covered by the first Patent. It must consist in something more than a mere distinction of the breadth or scope of the claims of each Patent. If the case comes within the first or second of the above classes, the second Patent is absolutely void."

Manifestly, where the second application is not made until after the first monopoly has been granted on the same disclosure, a valid Patent cannot be granted. This is the case here.

Canadian Patent Number 196,390 was issued to the Canadian General Electric Company Limited and that monopoly was granted in exchange for the same knowledge as was offered by the Canadian General Electric Company Limited, in exchange for the monopoly of the patent in suit. The Canadian General Electric Company Limited, having given this knowledge to the public in exchange for a monopoly, there was no consideration for the second grant.

The Patent in suit is identified as the Alexanderson Patent, because it is based on the work of Alexanderson. The Patent Number 196,390 is identified as the Langmuir Patent because it is based on the work of Langmuir, another employee of the General Electric Company (U.S.A.). Before application was filed for either Patent, the Canadian General Electric Company, Limited, had the knowledge contained in both applications and the right to apply for Patents in exchange for this knowledge. The applications when filed were formally executed by Alexanderson and Langmuir, respectively, but were assigned at the time to the Canadian General Electric Company, Limited. The Patents issued to the Canadian General Electric Company, Limited. The case may, therefore, be considered to be one where the Patents were both to one inventor.

In re Dunbar—278 Fed. Rep. 334.

Patent Number 196,390 was applied for on October 6, 1919, and was granted on January 20, 1920. The Patent in suit was not applied for until September 17, 1920—eight months after the other had issued—although the papers were sent to the Canadian Company by the United States Company in 1913—seven years earlier (Exhibit V.).

If, then, everything claimed by the second Patent was given to the public in exchange for the first grant, there was no consideration for the second grant, and it is void; a fortiori, when the claims of the first grant include the subject matter claimed by the second, the Patent is void because then the subject matter formed the actual basis for the first grant.

FIG 2

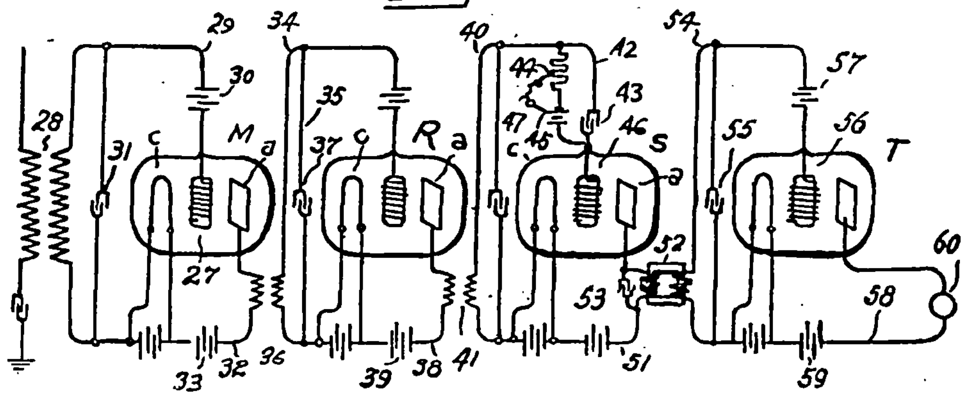


Fig. 2—Patent Number 196,390.

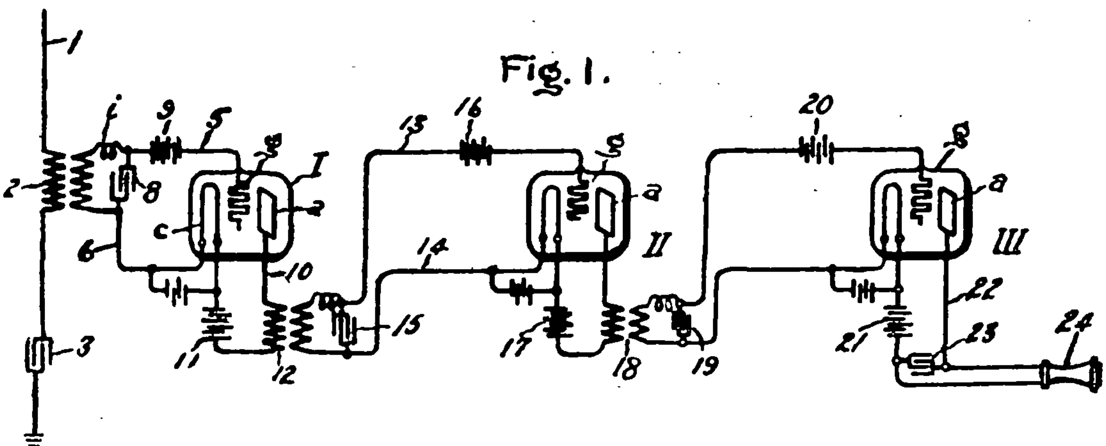


Fig. 1—Patent Number 208,583.

Both of these figures illustrate a receiving set in which the received wave is selected by a tuned circuit, repeated by a vacuum tube and again selected by a tuned circuit. This is what both Patents claim.

Both of these figures are in this respect fully described in the specifications, as functioning in exactly the same way, and for the same purpose. (Patent Number 196,390, Ex. Z.)

In Patent Number 196,390, it says:

> "It will be noted that by thus tuning successive circuits the undesired oscillations are reduced in each case in geometric proportion. This progressive tuning thus produced in my present invention is described and claimed in its broad aspect in an application filed by E. E. F. Alexanderson, Serial No. ."

Even if this be construed as an attempted reservation of right to another Patent, it is ineffective.

Miller v. Eagle, 151, U.S. 186; *Palmer v. Lozier,* 90 Fed. 732.

But no Alexanderson application had been filed. In the reissue of this

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Patent (Number 244,847, Ex. F), which has the same effect as the original (Patent Act of 1906, Sec. 24, (3)), this vague reference was made clear. The reissue says :

" This progressive tuning thus produced in our present invention is described and claimed in its broad aspect in a United States Patent of Ernst F. W. Alexanderson Number 1,173,079."

It would seem that the Canadian General Electric Company, Limited had elected to secure its monopoly in exchange for the disclosure in Patent Number 196,390.

Patent Number 196,390 makes this disclosure the basis of its claims. Claim 3 reads :

" A selective system for detecting signals consisting of groups of high frequency oscillations, comprising the combination of a plurality of circuits resonant to the frequency of the oscillations to be selected, relay means interposed between said respective circuits and operative to impress upon one circuit oscillations proportionate to oscillations in another circuit, means for integrating the high frequency oscillation in one of said circuit to produce a variable current having a frequency equal to the group frequency of the signals, a circuit connected thereto resonant to said group frequency and means for detecting current in said circuit."

This is also Claim 1 of the reissue. The reissue also contains as Claim 5:

" A system for selecting groups of high frequency oscillations from disturbing oscillations comprising the combination of a circuit resonant to the frequency of the oscillations to be selected, a second circuit resonant to the group frequency of said oscillations, relay means interposed between said circuits operative to impress upon the second circuit amplified oscillations proportionate to oscillations in the first circuit, and means for receiving and detecting a current in the second circuit."

Patent Number 196,390 (originally or as reissued), therefore, completely discloses and claims the selective system claimed by the Patent in suit.

The second Patent, (the one in suit) therefore, fails to give to the public in exchange for the Patent Grant, that consideration upon which the whole theory and principle of a Patent monopoly rests ; and the Patent is, therefore, void.

The Patent was obtained upon an allegation in the oath taken by Alexanderson, accompanying the application for the Canadian Patent, which was material and which was untrue, and which Alexanderson could not actually and honestly have believed to be true.

In his reasons for judgment, the learned trial Judge does not discuss the basis upon which his conclusion upholding the patent on this point, is reached, but apparently rests it upon the reasons given by him in another cause (*) between the parties hereto. " I do not think therefore that it is necessary for me to engage in a prolonged discussion of this point in this cause, and I would refer to my reasons for judgment given in the other

* *Canadian General Electric Co. Ltd.* v. *Fada Radio Ltd.* (*1927*), *Ex. C.R., p. 108.*

cause mentioned, and which is numbered 7244 in the records of this Court." Certain facts in that case are different from these in the one at issue, and the difference may be material. The reasons of the learned trial Judge and the position taken by the defendant in that case, suggest that it is.

On 29 October, 1913, Alexanderson filed an application in the United States Patent Office for a patent covering the invention forming the subject matter of this appeal. On 22 February, 1916, there issued upon that application, United States Letters Patent Number 1,173,079, to the inventor's assignee, The General Electric Company.

On 17 September, 1920, an application was filed in Canada for the same invention, on an oath by Alexanderson. On 15 February, 1921, there issued upon that application, Canadian Letters Patent Number 208,583, to the inventor's assignee, The Canadian General Electric Company.

In both the earlier United States and the later Canadian applications, Alexanderson signed the application for patent and took the oath accompanying it. In the oath in the Canadian application he said " that the same (invention) has not been patented to me or to others with my knowledge or consent, in any country."

In the other case No. 7244, to which the learned trial Judge refers, Langmuir took substantially the same oath in the later Canadian application, but did not sign the earlier German application, nor did he take the oath accompanying it. That was done, under the German practice, by a third party, and there is no evidence that Langmuir had anything to do with the preparation and filing of the application. Langmuir's name does not appear in the German Patent which issued upon that application.

This difference would seem to vest with peculiar significance the statement of the learned trial Judge in the other case referred to, that he had no evidence before him that Langmuir, who made oath supporting the application for Canadian Patent Number 196,390, knew of the issue of the German Patent, and that the issue of the German Patent would not in itself have been a ground for voiding the Canadian Patent in the absence of fraud " which is not suggested."

Manifestly, in the present appeal, where Alexanderson himself signed both applications and took the accompanying oaths, his ignorance of the issue of the patent upon the earlier application, cannot seriously be suggested, nor his blamelessness so readily accepted. On the contrary, it is submitted, that having himself executed the earlier application upon which the United States Patent issued, Alexanderson took the oath in the Canadian application recklessly, and without an actual and honest belief in its truth. It was untrue, and the Patent which issued upon that untruth, issued in fraud of the public of Canada and of the Canadian Patent Office. Had the oath been correct the Patent would never have issued.

Paragraph 1 of Section 8 of the Patent Act, Chapter 69 R.S.C. 1906, reads as follows:

" Any inventor who elects to obtain a Patent for his invention in a foreign country before obtaining a Patent for the same invention in Canada, may obtain a Patent in Canada, if the Patent is applied for within one year from the date of the issue of the first foreign Patent for such invention."

To ensure compliance with the provisions of this paragraph, the

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Commissioner of Patents established a certain rule requiring the inclusion in the oath, which, under Section 10, must be taken by every inventor before a Patent can be obtained, of the allegation " that the same has not been patented to me, or to others with my knowledge or consent, except in the following countries " . . . or . . . " in any country " ; as the case might be. If the Commissioner of Patents had not required such an oath, and if he had not relied upon that oath, it would have been necessary for him to determine through investigation, whether or not any foreign Patent had actually issued. The allegation in the oath was duly made by Alexanderson, who swore " and I further say that the same has not been patented to me, or to others with my knowledge or consent, in any country."

Because of the fact of the issue of United States Patent Number 1,173,079, this allegation was not true. Moreover, this allegation was essentially material, since any disclosure in the application, of the fact of the grant of the United States Patent, more than one year before the filing of the Canadian application for a Patent for the same invention, would have brought into operation the provisions of Section 8, and a Patent in Canada could not have issued. The Commissioner of Patents must and would have refused Alexanderson's application. That he did refuse many others for non-conformity with Section 8 is a matter of record in the Patent Office. Having issued only because of this untruth in the oath, the Patent was void *ab initio.*

Paragraph 1, Section 29 of the Act of 1906 (Sn. 31 of the Act of 1923) reads : " A Patent shall be void, if any material allegation in the petition or declaration of the applicant hereinbefore mentioned in respect of such Patent is untrue, or if the specifications and drawings contain more or less than is necessary for obtaining the end for which they purport to be made, when such omission or addition is wilfully made for the purpose of misleading. Provided that if it appears to the Court that such omission or addition was an involuntary error, and if it is proved that the patentee is entitled to the remainder of his patent pro tanto, the Court shall render a judgment in accordance with the facts, and shall determine as to costs, and the Patent, shall be held valid for such part of the invention described, as the Patentee is so found entitled to."

