THE

RADIO REVIEW

A MONTHLY RECORD OF SCIENTIFIC PROGRESS IN RADIOTELEGRAPHY AND TELEPHONY

VOL. II DECEMBER, 1921 NO. 12

Editor:
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THE

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Editorial.

The Natural Frequency and Self-capacity of Coils.—At a paper on the calibration of wavemeters read before the Physical Society of London in 1912 we showed that the self-capacity of coils could be allowed for to a high degree of accuracy by assuming a condenser of constant capacity to be connected across the terminals of the coil. It appeared somewhat surprising that this effective self-capacity was independent of frequency right up to the natural frequency of the freely oscillating coil, but subsequent tests made by various experimenters, notably by Hubbard, have fully confirmed this result. This fact simplifies very considerably the allowance which has to be made for the self-capacity of the coil. In our address as Chairman of the Wireless Section of the Institution of Electrical Engineers we have shown that if it be assumed that the current is distributed along the coil according to a sine law then the self-capacity must necessarily be independent of the frequency and dependent only on the radius of the coil, to which it is directly proportional, and on the shape of the coil. The capacity will also depend on any dielectrics of specific inductive capacity greater than unity which may be near the coil, *e.g.*, the insulation on the wire and the bobbin if any on which the coil is wound. If the current has a sine distribution, the charge on the coil must necessarily have a cosine distribution and the current and charge will have a simple relationship depending on the frequency. For a coil of a given ratio of length to diameter the E.M.F. induced in the whole coil by such a distributed current can be calculated; it will depend of course on the frequency. The E.M.F. must be equal however to the electrostatic P.D. between the ends of the coil due to the distributed charge, which can also be calculated. Now there is only one frequency at which the E.M.F. can be equal to the P.D. and that frequency which one thus obtains is the natural frequency of the coil. Strictly speaking, the current and charge must have such a distribution along the coil that the E.M.F. and P.D. neutralise each other over every section of the coil and not merely at the terminals and this is the criterion of the correctness of the assumed distribution. On the assumption of a sine distribution a formula can be established for the capacity which connected across the coil gives the effect of the self-capacity, and this formula is independent of the frequency employed. Another fact which is of interest is that the calculated effective self-capacity varies very little with the length of the coil, if the diameter is kept constant, which agrees with the result of experiment.

Y Y

The High-frequency Resistance of Coils.—Papers of a theoretical character read before the Royal Society are apt to be overlooked by those engaged in the design and construction of apparatus; we therefore wish to draw special attention to a paper read in June by Mr. S. Butterworth, of the National Physical Laboratory, on the high-frequency resistance of coils. After a somewhat complex mathematical analysis of the losses occurring in a cylindrical wire situated in an alternating magnetic field the results are applied to the losses in coils and very important practical results are obtained which are compared with measured values. Although some discrepancies of an interesting nature are found to exist between the calculated and the measured values, these detract little from the value of the results. Formulæ are given to enable one to choose the best shape and size of coil and the best stranding to employ to fulfil given conditions. Perhaps the most striking fact brought out in the paper is the excessive losses in the end turns of short coils. If the coil be divided into four equal sections, then of the total eddy current losses in the coil 93 per cent. take place in the two end sections and only 7 per cent. in the two middle sections. Tests made at the Imperial College by Mr. A. G. Warren on the initial rise of temperature of the various turns on first switching on the current gave similar results. It shows that great care is necessary in deducing high-frequency resistance from single thermojunction measurements on coils since the temperature distribution with A.C. is likely to differ considerably from that with D.C. A point of considerable academic interest is that the two inner sections of the coil have the higher effective resistance, since they act as the primary of a transformer of which the two outer sections constitute the secondary and the excessive losses in the latter cause an excessive effective resistance in the former. Mr. Butterworth shows that the end turns may even have a negative effective resistance in spite of the large losses occurring in them.

The Transmission of Wireless Signals between Toulon and Tahiti.*

By Lieutenant M. GUIERRE.

Objects.