Therefore, the Appellant submits that because the declaration of the applicant for Patent Number 208,583 contained a material allegation which was untrue, the Patent was void and never had any existence in law.

If a Patent granted under such circumstances were not void, a premium would be placed upon incorrect and untrue oaths. When faced with the fact that a patent could not be secured on a true oath, an untrue oath might be executed and a patent secured, in the hope or on the chance that some later statute would prevent its being held invalid.

Sec. 29, however, by providing that the patent is void, destroys its being, so that there is nothing, real or potential, upon which a later Statute could act.

The learned trial judge held in the other case to which he refers, that Chapter 44, Section 7 (1), of the Statutes of Canada 1921, " must be read in amendment of Section 8 of the Patent Act," and that the application and the patent issued thereon, was valid by virtue of the provisions of the Statute.

The Appellant agrees that Chapter 44 operated in precisely the way suggested by the learned trial Judge. It permitted an applicant to apply for a Patent in Canada at any time up to January 4, 1922, provided there had not issued to him prior to the 1st of August, 1913, any foreign Patent. And it further said that if a Patent had issued on such an application, it was not to be held to be invalid because of the earlier foreign Patent. If, therefore, Langmuir had withheld his application until the coming into force of Chapter 44, then (assuming he had complied with the Patent Act in all other respects) a Patent would have issued to him; or had he obtained a Patent by special petition under one of the War Measures Acts, all of which required proof that the default was because of causes arising out of the War, Chapter 44 would have confirmed and validated the grant of that Patent. Indeed, it is suggested that for that purpose, Chapter 44 was enacted; to equalize all grants of patents made under any of the War Time Acts or Orders-in-Council and to remove any inequality which might theretofore have existed between citizens of this or any other country. However that may be, Chapter 44 was certainly not designed to validate or restore, and does not in terms validate or restore, a Patent obtained in violation of a statutory enactment requiring a true oath, in force at the date of the issue of the Patent. Under Sec. 29, the Patent was void *ab initio*, and so the Respondent could not well seek relief under Chapter 44, which necessarily deals only with applications for Patents, and with Patents, *in esse*.

W. D. HERRIDGE,
of Counsel for the Appellant.

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Factum of Canadian General Electric Co., Ltd.

PART I.

STATEMENT OF CASE.

1. This is an appeal from the judgment of the President of the Exchequer Court in favour of the plaintiff, the present Respondent, in an action for the infringement of a patent No. 208,583, issued on the 15th day of February, 1921, to the Respondent Company on an invention made by one E. F. W. Alexanderson and relating to a method whereby, in the reception of wireless signals, a high degree of selectivity could be secured without loss of signal strength.

2. Though exceptional individuals are capable of hearing vibrations having a somewhat lower or higher frequency, the average human ear is sensitive to vibrations of the air having a frequency of from about 25 to about 10,000 a second. Electric pulsations or vibrations having a frequency within this range can, by appropriate apparatus, be made to produce audible vibrations of equal frequency, and such vibrations are accordingly referred

to as being of " audio frequency," thus distinguishing them from vibrations of higher frequency which cannot be made directly audible and are referred to as being of " radio frequency."*

3. A wireless signal early became, and still consists, of an electric impulse alternating at a given radio frequency (that is, reversing from positive to negative at a selected rate from say 20,000, or more usually 500,000 to 1,500,000 times or more a second) as affected or modified by another electric impulse having a single frequency, or a number of varying frequencies, within the range of audibility. In the transmission of telegraph signals the modification is produced by varying or interrupting the radio frequency impulse at a pre-determined audio frequency and by then chopping up this audio frequency variance or interruption into lengths representing dots and dashes. In the transmission of speech, music, etc., the modification results from super-imposing on the radio frequency impulse a succession of varying audio frequency vibrations corresponding to those of the audible sounds.

4. The reception of a wireless signal, therefore, primarily involves (*a*) the " interception " of the radio frequency impulses and (*b*) the " detection " of the impressed audio frequency vibrations, or, in other words, their separation from the radio frequency impulse and transformation into mechanical movement or audible vibrations in the air.

But as the art developed, it became necessary that a receiving apparatus should perform two additional functions. In order to permit communication over greater distances, it became important to develop means whereby at a receiving station weak impulses received from far away might be increased in strength, that is to say, means of (*c*) " amplification." Moreover, since, as sending stations multiplied, a given intercepting device necessarily interrupted all signals passing it and hence might at any given point of time intercept many radio frequency impulses of different wave lengths (some of them perhaps of natural origin but some, more and more numerous as time went on, emitted from different sending stations), it became essential to improve the receiving apparatus so as to develop its delicacy of (*d*) " selection " *i.e.* its capacity to distinguish between, or its quality of being affected only by, impulses of a given frequency.

6. In order to understand the position of the art at the end of 1912 and beginning of 1913 when Alexanderson made his invention, it is necessary, by reference to the patents and evidence, to outline the progress of the art along these four lines, of which the two latter are for the present purpose the more important. The several successive advances made in amplifying and selecting devices are accordingly shown diagrammatically on the sheet attached to this factum, the same symbols being used in representing all the successive devices instead of the varying symbols which the inventors used from time to time in the drawings attached to their several patents. Alexanderson's invention, as will appear, consisted in a synthesis as a result of which he made an important step along the particular line of selectivity.

* The expressions " frequency " and " wave length " are merely alternative methods of statement. All electric vibrations travel at speed of light, namely 300,000 kilometers or 300,000,000 metres a second. The wave length in metres is accordingly the quotient obtained by dividing the frequency into 300,000,000 and the frequency is the quotient obtained by dividing the wave length into the same number.

(*a*) *Interception.*

7. On this point there is little to be said. It was early discovered that if at any point there was suspended an insulated wire which had its lower extremity connected to the earth, there would be reproduced in the wire an alternating electric impulse corresponding to that emitted at a sending station and of a strength proportionate to a combination of the original strength of the impulse and the distance between the points of its emission and reception. Until after the time of Alexanderson's invention this form of aerial continued to be the standard method of interception and it is still in use at the great majority of receiving stations.

(*b*) *Detection.*

8. The alternating impulse set up in an aerial is not of a character such that it can by itself be made to operate any device which will give a useful mechanical or audible signal. It can however be used to release, create or control a local direct (i.e. non-alternating) electric current. Provision of means for making it release such a direct current was Marconi's important pioneer invention. His coherer was a device in which metal filings were so acted upon by the alternating impulse interrupted by an aerial as to constitute them as efficient conductor of a direct current derived from a battery introduced into the local circuit at the receiving station. The energy from this battery, when thus released, might be used to operate a telegraph sounder or like device. When it had done so the coherer was instantly and automatically restored, by tapping or shaking it, to the condition in which it prevented the passage of the direct current, whereupon a fresh alternating impulse from the aerial might again constitute it a conductor. There would thus be produced a sufficiently rapid succession of releases and stoppages of the direct, controlled current to permit the detection by its means of dots and dashes made by properly timed interruptions and releases of the originating alternating impulse emitted from the sending station. A diagram showing a receiving station circuit including a coherer is to be found in Marconi's U.S. Patent No. 627,650 (Diag. No. 1).

9. In the early days when a coherer was used for detection, what was transmitted from a sending station was a simply produced wave without modification at audio frequency; this wave merely operated the coherer and was started and stopped to produce the dots and dashes recorded by the direct current alternately released and blocked. A sending wave modified at audio frequency was, however, required when other forms of detector were developed and a telephone was used as a receiver. Of these a crystal detector was typical. Certain crystals have the property of permitting an alternating current to pass through them only in one direction. By introducing such a crystal into a receiving circuit, one-half of an alternating impulse intercepted by the aerial was cut off, with the result that beyond the crystal there was only a direct current interrupted at the same frequency as the alternating current thus cut in two. If then into this second circuit a telephone receiver was introduced, it became possible to hear or record any alteration in the audio frequency modulations due to interruptions of the alternating impulse or imposed upon it during its emission. A diagram of a receiving circuit including a crystal would not be unlike that of one

In the Supreme Court of Canada.

No. 34. Factum of Canadian General Electric Co., Ltd. —*continued.*

including a coherer except that it would include a telephone instead of a telegraph sounder.

10. There were other detectors which operated either like a coherer or like a crystal, but none of these are presently material except the "audion" which was invented and named by Lee De Forest and was covered by the U.S. Patent 879,532 for which DeForest applied in 1907. The result of the use of the audion as a detector is practically the same as that of the crystal. Its operation depends upon the fact that if the two terminals of an electric circuit enter opposite sides of an exhausted glass bulb and the negative terminal is heated to incandescence, the circuit will be completed by a flow of negative electrons from the heated terminal (the cathode) to the cold terminal (the anode). If then between these terminals a charged "grid" is interposed, the movement of the electrons across the intervening space will be assisted or obstructed in a proportion corresponding to the potential (i.e. the amount of the positive or negative charge) on the grid. By making such appropriate connections between the grid and an aerial that the potential on the grid varies in step with the impulses emitted from a sending station, there is permitted to flow, in the local circuit of which the hot cathode and the cold anode are the terminals, a direct current pulsating in step with the varying impulses on the grid.

This direct current is of the same character as that which results from detection by a crystal and sensible signals can be produced by it in the same way as by the latter. The audion is the device now generally employed for detection.

(c) *Amplification.*

11. Before the audion the only amplifying devices were those used in wired telegraphy and telephony and it was in that field that the use of the audion was first suggested by DeForest in his earliest patent of 1906-7 (U.S. No. 841,387). The audion's utility as an amplifier depends upon the relation of the potential of the battery in the local circuit containing the hot cathode and cold anode to the potential impressed upon the grid. A very slight change in the latter serves, if the battery potential is properly adjusted, to produce a very considerable change in the direct current flowing between the hot cathode and cold anode through the grid, so that the extent or intensity, though not the frequency, of the variations in the latter may be considerably greater than the intensity of the variations of the alternating impulse on the grid. The useful strength of the incoming impulses may thus be substantially increased.

12. In the patent of 1906-7 DeForest describes the audion he had invented as a device "for amplifying feeble electrical currents such, for example, as telephone currents," and defines his purpose as having been "to produce an amplifying device of greater efficiency and simplicity than those heretofore employed." In wired telegraphy and telephony no problem of selection arose, and when in 1911 Von Lieben, Reisz & Strauss first suggested the use of the audion for wireless signalling, they did not alter the character of its application. In their French Patent No. 13,726, being an addition to No. 425,047 (Diag. No. 7), they contemplate its use only "to strengthen electrical waves having the most varied frequency and shapes

of curves." This was to be effected by inserting one in a wireless receiving apparatus after the incoming signals had been made audible in a microphone. The amplification thus proposed was therefore of audio frequencies only ; all radio frequencies would necessarily have been eliminated at the microphone.

13. The next step was the transfer of the audion to the radio frequency side where it might amplify the incoming high frequency alternating impulses before detection. This step was made by Von Bronk in the latter part of 1911 in his German Patent No. 271,059 (Diag. No. 8). Again there is no suggestion of the audion's use as a selective device ; it was to amplify indifferently all incoming radio frequencies within the broad band which would affect a roughly tuned aerial. The patent opens with a reference to the use of an audion for detection and states that the inventor has a different object, namely, its use " only to strengthen the electrical oscillations irrespective of their curved form " i.e. irrespective of the peculiar form given them by a detector. Detection in this arrangement is to be carried out " by means of special indicators, e.g. thermo-cells or electrolitic rectifiers," after amplification by the audion, and the patent points out that if the detector is introduced into the circuit before the audion, the desired amplification will not take place since " as is known, the electrical oscillations of high frequency cannot affect such instruments " i.e. such detecting devices as those to which reference has been made.

14. There then followed a joint development by Schloemilch and Von Bronk, which the plaintiff contends is subsequent in date to Alexanderson. The step Schloemilch and Von Bronk proposed was first described in a German Patent (No. 293,300 : Diag. No. 10), applied for on February 9, 1913, and it was covered, together with Von Bronk's arrangement of 1911, by U.S. Patent No. 1,087,892, applied for on March 14, 1913, by British Patent No. 8,821 of 1913, applied for on April 15 of that year, and by French Patent No. 456,788, applied for on June 26th following.

In the German patent, which covers Schloemilch and Von Bronk's joint proposal alone, the new device is described as " an improvement of the wireless telegraphy system protected by Letters Patent 271,059 [i.e. Von Bronk, 1911] in which use is made of " an audion " for the purpose of amplifying the incoming oscillations and in which the amplified oscillations are rendered perceptible by a special rectifier," and the suggestion for the improvement of the Von Bronk device is that after amplification " the low frequency impulses coming from the rectifier are further amplified " by additional audions " before they are passed on to the telephone or any other indicating instrument."

There is still no suggestion that audions might be used to secure selectivity and indeed Schloemilch and Von Bronk's joint improvement was, so far as material, nothing more than a combination of Von Bronk's proposal with that earlier made by Von Lieben, Reisz and Strauss. Schloemilch and Von Bronk's patents, however, also cover a special arrangement of the circuits whereby a single audion may be used contemporaneously for the amplification of both the radio frequency impulse before detection and the audio frequency modulations after detection ; this special arrangement is not now in question.

(*d*) *Selection.*

15. Selection became a problem very early in the development of the art of wireless signalling. When for the purpose of sending a given frequency was selected, it became important to make the proposed receiving station sensitive to the same frequency. Indeed, the tuning of corresponding sending and receiving stations to the same frequency proceeded contemporaneously. In receiving circuits it was effected by a balancing of induction coils and condensers such that the circuits were electrically resonant to the frequency of the signals to be emitted by the sending station just as a piano string tuned to vibrate on a certain musical note, that is to vibrate at a given frequency, will, without being actually touched, be caused to vibrate at the frequency to which it is tuned if vibrations of that frequency are produced in its neighbourhood by a tuning fork or otherwise ; it is said to be resonant to that frequency.

16. In the earliest stages of the development of the art, the receiving station's circuit had a fixed electrical resonance and was adapted to receive signals most effectively from a sending station emitting waves of only one particular frequency. Very soon, however, provision was made for varying the resonant pitch of the circuit at the receiving station so that it could at will be so adjusted as to become sensitive to impulses emitted from different sending stations using different frequencies. This was done by providing means for varying either the inductance or the capacity of the circuit. Thus the earliest of Marconi's receiving circuits (1899, U.S. No. 627,650 : Diag. No. 1) shows a fixed tuning, but his next following one (1900, U.S. No. 763,772 : Diag. No. 3) shows a roughly tunable inductance on the radio frequency side of the coherer. Marconi states in the later patent that by the arrangement therein proposed, he is " able to secure a perfect ' tuning ' of the apparatus at a transmitting station and at one or more of a number of receiving stations."

17. A few months before Marconi applied for this last patent in 1900 a more highly developed system of tuning to radio frequencies had already been proposed by one Stone. Both applications were pending together, Stone's patent (U.S. No. 714,756 : Diag. No. 2) having issued in 1902 and Marconi's not until 1904. Stone proposed to insert, between the (untuned) aerial and the detector or coherer, two or more coupled circuits each tuned to a fixed and invariable electrical resonance. He says in his patent that the receiving apparatus is thus made " selectively responsive to waves of but a single periodicity " and " corresponds to an acoustic resonator capable of absorbing the energy of only that simple musical tone " sent out by the transmitting station. It does not appear that Stone's device ever came into general use.

18. Marconi made a further short step in advance seven years afterwards in his British Patent No. 12,960 of 1907 (Diag. No. 4). In that patent he indicates as a postulate the fact which constituted the real objection to Stone's arrangement, namely, the fact that if successive accurately tuned circuits, such as those proposed by Stone or himself in 1900, are so connected together as to permit the transfer from one to the other of full strength signals, they react upon one another and in combination have a composite electrical pitch different from that to which they are severally

tuned. His invention accordingly was for a particular arrangement whereby selectivity could be obtained " without *great* loss in the strength of signals " by resort to a special form of double circuit. He also proposed that the couplings between the successive circuits should be " simultaneously and equally varied " when the tuning was changed in order to receive transmitted signals of different frequencies.

19. The next step was also taken by Marconi in his British patent of 1909, No. 18,922 (Diag. No. 5). *This proposal was for the introduction* after detection of coupled tuned circuits similar to those which Marconi, in the preceding patent, had suggested should be used before detection. The additional circuits now proposed would of course necessarily involve a further loss of signal strength. They could, moreover, be used only when the audio frequency was constant, *i.e.* as it would be when the signals consisted of dots and dashes all made audible on a single pitch. The additional audio frequency circuits were accordingly inapplicable to the reception of speech, music or other sounds for the reproduction of which many audio frequencies are essential.

20. The loss of signal strength, which by his 1907 arrangement Marconi said he has prevented from being " great," nevertheless remained a serious difficulty which Schloemilch, working this time with Lieb, sought to surmount by a proposal made in 1910 (British Patent No. 10,210: Diag. No. 6). This proposal was that only the aerial should be tuned to a given radio frequency, that all audio frequencies should be detected immediately and, that a selection should then be made from among those audio frequencies of the particular one used by the telegraph sending station desired. The selection was to be effected by means of a series of circuits each containing a reed so adjusted or tuned as to vibrate at the audio frequency desired and each successive tuned reed transmitted its note acoustically to a microphone in the next succeeding circuit. Loss of signal strength in the operation of these (electrically speaking, very ponderous) circuits was prevented by the introduction into each of a battery by the energy derived from which the inertia of the circuit was overcome.

These successive circuits were the first of their kind which did not react on one another. Because they were connected only acoustically and not electrically, there was no electric reaction to interfere with their operation, but, like Marconi's device last described, Schloemilch and Lieb's tuned reeds were really adapted only for the reception of telegraph signals on a single audio frequency; they might perhaps be used for the reception of speech, but only by causing them to vibrate off the low audio frequency pitch to which they were tuned and so inevitably producing distortion.

21. The step next preceding Alexanderson's was made by Lorenz in 1912 (German No. 258,478: Diag. No. 9). His device was for a series of circuits coupled acoustically through intermediate electric connections and with such independent batteries as were necessary to overcome the inertia of the acoustic connections. The character of these was different from, and probably more delicate than those described by Schloemilch and Lieb, but the general scheme of Lorenz' device was the same as theirs. Like their arrangement and Marconi's device of 1909, Lorenz' proposal was inapplicable to the effective reception of speech.

Alexanderson's Invention.

22. At this point Alexanderson made a revolutionary suggestion. He became familiar with the audion in the autumn of 1912, conceived his idea immediately and at once set two subordinates successively to work out the mathematics involved. This they did between October, 1912 and February, 1913, their notes being introduced as Exhibits Z1 and Z2. Alexanderson's idea was to make use of the audion for an entirely new purpose. It was not to be used as an amplifier of audio frequencies as had been suggested by DeForest in 1906 and Von Lieben, Reisz and Straus in 1911, or merely as an amplifier of radio frequencies as Von Bronk had suggested in 1911, but was to be harnessed in tandem in order to make a selection of one single radio frequency among many. Thus there would be permitted to reach the detector only that particular high frequency alternating impulse which carried the audio frequency modulations which it was desired to hear, these audio frequency modulations being left entirely unaffected and capable of being made audible no matter what their frequency might happen to be.

23. Alexanderson's sole doubt was whether the existing DeForest audion invented six years before was sufficiently sensitive to respond readily to impulses at the high radio frequencies actually in use. He had been informed that it was sluggish. On this point, therefore, sometime in January, 1913, he consulted his colleague Langmuir who said he could produce a tube which would be sufficiently sensitive. Therefore, on February 4th Alexanderson wrote a letter describing his invention to the head of the Patent Department of the General Electric Company by which he was employed, copies of this letter being distributed among others in the company who would be interested (Exhibit Z3).

It appears from this letter that Alexanderson was thinking in terms of telegraphy. He opens it with the statement that " the most important improvements that are to be expected in the art of wireless telegraphy is (*sic*) to provide means for undisturbed communication by the use of highly selective systems." He was thus attacking the problem to which Stone's attention had been directed eleven years before and in his letter he describes fully how it is to be solved by the use of a series of circuits each containing an audion.

24. Langmuir proceeded to improve the audion and by May 9th had developed the " hard tube " which was then made use of according to Alexanderson's arrangement. Later it was ascertained that the old unimproved DeForest tube would serve the purpose and Alexanderson accordingly, in his United States patent application which was filed on Nov. 13th following (U.S. Patent No. 1,173,079: Diag. No. 11), expressly contemplates the use of either " soft " or " hard " (pure electron discharge) tubes.

His specification opens with a statement of the problem and of the attempts to solve it, this statement being as follows :—

> " One of the chief problems encountered in radio-telegraphy is the suppression of waves of various lengths interfering with the waves constituting the signal to be received. The method now commonly employed for this purpose consists in using an electric circuit in which a train of waves of a given frequency acts cumulatively so that each

successive impulse adds its energy to the previous impulse, while disturbing impulses of a different frequency have little effect. However, to screen out strong disturbing impulses effectively, when weak signals are to be received, requires an accuracy of adjustment which imposes a definite limit upon the possible selectivity of the system."

There then follows a very full description of the arrangement he proposes and a number of claims, of which Nos. 1, 2, 3 and 7 are sued upon, the first two of these being more broadly and the two latter more narrowly expressed.

25. The invention, as described in the letter of Feb. 4th, 1913, and in the subsequent patent, consisted of a series of tuned circuits each containing an audion, a separate battery to provide a current to be controlled by each grid and another battery to heat each filament; each circuit was to be capable of being variably tuned to any desired radio frequency. It is explained that each circuit of the series is tuned to be resonant to the same selected radio frequency, that the first circuit will eliminate all other frequencies in a given proportion, that this remnant will again be eliminated in the same proportion in the second circuit and that the process of elimination may proceed in additional circuits until there has been an effective suppression of all radio frequencies except that desired to be received.

To describe this pre-detection process, Alexanderson uses the expression "geometric selection"; it might also be described as "selection by repetition," a definite proportion of the remnant of unwanted frequencies being successively eliminated at each repetition of the pure signal, without reaction between circuits and independently of amplification, which is merely recognized as a possible concomitant of the selection. After the process has been completed, the audio frequency modulations impressed upon the particular selected radio frequency impulse alone reach the detector and will alone be heard in the telephone.

26. Alexanderson's arrangement has come into very general use. It extended the possibility of selection, and consequently of reception, to signals of a new order of strength, or rather of weakness. His arrangement, like comparable preceding ones, depended upon the effect of the tuning of circuits in diminishing, in geometric progression, the strength of the undesired signals by comparison with the strength of those desired. Before him, however, this was accomplished only by coincidently weakening the absolute strength of the latter. This weakening was likewise in a geometric progression (though perhaps less rapid) and the desired signals, to permit their reception after selection had therefore to have an original strength a certain number of times greater than would have been sufficient to permit their reception if no selective process had been necessary.

Alexanderson's arrangement overcame this difficulty. It involved no weakening of the desired signals. On the contrary it permitted the maintenance of their original strength and even their amplification within certain limits and on condition that the undesired signals were likewise amplified in an equal or less degree. Thus it permitted the reception free from interference of signals of an absolute weakness, as compared with the strength of interfering signals, such as previously to exclude them altogether from practical consideration.