The objects of the radiotelegraphic investigations carried out by the s.s. *Aldebaran* were to receive and measure the strength of the special signals sent out by the radio stations at Lyons–la Doua (French Army), and Nantes–Basse Landes (French Navy).

The research was particularly concerned with :—

(1) The reception of radio signals in the Indian Ocean, with a view to establishing the laws of wave propagation over an almost completely continental path ;

* Abstracted from the *Bulletin de la Société Francaise des Électriciens*. See RADIO REVIEW Abstract No. 2774 in this issue, for references.

(2) Reception at ranges of 7,000 to 10,000 km ;
(3) Comparison of day and night ranges ;
(4) Reception in the neighbourhood of Noumea and the Antipodes ;
(5) Investigation of the field strength at Tahiti (the waves travelling almost completely over sea).

Route.

The route followed by the sloop *Aldebaran* during the six months' voyage was as follows : Toulon, Port-Said, Djibouti, Mahé-des-Seychelles, Diego-Suarez, Saint Denis (Reunion), Mahé-des-Seychelles, Colombo, Singapore, Bataira, Freemantle (West Australia), Melbourne, Auckland, Antipodes, Bluff Harbour (New Zealand, South Island), Auckland, Noumea, Loyalty Islands, Fiji Islands, Samoan Islands, Tahiti.

Aerials and Wavelengths.

The wavelengths used for the investigations were 9,000 and 11,000 metres for the transmissions from Nantes, and 15,100 metres for Lyons. The aerials of these stations had the following characteristics :—

Lyons.—Inverted **L** antenna, with the horizontal portion in east-west direction, consisting of twenty copper wires 840 metres (2,750 feet) long, supported by eight towers 180 metres (590 feet 6 inches high). Width of aerial = 160 metres (525 feet). This antenna had the following constants : Static capacity, at 6,050 metres wavelength, $= 3{\cdot}9 \times 10^{-3}\,\mu\text{F}$; and at a wavelength of 15,600 metres,

$$R = 2{\cdot}1\,\Omega,\ C = 3{\cdot}7 \times 10^{-3}\,\mu\text{F},\ L = 1{,}875\ \text{mH}.$$

Nantes.—**T** antenna, having a horizontal part composed of ten wires with fan-shaped down leads in the centre ; height above the ground 180 metres (590 feet 6 inches) ; six towers ; length of horizontal part, 500 metres (1,640 feet), width, 200 metres (656 feet) ; capacity of the aerial $18 \times 10^{-3}\,\mu\text{F}$, inductance 125,000 cm. Series inductance for

$$\lambda = 9{,}100\ \text{m}, \qquad 1{,}100{,}000\ \text{cm}.$$
$$\lambda = 11{,}000\ \text{m}, \qquad 1{,}700{,}000\ \text{cm}.$$

Effective resistance of the antenna for

$$\lambda = 9{,}000\ \text{m}, \qquad 3\ \text{ohms}.$$
$$\lambda = 11{,}000\ \text{m}, \qquad 3{\cdot}6\ \text{ohms}.$$

Aldebaran.—Aerial consisted of two 6-wire cages 0·93 m (3 feet) diameter parallel with the deck. Total length of antenna = 37 m (121 feet 4 inches), height above deck = 23 m (75 feet) ; down leads formed by two small cages in **V** shape.

Signals and Hours of Transmission.

Continuous wave transmission by arc generators was employed. The aerial current at Nantes was 200 amperes, and at Lyons 185 amperes. The signals were sent out from Nantes at 0823 h, and 2023 h, G.M.T., on 9,000 metres, at 1023 h and 2053 h on 11,000 metres wavelength, and from Lyons at 0845 h G.M.T.

Previous Work.

It may be of interest to recall that M. H. Poincaré was the first to investigate the law of the decrease of the amplitude of the oscillations. This law as given by him was of the form $\epsilon^{-md/\sqrt[3]{\lambda}}$, d being the great-circle distance from the transmitter, λ the wavelength, and m an appropriate factor. As a result of the investigations of March, corrected by von Rybczinski, this law takes the form of a product of two terms, one being $2/A\sqrt{\theta}\sin\theta$, and the other Poincaré's exponential, θ being the angle which the two stations subtend at the centre of the earth.