No equally advantageous method of receiving signals of this order of absolute and comparative weakness appears to have been found even in the fourteen years which have elapsed since Alexanderson's invention.

PART II.

Judgment and Grounds of Appeal.

27. The defendants based their defence chiefly on the ground that, having regard to the state of the art and the previous patents, Alexanderson made no invention. As anticipations they relied on the one hand on the devices shown in Stone's patent of 1902 (Diag. No. 2) and Marconi's patent of 1907 (Diag. No. 4) and, on the other, upon the work of Schloemilch and Von Bronk of 1913. They also relied upon a defect in Alexanderson's affidavit in support of his application for the patent in question.

The learned trial Judge held that Stone's and Marconi's devices were not anticipations of Alexanderson's proposal since they secured selectivity only at the expense of signal strength, and that Alexanderson's arrangement for the use of the audion to obtain selectivity was new. He also held that Schloemilch and Von Bronk were dealing with amplification, not selection, and that consequently their arrangement likewise failed to constitute an anticipation of Alexanderson's, assuming to be prior to date. He therefore found it unnecessary to deal with the question whether Alexanderson's invention was or was not made prior to the time Schloemilch and Von Bronk reached their results.

On the point of the sufficiency of Alexanderson's affidavit, the learned trial Judge followed his judgment in another case, *Canadian General Electric v. Fada* (1927) Ex. C. R. 113, which judgment has, since the judgment now under appeal was delivered, been affirmed on appeal. (17th June, 1927.)

PART III.

ARGUMENT.

As to Invention.

28. Early in the trial it was conceded by counsel for the defendant that if Alexanderson was the first to invent the arrangement described in his patent, he was entitled to obtain a patent upon it, that is, that independently of anticipation, the arrangement represented invention. The question at issue was, therefore, really whether preceding inventors had, before Alexanderson, reached results so closely approximating to those Alexanderson reached that to pass from these preceding results to Alexanderson's did not involve invention. There is little or no distinction between the question as thus framed and the question whether there had been anticipation. The inquiry is narrowed to an examination of the results of previous work as described in the evidence and the several patents in the record.

29. The Stone and Marconi patents, so far from constituting anticipations, afford strong evidence that Alexanderson's advance involved

invention. There had been an interval of over twelve years between Stone's patent application and the time Alexanderson conceived the idea. The advance Marconi made over Stone in 1907 was a slight one and the work of these and other inventors, as well as the evidence that Marconi's arrangement had become common practice, shows that selectivity was desirable and was being sought for. De Forest had applied for his first patent on the audion in 1906 and German inventors had in the six years following been working out fresh applications of it. None of them had suggested its use to obtain a high degree of selectivity until Alexanderson, coming to the problem with a fresh mind and having recently worked on an improved form of transmitter, was struck by the possibility of applying the audion to this fresh and advantageous use. If his application of it was obvious, it could not possibly have failed to have been suggested by some one of the numerous and highly skilled technicians who had been working the field during the preceding six years.

30. Hazeltine, the defendant's expert, chiefly emphasized the work of Schloemilch and Von Bronk as an anticipation. He says that their work, as represented by him in a drawing, Exhibit M, which differs very widely from any arrangement they themselves showed in their patents or contemporaneous diagrams, " seems to be the first complete embodiment of the arrangement which Alexanderson believed he had invented." This drawing of Hazeltine's is based partly upon a diagram produced by Von Bronk (Exhibit P). This diagram shows something the patent did not, namely, a variable condenser connected in parallel with the secondary of the transformer between the aerial and the first circuit. Even if this arrangement was used by Schloemilch and Von Bronk, it would not indicate that they had any conception of the use of the audion which Alexanderson proposed. The contemporaneous written record contained in the patent makes it entirely clear, as the learned trial Judge found, that all they sought was amplification and that their minds were not directed to the attainment of selectivity, which was the object Alexanderson had in view. On these points the respondent relies upon the statement of the position contained in the very full and elaborate judgment at the trial.

As to Date of Invention.

31. Alexanderson's proposed circuit arrangements are sufficiently shown in the Vivian notes made in the latter part of 1912 (Exhibit Z1). A complete oral description of them was given to Dr. Langmuir in January 1913. On February 4th a complete written description was contained in the letter to be distributed to the heads of the departments in the General Electric Company (Exhibit Z3). Although the defendant's expert says that this letter contains certain doubtful expressions, he does not suggest that it did not contain enough information to enable one skilled in the art to carry out Alexanderson's proposals. On the other hand, Waterman, the plaintiff's expert, Dr. Langmuir and Alexanderson himself all say that the letter contained everything a competent person would require and constituted a full and adequate description of the proposals.

32. Even assuming, that when they applied for their patent on February 9th, Schloemilch and Von Bronk had reached the same point as Alexanderson,

Alexanderson was, nevertheless, the "first inventor." All that Schloemilch and Von Bronk can do in the way of dating their invention earlier than the patent application is to exhibit a photograph, Exhibit O, dated February 8th, and blue print, Exhibit P, of the same date. It is true that they state that the preparation of a patent application ordinarily took from ten to fourteen days after the device proposed to be covered had been set up, but they are wholly unable to say whether the time ordinarily occupied was in fact occupied in the case in question. Nothing, therefore, in their evidence is sufficient to discharge the onus resting upon the defendants' to prove priority of invention by them over Alexanderson, even if this is material, as the respondent contends it is not.

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Of Counsel for Respondent.

APPENDIX.

Unreported Judgment in RADIO CORPORATION OF AMERICA vs. EDMOND, delivered 11th July, 1927, by Thacher, District Judge of the United States Federal Court for the Southern District of New York.

THACHER, *D.J.*: The patent and claims in suit were held valid and infringed in *Radio Corporation et al.* v. *Splitdorf Electric Co.*, 14 Fed. 2d. 643, by BODINE, *D.J.*, whose conclusion finds strong support in the thoroughly well considered opinion of MACLEAN, *J.*, of the Exchequer Court of Canada, in *Canadian General Electric Co. Ltd.*, v. *Fada Radio Ltd.*, decided April 14, 1927, where Alexanderson's Canadian patent No. 208,583, covering the same invention, was held valid and infringed.

The patent relates to radio receiving apparatus, and particularly to a system for the selection of oscillations of a given wave length from mixed oscillations. The problem of selecting oscillations of a given wave length from the confusion of oscillating currents affecting the antenna of radio receiving apparatus had long been known in the prior art of radio reception. The Stone patent No. 714,756 of December 2, 1902, and the Marconi-Franklin British patent No. 12,960 dated December 23, 1907, disclose tuned circuits inductively coupled, arranged in cascade to obtain selectivity. Stone and Marconi attained high degrees of selectivity through the use of successive tuned circuits, each of which to a degree screened out the interfering oscillations with which they were not in resonance and passed on the desired oscillations with which they were in resonance. Selectivity in such circuits was, however, dependent upon loose inductive coupling between the successive circuits, and with loose coupling the strength of the desired signal was greatly diminished. If close coupling was employed to increase the signal strength the undesired oscillations were carried from one circuit to another and the system ceased to be selective. Thus, in Stone and Marconi it was extremely difficult if not impossible to detect the weak signals of far distant stations when the antenna was affected by the interference of powerful nearby stations.

In the Fall of 1912, Alexanderson first learned of the De Forest audion from Hammond. Immediately the thought occurred to him that it might be used as a relay for radio frequency currents in a series of tuned circuits. It was his conception that by a series of tuned circuits, connected by suitable relays, which would effectively impress upon the succeeding circuit the selected oscillations of the preceding circuit, a very high degree of selectivity could be attained without loss of signal strength. This conception may have occurred to others, but whether it did or not, Alexanderson was the first to use the audion as a relay for this purpose. That this was invention I have no doubt. When Alexanderson told Hammond of his intention to try the audion as a relay of radio frequency oscillations connecting tuned circuits, Hammond said he believed the audion was too sluggish for this purpose, but Alexanderson and the engineers of the General Electric Company working under his supervision constructed a series of resonant circuits connected by audions as relays, and attained, without loss of signal strength, a greater degree of selectivity than had theretofore been possible. The audion was known in the art as early as February, 1908, and the fact that no one had used it for this purpose prior to Alexanderson is persuasive evidence of invention.

That the prior art does not disclose anticipation of Alexanderson's invention is very clearly shown in the *Splitdorf* and *Fada* cases, cited *supra*. Indeed, the only references claimed to be in anticipation of Alexanderson which are discussed in the defendant's brief are Schloemilch and Von Bronk, patent No. 1,087,892, and Armstrong, patent No. 1,113,149. I find in the disclosure of Schloemilch and Von Bronk nothing which can be said to advance the art of selectivity in radio receivers or anticipate Alexanderson. The purpose of this invention was to amplify radio frequency currents, and nothing is said about selecting desired signals or excluding interfering signals. In one of the patent drawings there is shown a tuned antenna circuit coupled by induction with the grid circuit of an audion amplifier, the plate circuit of which is in turn coupled by induction with a detector circuit. Neither the grid nor the plate circuit of the audion is tuned. Connected with the detector circuit an intermediate tuned circuit is shown. There is no association of successively tuned circuits connected by relays, and all that is said of the tuned circuit which is associated with the detector is : " An intermediate circuit N syntonized to the oscillations will preferably be provided." For what purpose is not stated. No doubt because it was well known that a circuit tuned to resonance of a desired signal would exclude interfering signals to some extent. This casual reference is not shown to have any relevance to the disclosure. Apparently it was merely a mechanical suggestion for the insertion in the receiving instrument of a tuned circuit, so that the system might be given some slight measure of selectivity by the insertion of a means to that end which was well known in the art. It was certainly not a disclosure or anticipation of Alexanderson's arrangement of successive circuits, all tuned to the same frequency and linked together by relays. The precise date of Alexanderson's invention becomes unimportant, and need not be considered, because the invention of Schloemilch and Von Bronk, even if prior in time, does not anticipate the invention of Alexanderson.

In Armstrong's feed back audion circuit, patent No. 1,113,149, to which priority of invention is conceded, selectivity is attained by regeneration. Prior to his invention the presence of radio frequency oscillations in the plate or wing circuit of an audion used only as a detector was not suspected. Armstrong tuned the plate circuit of an audion detector to radio frequency in resonance with the grid circuit, and through his feed back connection between the two circuits found that he could feed back from the plate circuit into the grid circuit radio frequency oscillations of the same frequency as that of the desired incoming signal, and thus obtain marked amplification of the desired signal. (*Armstrong* v. *DeForest Radio Tel. & Tel. Co.*, 280 Fed. 584, 587-588.) Armstrong, who was a witness for the defendant, testified that the regenerative selectivity attainable in his feed back circuit is due to the fact that energy is fed back from the plate circuit to the grid circuit in phase with and assisting oscillations in the grid circuit; that the energy which is fed back passes only one way, from the plate circuit to the grid circuit, and that consequently selectivity in this system is due solely to the amplification of the desired signal, with no appreciable screening or exclusion of the undesired signal. His plate circuit is tuned so that the energy fed back will reinforce the desired oscillations in the grid circuit. The interfering signal is not depressed, diminished or decreased. Geometric tuning by means of a succession of resonant circuits coupled by relays is neither disclosed nor employed in the Armstrong feed back audion circuit. There is superficial resemblance between the circuit drawings of the two patents, but when the operation of the two devices is understood it is quite apparent that there is no similarity of invention. In Alexanderson's tuned circuits the audion is not used as a detector, detection occurring at a later stage, while in Armstrong the set has but one audion, which is used as a detector and as a regenerator of radio frequency oscillations. The two inventions are utterly different, and Armstrong does not disclose or anticipate Alexanderson.