The only practical verification of these theoretical results was made by Austin over ranges up to 3,700 km over sea, who derived the formula.

$$I_R = 4{\cdot}25\, I_S \frac{h_r h_s}{\lambda D}\, \epsilon^{-0{\cdot}0015D/\sqrt{\lambda}}$$

This formula is the only one now used in the design of radio stations, but the measurements made by the *Aldebaran* show that it is inaccurate for long ranges.

Method of Measurement.

The possibility of effecting reliable measurements of signal strength on board ship is due to an application of a method due to M. de Bellescize.

(1) *Object of the Method.*—To investigate the variation of the electromagnetic field set up by a station transmitting with constant power and wavelength, as a function of the distance. In all the measurements carried out on board, the inductive effect of the field under investigation on an open aerial was compared with the induction from a local transmitter under the control of the receiving operator. All measurements are relative, and are referred to an arbitrary but invariable scale.

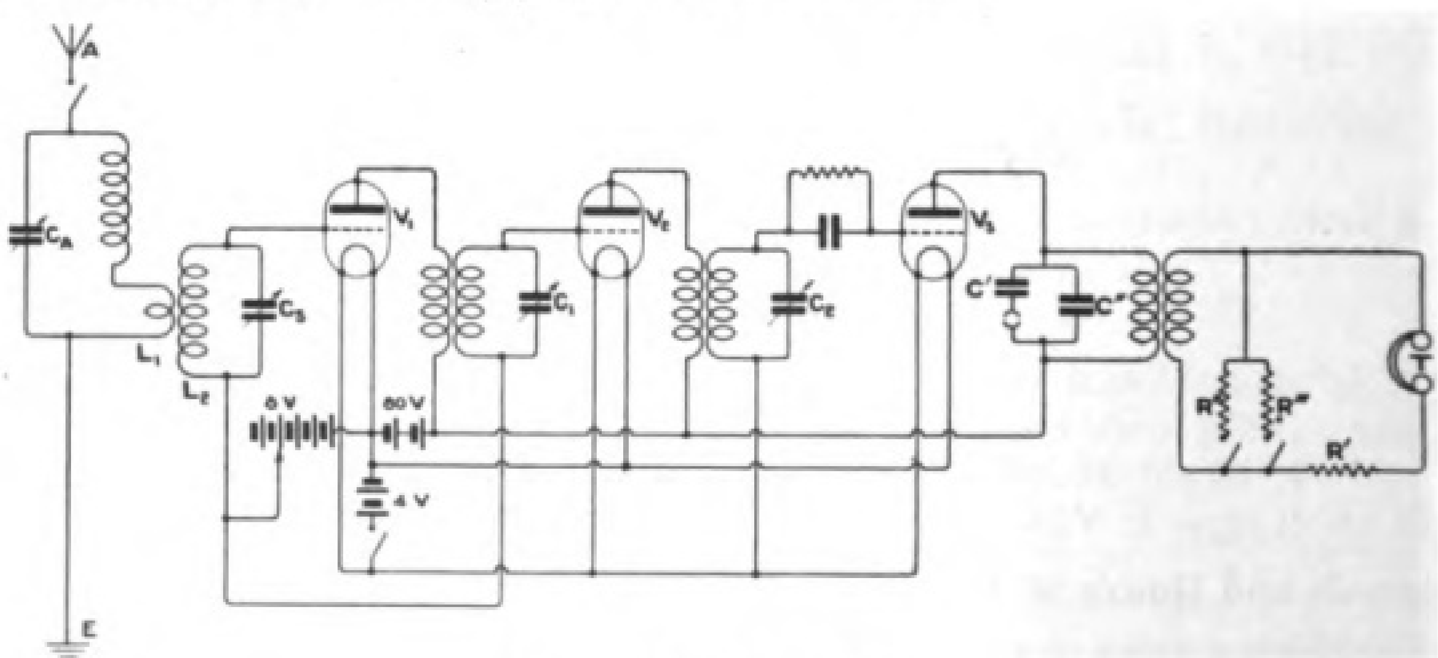


FIG. 1.—Receiving Circuits.