It is contended that a device, built in accordance with the disclosure of the patent, with such knowledge only as was common to those skilled in the art at the time of its issue, would be inoperative and useless. Upon this issue the burden rests heavily upon the defendant. (*Remington Cash Register Co.* v. *National Cash Register Co.*, 6 Fed. 2d. 585; 618.) And of course perfection in operation is not the true test of operativeness. (*Engineer Co.* v. *Hotel Astor*, 226 Fed. 779, 783.) A patented device is not inoperative because when built or operated in a certain way it will not work, if other ways of building and operating it are fairly indicated by the patent or the prior art. A patent is addressed to men who know the art, and if such men can build and operate the device so that it functions as the patent says it will, although imperfectly and only after trial and error, that is enough. (*A. B. Dick Co.* v. *Barnett,* 288 Fed. 799, 801; *American Stainless Steel Co.* v. *Ludlum Steel Co.*, 290 Fed. 103, 108.) Here, the claim of inoperativeness is based upon the contention that Alexanderson's arrangement is subject to the regenerative influence of feed back from the plate circuit to the grid circuit of each audion, by which self-oscillations are produced and which prevent the functioning of the device. That such oscillations may occur in operation is quite clear from the tests and testimony. The cause of these oscillations was first disclosed by Armstrong in his patent No. 1,113,149, issued October 6, 1914, covering his regenerative feed back system of amplification. Modern methods for the control of regeneration and the undesirable self-oscillations which result therefrom were unknown in the art when the patent in suit issued. These improved methods have perfected Alexanderson's system of geometric tuning, and are employed by the defendant. Their importance cannot be denied (see *Hazeltine Corporation* v. *Electric Service Eng. Corp'n.*, 18 Fed. 2d. 662), and it may be conceded that the Alexanderson device, without some such improvement, would be of little commercial value to-day.

But, infringement of the Alexanderson patent of 1913 is not avoided by using his invention with subsequent improvements. (*International Time R. Co.* v. *Bundy R. Co.*, 159 Fed. 464, 469.) The question is whether without improvement the invention was operative. The evidence clearly shows that regeneration occurs in the patented device only under conditions dependent upon elements variable in operation. By empirical variation of these elements the device can certainly be made to work. Thus, self-oscillation can be suppressed by reducing the amplifying voltage or by loosening the inductive couplings between the circuits and, in general, by changing the ratios of resistance, inductance and capacity in the various circuits. If the strength of the plate current is merely sufficient to sustain the original signal strength without amplification, there will be no objectionable regenerative effect. None of the elements upon which self-oscillation depends are fixed by patent specification. On the contrary, the instruction of the patent is that they are to be varied in operation. When so varied by the operator the objectionable regenerative effects can certainly be eliminated by trial and error, if too great amplification is not insisted upon.

The tests recited by the defendant's expert are not convincing. In the first place, he omitted variable inductances from the grid circuits and constructed an instrument which he knew in advance would not function. No room was left for trial and error, and little, if any, allowance was made for the knowledge of one skilled in the art in the year 1913. In *Loom Co.*, v. *Higgins*, 105 U.S. 580, 586, it was said : "When the question is whether a thing can be done or not it is always easy to find persons ready to show how not to do it." In *Ryncar Co.* v. *Evans*, 83 Fed. 696, 697, Judge Coxe said that "When an expert undertakes to prove that his adversary's process or machine is a failure, he always scores a success. It is much easier to make a machine that will not work than one that will." The defendant's tests show that an Alexanderson device can be made which will not work. They do not show that such a device could not have been made to work by one skilled in the art in 1913.

The tests of the apparatus conducted upon the trial convincingly demonstrated that within certain limits a very high degree of selectivity was attained, with substantial amplification of signal strength, and that when the system was caused to oscillate these oscillations were easily eliminated by the variation of inductance or voltage, which any operator of the device in 1913 certainly would have tried in an intelligent effort to make it work, even though he was entirely ignorant of the mysteries of the audion which were later explained by Armstrong.

Alexanderson's system was actually used with success in receiving in Schenectady radio signals transmitted from Honolulu, and since 1920 in the transoceanic service of the Radio Corporation of America, where a high degree of selectivity is essential, fifteen receiving sets being connected with a single antenna and each receiver being used for the selection of radio frequency oscillations of a frequency differing from those received on the other sets. With improved methods of neutralizing the effect of regeneration the system is extensively used in commercial receiving sets to-day. Alexanderson's contribution to the art was important, and the validity of his patent cannot be disputed upon the ground of inoperativeness.

Nor do I think the point well taken that Alexanderson did not invent the device described in the patent, but that his assistant, Langmuir, did. Langmuir was one of the engineers of the General Electric Company associated with Alexanderson in the Research Department of that Company. What he did was done pursuant to Alexanderson's request, and in execution of the conception which was Alexanderson's. He contributed no inventive thought to the plan which had been fully outlined by Alexanderson. His task was to construct a series of tuned circuits connected by audion relays. It is true that before he undertook to do this he and his assistants manufactured audions with a very high vacuum so as to exclude the possibility of gas ionization in the operation of the audion. These improved audions are preferred in the Alexanderson patent but are not specified as essential, nor is there proof that they are essential. If credit is due to Langmuir for the invention of these improved audions, this should not deprive Alexanderson of his invention of a selective tuning system in which they are used as relays.

Claims 1, 2 and 12 are sufficiently broad to cover any relay in place of the audion. Claims 3 and 9 are limited to devices in which the audion is used as a relay between the cascaded tuned circuits. Inasmuch as it does not appear that any effective relay for radio frequency currents other than the audion was known to Alexanderson, it may be that claims 1, 2 and 12 are too broad. This question should, I think, be reserved until it arises in a suit in which infringement is asserted against a device in which a relay other than the audion is employed.

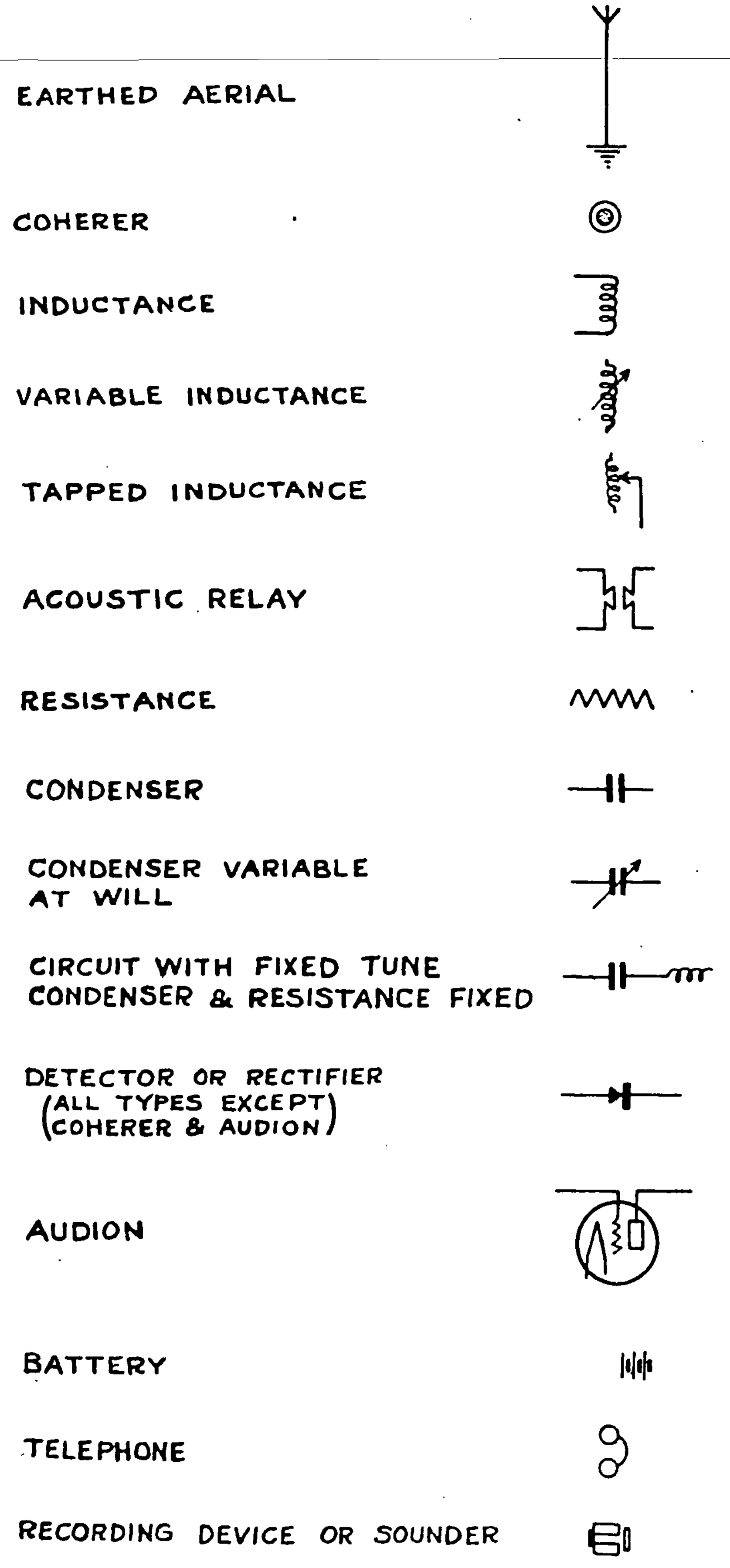
Claims 3 and 9 are clearly valid, and as clearly infringed. A decree to this effect may be entered, upon the usual notice. The decree may contain appropriate recitals of the fact which appears from statements made upon the trial by defendant's counsel that this suit was openly defended by the Atwater Kent Manufacturing Company, a Pennsylvania corporation, the maker of the infringing device. The motion to make this foreign corporation a party to the record, which was made upon the trial, is denied on authority of *Parsons Non-Skid Co., Ltd.* v. *E. J. Willis Co.*, 176 Fed. 176; *Freeman Sweet Co.* v. *Luminous Unit Co.*, 264 Fed. 107; *Van Kannel Revolving Door Co.* v. *Winton Hotel Co.*, 263 Fed. 988. In *Dick's Press Guard Mfg. Co.* v. *Bowen*, 229 Fed. 193, where such a motion was granted, the motion was unopposed and the decision of Judge Noyes in the *Parsons* case, *supra*, apparently was not called to the attention of the Court.