(2) *Arrangement of Apparatus.*—The receiver (Fig. 1) consisted essentially of an inductive coupling L_1L_2 between the receiving aerial A and the two-

stage amplifier V_1V_2. The detecting valve V_3 is interposed between this amplifier and the receiving telephones T. The coupling between L_1 and L_2 can be varied over wide limits by sliding the primary along a graduated scale. The telephones T are shunted by a variable resistance (R″ or R‴) with a resistance R′ of 2,500 ohms placed in series; and the circuit is suitably earthed in order to keep the static potential constant and to eliminate currents in the telephone receivers due to their capacity to the operator and earth—such currents interfere with the measurements made with small values of shunts R″, R‴. The transformer primary is shunted by a capacity $C' + C''$, the condenser C′ being put in or out of circuit by means of a plug; on removing the plug, the sensitiveness of the amplifier is increased, but so also is the tendency to oscillate. A heterodyne not shown in the figure completes the arrangement for the reception of undamped waves.

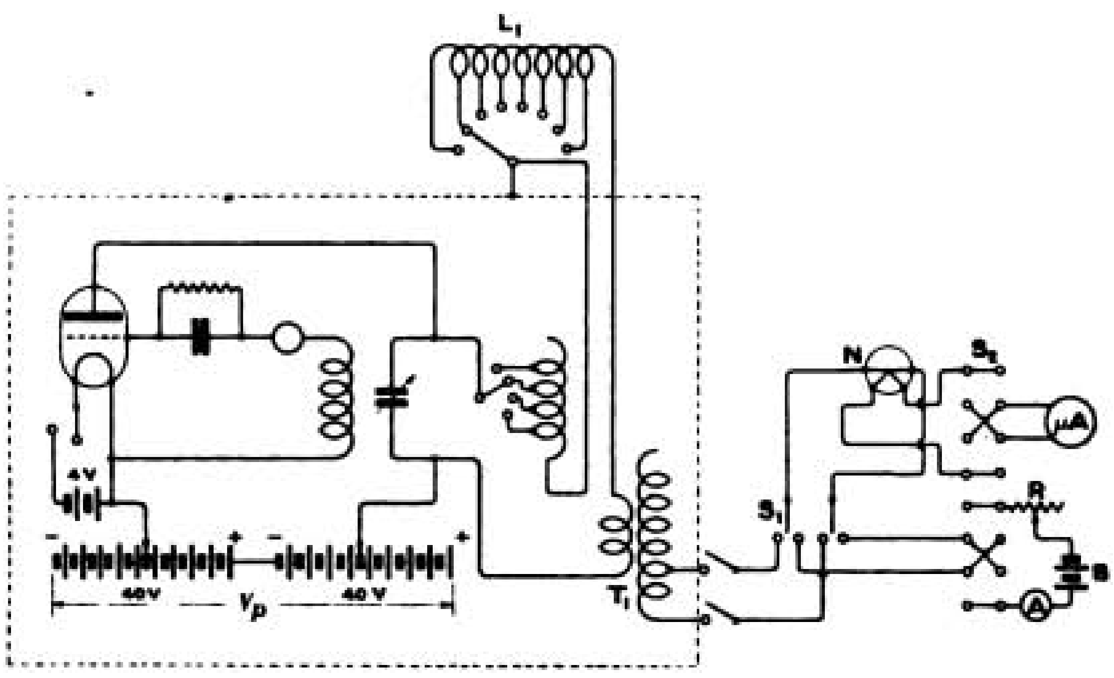


FIG. 2.—Arrangement of Auxiliary Transmitter.

The auxiliary transmitter (Fig. 2) employs an oscillating valve and is suitably screened, with the exception of the coil L_1 which comprises the radiating part of the transmitter. The number of turns n in this coil is adjustable between 1 and 8.