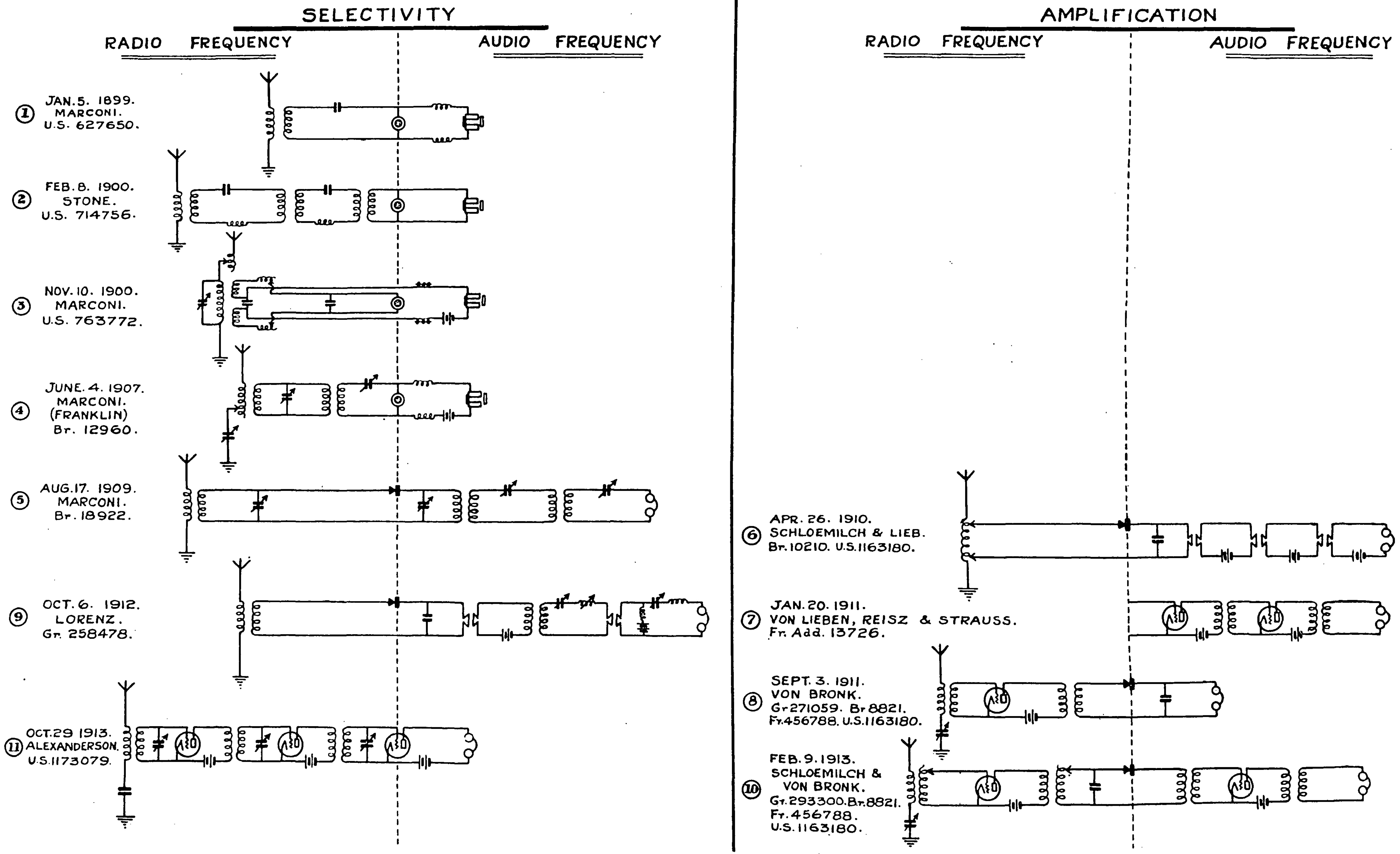
(Sgd.) Thomas D. Thacher,
U.S.D.J.

July 11th, 1927.

DIAGRAMS SHOWING DEVELOPMENT OF THE ART OF RADIO TRANSMISSION IN RESPECT OF SELECTIVITY AND AMPLIFICATION.

SYMBOLS





No. 35.

Formal Judgment.

In the Supreme Court of Canada.

Tuesday the 7th day of February, A.D. 1928.

Present

The Right Honourable Francis A. Anglin, P.C., Chief Justice,

The Right Honourable Mr. Justice Duff, P.C.

The Honourable Mr. Justice Mignault.

The Honourable Mr. Justice Lamont.

The Honourable Mr. Justice Smith.

Between

Fada Radio Limited ... ... (Defendant) Appellant,

and

Canadian General Electric Co., Ltd. ... ... (Plaintiff) Respondent.

The appeal of the above named Appellant from the Judgment of the Exchequer Court of Canada rendered in the said cause on the fourteenth day of April, in the year of our Lord one thousand nine hundred and twenty-seven, having come on to be heard before this Court on the ninth, tenth and eleventh days of November, in the year of our Lord one thousand nine hundred and twenty-seven, in the presence of Counsel as well for the Appellant as for the Respondent, whereupon and upon hearing what was alleged by Counsel aforesaid, this Court was pleased to direct that the said appeal should stand over for judgment, and the same coming on this day for judgment.

This Court did order and adjudge that the said appeal should be and the same was allowed, and that the said Judgment of the Exchequer Court of Canada should be and the same was reversed and set aside and the action dismissed.

And this Court did further order and adjudge that the said Respondent should and do pay to the said Appellant the costs incurred by the said Appellant as well in the Exchequer Court of Canada as in this Court.

(Sgd.) E. R. CAMERON,
Registrar.

In the Supreme Court of Canada.

No. 36. Reasons for Judgment. Lamont J. (Concurred in by Anglin C.J.C., Duff, Mignault and Smith JJ.).

No. 36.

Reasons for Judgment.

LAMONT J.

(Concurred in by Anglin C.J.C., Duff, Mignault and Smith JJ.).

This is an appeal from a judgment of the President of the Exchequer Court in favour of the plaintiffs, the present Respondents, in which he held that Claims 1, 2, 3 and 7 of the Canadian Letters Patent No. 208,583 issued to the Canadian General Electric Company as assignees of Ernest F. W. Alexanderson were valid and had been infringed by the defendants, the present Appellants.

The Respondents' patent had to do with radio art and covered a device by which it was claimed a higher degree of selective tuning could be obtained in a receiving set than had been previously obtainable, while at the same time the desired signal could be received at its maximum effect.

The function of a transmitting apparatus is to generate high frequency continuous waves or sustained oscillations. Upon these are impressed by way of modulation a message. From the transmitting station these surging oscillations go out in all directions with the speed of light (186,000 miles per second) and in travelling past a receiving aerial they cause in it oscillations of the same frequency as those sent out by the transmitting station. The receiving aerial, however, has impinged upon it not only the oscillations from the transmitting station, from which reception is desired, but also the oscillations from every other transmitting station within range, then in operation. The signal desired may come from some far distant station and be relatively weak, while undesired signals may be coming at the same time from near by or possibly more powerful stations and thus be relatively much stronger. To eliminate or screen out all signals from other transmitting stations and disturbances arising from natural causes so that the desired signal may be received and understood, is the function of a receiving set. Elimination of the undesired signals is secured by what is known in the art as "selectivity." The selectivity of a receiving set is the measure of its ability to exclude what is not wanted. Its ability to receive what is wanted at its greatest strength is known as its "sensitivity." Sensitivity is frequently spoken of as "amplification" because present day receivers always amplify the desired signals.

Selectivity is secured by "tuning." Tuning consists in so adjusting the circuits of the receiving set that their oscillations are at the same rate as those of the high frequency wave which constitutes the desired signal.

It has long been known that if a receiving set is tuned to the same frequency as the desired wave, that wave has more effect upon the receiving set than any other. When thus tuned the receiving set becomes highly responsive to the desired wave and at the same time less responsive, or more opaque, to waves of different frequencies. And it is upon the basis of this well known fact that different inventors have constructed devices calculated to eliminate undesired signals and to secure and strengthen the desired signal. The more perfectly the undesired signals are excluded the better the selectivity of the receiving apparatus.

Patent No. 208,503, which the Appellants are alleged to have infringed, was issued to the Respondent Company on February 15th, 1921. The invention, however, which was that of Ernst F. W. Alexanderson, an electrical engineer in the employ of the Respondent Company, was patented in the United States on October 29th, 1913. The chief claim made for it was that it secured a high degree of selectivity without diminution of signal strength.

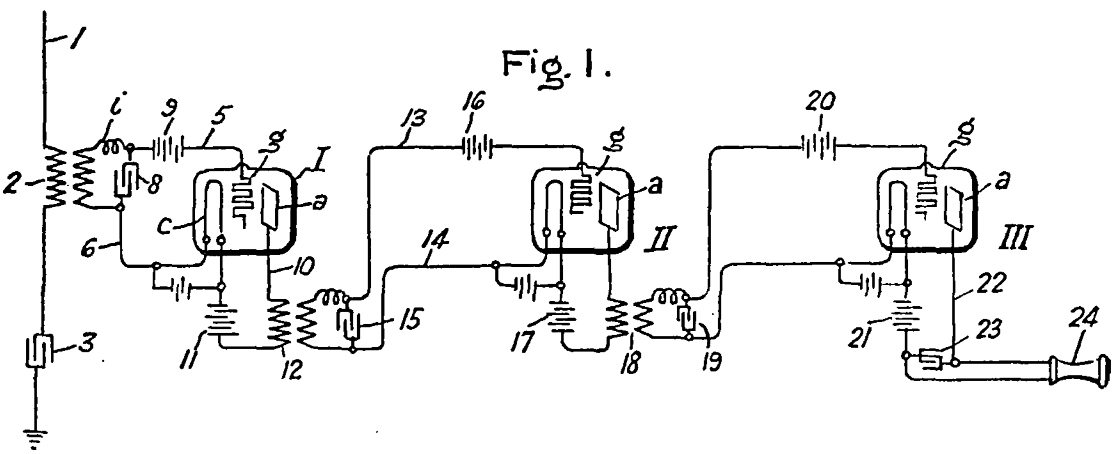
In the specifications of his Letters Patent Alexanderson says :—

" One of the chief problems encountered in radio-telegraphy is the suppression " of waves of various wave lengths interfering with the waves constituting the " signal to be received. The method now commonly employed for this purpose " consists in using an electric circuit in which a train of waves of a given frequency " acts cumulatively so that each successive impulse adds its energy to the previous " impulse, while disturbing impulses of a different frequency have little effect. " However, to screen out strong disturbing impulses effectively when weak signals " are to be received requires an accuracy of adjustment which imposes a definite " limit upon the possible selectivity of the system.

" In accordance with the present invention, selective tuning is secured by the " use of a plurality of resonant circuits arranged in cascade in such a manner that " the selectivity of the system increases in geometric ratio with the number of " circuits employed. The selective circuits are respectively interlinked by a relay " controlling a separate source of energy to initiate oscillations corresponding to " potential oscillations impressed upon the relay. As each tuned circuit is more " or less opaque to disturbing oscillations differing in frequency from the oscillations " to be selected, a certain percentage of the disturbances is eliminated in each " circuit of the series, so that the purity of the incoming train of oscillations pro- " gressively increases as it is successively relayed. The relay preferably used for " this purpose is an electron discharge tube having an incandescent cathode, an " anode and a grid.

" In the accompanying drawings, Fig. 1, is a diagram illustrating a system " in which three tuned circuits are employed the last being provided with a telephone " receiver."

Fig. 1 is as follows :—



After describing the operation of his device Alexanderson goes on to say :—

> "As the incoming oscillations are received by a resonant circuit tuned to the particular frequency of the signals which are to be received, the effect of disturbing waves having a different frequency is suppressed to an extent dependent upon the tuning of the circuit. Because of its resistance and special distribution the antenna circuit cannot be closely tuned, so that the suppression of interferences in this circuit may be disregarded in the present case. However, the waves of various frequencies picked up by the antenna are transferred by the transformer 2 to a resonant circuit 5, 6, the inductance and capacity of which may be closely adjusted so that the oscillations having the desired frequency have a maximum effect whereas the effect of wave impulses having a different frequency is suppressed to say, for example, one-tenth their original value. The resulting voltage oscillations are super-imposed upon the definite negative potential maintained upon the grid *g* of the electron discharge tube by the battery 9, and this varies the conductivity between the cathode *c*, and the anode *a* in accordance with the variations of voltage. Preferably the negative terminal of the battery 9 is connected to the grid. The battery 11 sends through the plate circuit 10 a variable current, the oscillations of which are in step with the oscillations in the resonant circuit 5, 6. These oscillations are transferred by a transformer 12 to the resonant circuit 13, 14. The latter circuit containing condenser 15 also tuned to give full effect to the oscillations of the desired frequency but to be largely opaque to oscillations different therefrom."

Alexanderson then points out that as the oscillations passed through several of these devices arranged in cascade each circuit being in tune with the oscillations received, the suppression of disturbing impulses would increase in geometrical ratio with each tuned circuit added to the system. He further says :—

> "If desired the size of the battery may be so arranged as to magnify the effect of the oscillations which are now practically free from disturbances and so may be readily distinguished by the telephone receiver."

The receiving apparatus according to Alexanderson's invention therefore, consisted of a tuned aerial for receiving the incoming oscillations; a tuned input circuit which led to the grid and filament of a vacuum tube (also called audion or valve) and a tuned output circuit containing the plate and the filament, the filament being common to both circuits. The incoming oscillations to the grid initiated new oscillations of the same frequency in the output circuit, the independent source of energy for which came from the battery attached to that circuit. These new oscillations carrying with them the message were relayed to another similar device where they again went through the same operation. In the third device of the series the oscillations were reduced from high frequency waves to audio frequency waves by a detector so that the message would be within the compass of the human ear. That this device gave a high degree of selectivity is not denied, and if the patent issued for it be valid there would not seem to be much doubt that the Appellants infringed the patent.

The main defences relied upon by the Appellants are :—

(1) That Alexanderson's device does not constitute invention; and (2) That if it does, he was anticipated by other inventors, particularly Wilhelm Schloemilch and Otto Von Bronk, in Germany.

In the Supreme Court of Canada.

No. 36. Reasons for Judgment. Lamont J. (Concurred in by Anglin C.J.C., Duff, Mignault and Smith JJ.) *—continued.*

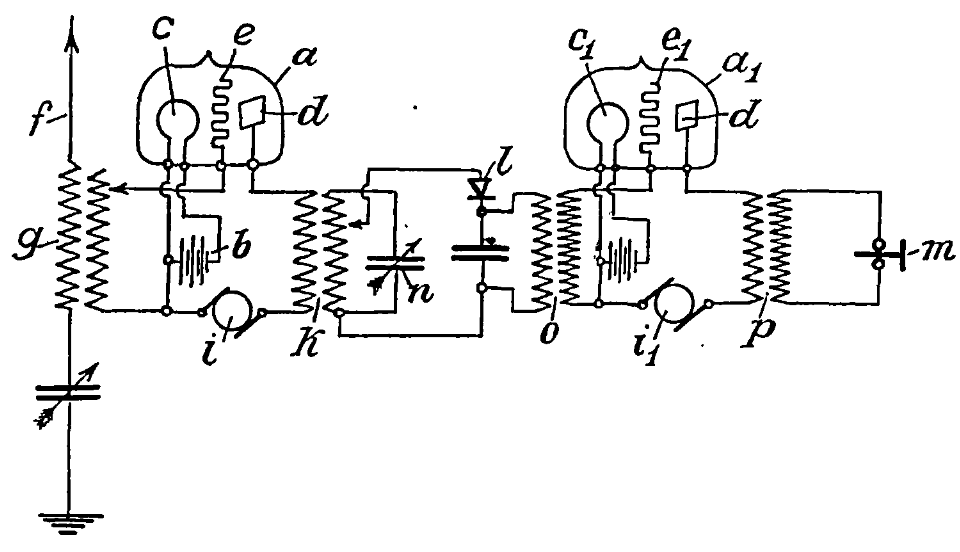
Dealing with the latter of these defences first, we find that in 1911, von Bronk, who was then at the head of the Patent Department of the Telefunken Company of Germany, obtained in that country a Patent, No. 271,059, for a receiving device for wireless telegraphy in which he used the vacuum tube both as a relay and as an amplifier. Von Bronk, however, did not tune his grid circuit and so did not obtain the highest degree of selectivity.

On February 9th, 1913, Schloemilch and von Bronk jointly applied in Germany for a Patent for a receiving apparatus, which patent was later issued to them as No. 293,300. Schloemilch was at that time an electrical engineer in the Telefunken Company. Their invention related to an improvement on von Bronk's Patent, No. 271,059, to which it was declared to be an addition. On March 14th, 1913, they applied in the United States of America for a patent for their invention and received a Patent dated February 17th, 1914, and Nod. 1,087,892.

In his German Patent No. 271,059, von Bronk used the vacuum tube for radio amplification, and as a relay. In the German Patent No. 293,300, Schloemilch and von Bronk added to this a claim of audio amplification. In their United States Patent they claimed for both radio and audio amplification.

Fig. 1 of Patent No. 293,300 is as follows:—

Fig. 1.



In their specifications the inventors say:—

"The annexed drawing shews two connection diagrams embodying the present "invention. In this case, too, a is the vacuum tube with the oxide-coated cathode "c heated by the battery b, the anode d and the auxiliary anode e. The oscillations "set up by the aerial f in the coil g are passed on to the auxiliary anode and cathode,

In the Supreme Court of Canada.

No. 36. Reasons for Judgment. Lamont J. (Concurred in by Anglin C.J.C., Duff, Mignault and Smith JJ.) —*continued.*

"as in the system of the principal patent. The amplified high-frequency oscilla-"tions then flow into the circuit closed by the source of direct current *i* over the "cathode *c* and anode *d*, and thence are passed on to the detector circuit com-"prising the detector *l*, by means of transformer *k*. In this case it may be preferable "to provide an intermediary circuit *n*. ('Zwischenkreis') tuned to the oscillations.

"In the example shown in Fig. 1, the low frequency impulses supplied by "the detector are passed over a transformer *c* on to a second tube *a*1, comprising "a cathode *c*1, an anode *d*1, and an auxiliary anode *e*1, in which they are again "amplified, the amplified low-frequency pulsating currents from the circuit of the "source of direct current *i*1, being finally passed through another transformer *p* "on to the telephone *m*, or other induction instrument. Obviously further stages "of amplification could be resorted to by means of additional vacuum tubes."

A comparison of the two figures above set out shows that the invention of Schloemilch and von Bronk is very similar to that of Alexanderson. It is, however, argued and it was held by the court below, that the inventions differed in two material respects: (1) That the input circuit of the invention of Schloemilch and von Bronk was not tuned, and that tuning of that circuit was necessary to obtain as high a degree of selectivity as was obtained by Alexanderson, and (2) That their invention was not for the purpose of securing selectivity at all, but simply for securing amplification.

The first question, therefore, is: Did Schloemilch and von Bronk intend the input circuit of their invention to be tuned?

In his evidence F. N. Waterman defined the input and output circuits as follows:—

"I may say that in our common terminology, in using these tubes, we refer "to that circuit which is connected between the grid and the filament as the input "circuit, while that circuit which is connected between the plate and the filament "we commonly refer to as the output circuit; the input being that which controls "but does not contribute to the output."

As to whether or not the drawings of the Schloemilch and von Bronk patents show tuning in the input circuit we have the evidence of Professor Hazeltine, who says:—

"The drawing to my mind clearly and unequivocally illustrates such tuning."

On the other hand the Respondents' expert, F. N. Waterman, says:—

"The best therefore that one can say is that the drawing is ambiguous"

and

"that there is no certain indication whether it is or is not tuned."

Then we have the evidence of von Bronk and Schloemilch. That evidence was taken on commission in Germany and was read in the court below. We are, therefore, in as good a position as was the trial judge to appreciate their testimony.

Von Bronk testified that in his Patent No. 271,059 the circuit connected to the cathode and grid was not tuned but that in the joint Patent No. 293,300 it was tuned. He says that Schloemilch stated to him that both the variable coils and the variable condenser were used for tuning purposes. Schloemilch, however, made the experiments and von Bronk frankly stated that he did not know what Schloemilch had in his mind but, as an expert, he would say, "that the tuning means served for the tuning." Schloemilch testified that according to Fig. 1 the antenna circuit was tuned. As to the grid circuit he said:—

> "The tuning of grid circuits in cathode tubes was something obvious, because we "were used to that already from earlier receiving even with the detector. I have "always tuned the grid circuit in cathode tubes."

He also testified that before February 8th, 1913, he tuned the grid circuit independently of the antenna. In Fig. 1 the circuit *n* after the first vacuum tube shows tuning and Schloemilch stated that the three circuits, that is the antenna circuit, the grid circuit and the anode or output circuit, were all tuned to the same wave length. In corroboration a blue print of a drawing illustrating the invention, bearing date February 8th, 1913, was produced. This showed the grid circuit tuned by means of a variable condenser. This condenser does not appear on the drawings of the patent. On being asked to explain why this condenser did not appear on the patent drawing, von Bronk said:—

> "At that time it was assumed that the tuning by the variable coil was sufficient. "In the first patent drawing the variable condenser was included, but with a view "to simplify the drawing it was cancelled, I have the original of the first drawing "in my file. It can be seen that the condenser which was originally shown, has "been eliminated."

The learned trial judge says he was not impressed by this evidence, and he held that the grid or input circuit in the Schloemilch and von Bronk patents was not tuned. He came to this conclusion largely, as I understand his judgment, by reason of the fact that in their patents the drawings show two arrow-heads, one against the secondary of the transformer *g*, in Fig. 1 of the German Patent, and Fig. 3 of the United States Patent: and the other against the secondary of the transformer *k*, forming part of the intermediate circuit *n*. The latter arrow-head clearly indicates a tap to control the voltage communicated to the detector as the tuning of this circuit is shown by means of a variable condenser.

Such being the meaning of the arrow-head in circuit *n*, it was held by the learned trial judge to have the same meaning in the input circuit and to indicate there a control of voltage instead of tuning.

In his evidence Professor Hazeltine stated that:—

> "an arrow-head is used in the art to represent a variation, and when placed against "the symbol for an inductance, represents a specific variation in the number of "turns or more generally a variation in the value of that inductance."

and that

> "the purpose of this variable inductance was to tune the circuit in the standard "and well known way."

The argument on behalf of the Appellants is that this arrow-head indicates tuning unless tuning is distinctly shown by some other symbol in which case the arrow-head must be taken to have another meaning.

If the evidence of Schloemilch and von Bronk be reliable it establishes that in their patents the input circuit was tuned as well as the others.

I have read and re-read the evidence of both these witnesses and I can see no reason for refusing to accept their testimony. They were independent witnesses having no interest in the result of this litigation. From a perusal of their evidence I am satisfied that each was stating exactly what he believed to be true. The evidence discloses that each guarded himself against making a statement unless sure of his facts. There is no indication of any effort to recollect conversations held many years before, and again and again each admitted that he was unable to do so. Their evidence, supported, as it is, by that of Professor Hazeltine, and by the blue print, carries conviction to my mind and I accept it and find that in their Patents Nos. 293,300 and 1,087,892, the grid circuit was intended to be, and was in fact, tuned to the same frequency as the other circuits.

It was also contended that the two inventions differed in the objects to be attained; that Alexanderson sought selectivity, while Schloemilch and von Bronk sought amplification only, and that no claim for selectivity is made in any of their patents. That they made no claim for selectivity, the Appellants admit, but the reason for that, they say, was because the securing of selectivity by means of tuned circuits arranged in cascade was, to their knowledge, already old in the art and their invention added nothing to the prior art as far as selectivity was concerned.

The evidence shows that years before 1913 both Stone and Marconi had obtained a high degree of selectivity—possibly as high a degree as Alexanderson—by inductively coupling several tuned circuits in cascade. This gave them geometric selectivity although not so designated. In the use of their inventions, however, it was found that to secure the desired selectivity the circuits had to be coupled loosely, otherwise they would react upon one another, and with loose coupling a portion of the strength of the desired signal was expended in overcoming the inertia of the circuits. This loss of signal strength inventors sought to overcome by various means. In 1910 Schloemilch and Lieb sought to overcome it by arranging the circuits in series with a relay between each two circuits and by introduction of a source of energy to overcome the inertia of the circuits. In his Patent No. 258,487 (October 6th, 1912) Lorenz claimed that by coupling several circuits together by means of an acoustic instead of an electric coupling the reaction of one circuit upon another would be done away with and much greater precision of the resonance secured.

These attempts were partially successful. At lower radio frequencies fairly good results were obtained but at high frequency the inventions were not entirely satisfactory owing to the fact that the relay, being a mechanical device, would not vibrate at the higher frequency. The means adopted in their inventions both by Alexanderson and by Schloemilch and von Bronk for passing on the desired signal at high frequency from one circuit to the next without loss of initial strength was the use of the vacuum tube as a relay. Unless, therefore, the use of the vacuum tube made by Alexanderson differed from the use made of it by Schloemilch and von Bronk, either in the manner of its application or the object to be attained, their invention would appear to be exactly the same as his.

A perusal of the specifications of their respective patents and an examination of the drawings show that the vacuum tube was used in exactly the same way and for the same purpose in both inventions. In each the tube contained a filament or cathode, a plate or anode and a grid or auxiliary anode. In each the filament was heated so that it gave off a cloud of electrons. These electrons passed through the grid to the plate which was positively charged by a powerful battery attached to the plate circuit. The flow of electrons was controlled by the incoming oscillations which alternately weakened and strengthened the electron stream from the filament to the plate. The oscillations of the grid circuit initiated new oscillations in the plate circuit in tune with the original oscillations, the source of energy for which was the battery attached to the plate circuit. When these oscillations were relayed to the next resonant circuit they carried with them the desired message. Each invention therefore comprised an aerial, an input and an output circuit, all tuned to the frequency of the desired signal and a vacuum tube to relay the oscillations from one resonant circuit to another. In the Schloemilch and von Bronk invention the tube was also used as an amplifier. Alexanderson's invention provided that amplification might be had if desired. Amplification was secured by adjusting the plate battery so that an increased voltage passed to the plate. Any operator skilled in the art could do this. In each invention, therefore, we have selectivity secured by coupling tuned circuits together in cascade, and sensitivity secured by using as a relay the vacuum tube which passes on in the form of new oscillations the desired signal, either at its original strength or in an amplified form, as desired.

That Alexanderson stressed selectivity and made provision for amplification, while Schloemilch and von Bronk stressed amplification only, is, in my opinion, of little moment, for although they made no claim that their invention secured selectivity—that having been obtained by prior inventors—the object of both devices was to eliminate undesired signals and secure and strengthen the desired signal and bring it within the compass of the human ear. Had Alexanderson, in February, 1913, possessed their knowledge of the prior art, it seems to me very doubtful if he would have claimed selectivity as he did.

I am, therefore, of the opinion that during the last months of 1912 and the early months of 1913 Schloemilch and von Bronk, in Germany, and Alexanderson, in America, working independently, produced devices for securing selectivity and sensitivity in a receiving set by precisely the same means.

The next question is, which device was prior in time. The application for patent No. 293,300 is dated February 9th, 1913. On that day at the latest the Schloemilch and von Bronk invention was completed. They, however, testify that it was completed some ten or fourteen days prior to February 9th, as it took that length of time to prepare the application papers for patent after the invention was completed. On February 5th, 1913, Alexanderson wrote a letter to A. G. Davis of the Respondent Company, in which after describing his invention as tuning by geometrical progression, he said:—

> "The device necessary to accomplish this is some form of high frequency relay "which enables one high frequency current to control another high frequency "circuit, without the first circuit being influenced by the phenomena of the second "circuit. Such a relay is the incandescent rectifier where the flow of current in

In the Supreme Court of Canada.

No. 36. Reasons for Judgment. Lamont J. (Concurred in by Anglin C.J.C., Duff, Mignault and Smith JJ.) —*continued.*

"the local circuit is controlled by a potential introduced in the path of the radiating "energy."

At that time he had seen the DeForest "audion", but had been told it was too sluggish for his purpose. The matter of furnishing a suitable relay for high frequency currents was referred to Dr. Langmuir, the Respondent's expert, who proceeded to ascertain if one could be made which would work. The actual construction of the relay was allotted to W. C. White.

On March 8th, 1913, Alexanderson wrote to Dr. C. F. Steinmetz, as follows :—

"I am sending you a report on investigations which have been made on characteristics of tuning circuits. It appears that the method of tuning in geometrical "progression is much superior to the ordinary method of tuning for wireless purposes.

"In order to make use of this system it is necessary to have a relay for high "frequency currents and it is probable that such a relay can be made on the principle "of the incandescent rectifier which is already used under the name of 'Audion' "in the wireless art, although in its present form it is too sluggish for relaying one "high frequency current to another current of the same frequency. However, "with the improvements that the Research Laboratory expect to make on the "construction of the 'Audion' this difficulty is expected to be overcome."

Under date of May 9th, 1913, the following entry appears in Dr. Langmuir's laboratory book :—

"*Audions.*

"This morning Alexanderson and Davy came over and I showed them several "Audions that White has made up. It was arranged that White and I should "test them out with Alexanderson's alternator to see if there is any sluggishness, "i.e., whether they will give a frequency in the relayed current equal to that in the "primary and of increased energy."

This increased energy sought for was nothing more or less than amplification. On May 14th, 1913, in a letter to W. W. Sage, of the Respondent's patent department, Alexanderson says :—

"Dr. Langmuir demonstrated to-day to Mr. Hawkins and myself a vacuum "tube relay of the incandescent type, which proved to be sensitive enough to respond "to the relay for alternating current up to 100,000 cycles, and probably much higher "if such frequencies had been available."

And on May 18th, 1913, Langmuir's note book, after recording a series of experiments, contains this entry :—

"Tuning by geometrical progression according to Alexanderson's scheme "is an accomplished fact."

At the trial Dr. Alexanderson was called and gave the following testimony :—

"Q. But is it not a fact, as I gathered from this correspondence, that at the "time you and Dr. Langmuir both thought that the audion as it then existed was too "sluggish for your purpose ?—A. The opinion had been expressed that it was "too sluggish for my purpose.

* * * * * * *

"Q. Were you and Dr. Langmuir not under the impression that that suggestion "was well founded ?—A. I cannot say for Dr. Langmuir just what he had in his "mind ; but I had perfect confidence that if it were so with the DeForest audion, "Doctor Langmuir could correct the matter.

" Q. That is precisely my understanding. You had great confidence, may " I say the greatest confidence, in the ability of Dr. Langmuir to perfect an audion " which would work—is not that true ?—A. Yes.

" Q. And you passed it on to him for that purpose as it were ?—A. Yes.

" Q. But he says that he himself did not know then that the DeForest audion " would work at high frequencies,—am I right in understanding that you also did " not know of that ?—A. I did not know it.

* * * * * * *

" Q. Is not the situation very plainly summed up, the extent of your knowledge, " in this letter to Doctor Steinmetz of the 8th March, 1913, where you say that " ' In order to make use of this system, it is necessary to have a relay for high fre- " ' quency currents and it is probable that such a relay can be made on the principle " ' of the incandescent rectifier which is already used under the name of " Audeum " " ' in the wireless art, although in its present form it is too sluggish for relaying " ' one high frequency current to another current of the same frequency. However, " ' with the improvements that the Research Laboratory expect to make on the " ' construction of the " Audeum," this difficulty is expected to be overcome.' " Does not that very accurately describe the situation as you understood it on the " 8th March ?—A. If I had been very careful in wording that letter I might have " said, instead of saying that it is too sluggish, ' it is alleged to be too sluggish.'

* * * * * * *

" MR. HENDERSON : And, as I say, with that correction that would have " completely represented your knowledge and understanding at that time ?— " A. I think so.

" Q. And it would really be a very accurate statement of your understanding " at that time ?—A. I think so."

In view of this testimony and the documentary evidence it seems to me idle to contend that on February 9th, 1913, Alexanderson had, or thought he had, a completed invention for which the Respondents afterwards received the patent which in this action they claim has been infringed. In my opinion Alexanderson's invention was not completed until May, 1913, when Dr. Langmuir had constructed audions which when tested were found to give a frequency in the relayed current equal to the incoming oscillations. Alexanderson's device was therefore, in my opinion, anticipated by Schloemilch and von Bronk.

Having reached this conclusion it is unnecessary to consider whether or not either of the inventions added anything to the prior art, for Alexanderson's device having been anticipated by Schloemilch and von Bronk, Patent No. 208,583 cannot be upheld as valid, and the Appellants are therefore not liable for infringing it.

I would allow the appeal with costs, set aside the judgment below and enter judgment for the Appellants with costs.

In the Privy Council.

No. 37.
Order in Council granting special leave to appeal to His Majesty in Council, 30th July, 1928.

No. 37.

Order in Council granting special leave to appeal to His Majesty in Council.

At the Court at Buckingham Palace

This 30th day of July, 1928.

Present,

The King's Most Excellent Majesty.
Lord President.
Earl of Onslow.
Chancellor of the Duchy of Lancaster.
Mr. Davidson.

Whereas there was this day read at the Board a Report from the Judicial Committee of the Privy Council dated the 19th day of July 1928 in the words following, viz.:—

" Whereas by virtue of His late Majesty King Edward the Seventh's Order in Council of the 18th day of October 1909 there was referred unto this Committee a humble Petition of the Canadian General Electric Company Limited in the matter of an appeal from the Supreme Court of Canada between the Petitioners Appellants and Fada Radio Limited Respondents setting forth (amongst other matters) that the Petitioners instituted an Action against the Respondents in the Exchequer Court of Canada on the 23rd October 1926 for an injunction and other relief in respect of the infringement by the Respondents of a patent of invention (No. 208,583) issued to the Petitioners on the 15th February 1921 on an invention made by Dr. E. F. W. Alexanderson one of the senior members of the General Electric Company's research staff at Schenectady New York: that the Respondents denied infringement and alleged the invalidity of the patent on the grounds of lack of utility lack of subject matter and anticipation: that the issues so raised were tried before the Exchequer Court and on the 14th April 1927 judgment was given in favour of the Petitioners: that the Respondents appealed to the Supreme Court which Court gave judgment on the 7th February 1928 allowing the Appeal and dismissing the Action: that the invention in question consists of an apparatus for the reception of wireless signals in which by means of a special mode of connecting circuits and vacuum tubes to an aerial it is possible out of many high frequency signals impinging on the aerial to select a particular signal consisting of a series of ether vibrations of the given high frequency desired and to transmit it by repetition to a detector with undiminished strength so that variations at frequencies within the range of audibility which have been impressed upon it at the sending station may be converted into air vibrations of equal frequency and so made audible: that in the United States and in Canada delicacy of selection is of exceptional importance owing to the large number of competing broadcasting stations and the arrangement Alexanderson proposed is specially effective in securing the elimination of nearby or strong signals and the reception of competing distant or weak ones : that it is accordingly incorporated in all but the simplest receiving sets and is found in perhaps 90 per cent. of all sets in use ; that a United States patent to Alexanderson corresponding to the Canadian patent in question has been the subject of litigation in the United States and questions similar to those now under consideration have been dealt with in *Radio Corporation of America* v. *Splitdorf Electrical Company* (1926) 14 Fed. 2d. 643 and in *Radio Corporation of America* v. *Edmond* (1927) unreported : that in both cases the validity of the Petitioners' patent was upheld : that in each an appeal was taken but not proceeded with each Defendant taking out a licence under the patent : And humbly praying Your Majesty in Council to order that the Petitioners shall have special leave to appeal from the Judgment of the Supreme Court of the 7th February 1928 and that Your Majesty may be pleased to make such further or other Order as to Your Majesty in Council may appear fit :

" The Lords of the Committee in obedience to His late Majesty's said Order in Council have taken the humble Petition into consideration and having heard Counsel in support thereof and in opposition thereto Their Lordships do this day agree humbly to report to Your Majesty as their opinion that leave ought to be granted to the Petitioners to enter and prosecute their Appeal against the judgment of the Supreme Court of Canada dated the 7th day of February 1928 upon depositing in the Registry of the Privy Council the sum of £400 as security for costs.

" And Their Lordships do further report to Your Majesty that the authenticated copy under seal of the Record produced by the Petitioners upon the hearing of the Petition ought to be accepted (subject to any objection that may be taken thereto by the Respondents) as the Record proper to be laid before Your Majesty on the hearing of the Appeal."

His Majesty having taken the said Report into consideration was pleased by and with the advice of His Privy Council to approve thereof and to order as it is hereby ordered that the same be punctually observed obeyed and carried into execution.

Whereof the Governor-General or Officer administering the Government of the Dominion of Canada for the time being and all other persons whom it may concern are to take notice and govern themselves accordingly.

M. P. A. HANKEY.

In the Privy Council.

No. 74 of 1928.

On Appeal from the Supreme Court of Canad

BETWEEN

CANADIAN GENERAL ELECTRIC COMPANY, LIMITED (*Plaintiff*) *Appellai*

AND

FADA RADIO, LIMITED (*Defendant*) *Responde*

RECORD OF PROCEEDINGS.

VOL. I.

PLEADINGS, EVIDENCE AND JUDGMEN

LAWRENCE JONES & CO.,
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