The screen is connected to a point on the coil by a short wire of very low resistance; the radiation from the coil may be stopped by a short circuiting switch. Calling the effective oscillating current in the auxiliary transmitter i_a its inductive effect Z is represented, for constant wavelength, by the product ni_a. The current i_a may be adjusted by varying the plate voltage V_p, between the limits 8 and 80 volts. The distance between the coil L_1 and the antenna is so adjusted that with the receiver at its maximum sensitiveness, and the product ni_a at its minimum value, the radiation from the auxiliary transmitter can just be heard.

Each measurement consists in the adjustment of the two transmitters under comparison (namely, the signals from the station under investigation and those from the auxiliary transmitter) so as to produce the same effect on the telephone. The sensitiveness of the receiver should of course remain constant throughout the test. Consequently the following ought to be practically constant during the measurements :—

Inductive coupling between aerial and secondary circuit.
Tuning of circuits.
Impedance of the plate circuit of last valve.
Sensitiveness of the detector.

These last conditions may be attained as follows. The shunts R″ and R‴ should be of the same value, and small compared with the series resistance R′; the coupling between the heterodyne and the receiver should be sufficiently close so that the rectifying effect of the detecting valve is linear.

When, however, the impedance of the shunts R″ or R‴ is small compared with that of the telephone T, the strength of the signal due to the auxiliary station will remain constant if it is equal to the product of Z and the telephone shunt; this provides a means for testing proper adjustment of the apparatus.

During a reading, the station to be tested and the auxiliary station transmit alternately continuous dashes of ten seconds duration on exactly identical wavelengths. The operator makes the following adjustments to equalise the signal strengths :—

Adjustment of the auxiliary inductive effect Z which is proportional to ni_a; adjustment of shunts R″ and R‴ so that the shunt R″ used with the field Z gives the same strength as when the shunt R‴ is used with the test signals. The strength of the latter is then $ni_a \frac{R''}{R'''}$. This is reduced if necessary to refer to a constant current of 200 amps in the transmitting aerial.

(3) *Investigation of the Inductive Field Z and of the effect of the Telephone Shunts.*—(*a*) Measurement of the oscillatory current i_a in the auxiliary transmitter.

This measurement is effected by means of a continuous current micro-ammeter μA (0—150 micro-amps) connected through a transformer T_1 and the thermo-element N (Fig. 2).

Two switches S_1 and S_2 enable the standardisation of arrangement to be effected by means of continuous current from the battery B. This current may be adjusted by a resistance R and is read on a milliammeter A. In order to determine the current i_a as a function of the plate voltage V_p the following operations must be carried out :—

(1) Standardisation of the thermojunction by continuous currents. For this purpose the switch S_1 is thrown over to connect in the battery B and the resistance R is adjusted to a convenient value. The continuous current i is read on a milliammeter and the two successive deflections δ_1 and δ_2 of the microammeter are read for the two positions of the switch S_2. The continuous current i_c given by the thermoammeter under the influence of an alternating current i_a assumed equal to i, will therefore be $i_c = \frac{\delta_2 - \delta_1}{2}$. The curve of

$i_a = \phi(i_c)$ can then be plotted between the possible limits of observation—that is $\delta_2 < 150\ \mu A$. Normally i_c is approximately proportional to i_a^2.

(2) Standardisation of the current i_a as a function cf the plate voltage V_p. For these measurements the switch S_1 is thrown over to connect in the transformer T_1. The voltage V_p is read on a voltmeter and the current i_a is determined from the reading i_c of the microammeter by means of the curve which has already been plotted. Prolonged tests have shown that with a constant filament temperature and between the limits of 8 and 80 volts with a given value, the alternating current is stable and is approximately proportional to V_p.

(*b*) Relation between the telephone shunt and the local current i_a for constant sound in the telephone.

The induction from the local transmitter is evidently proportional to the oscillating current producing it. This means that if the receiver is properly adjusted (see § 2) the telephone shunt R' (or R'') ought to be inversely

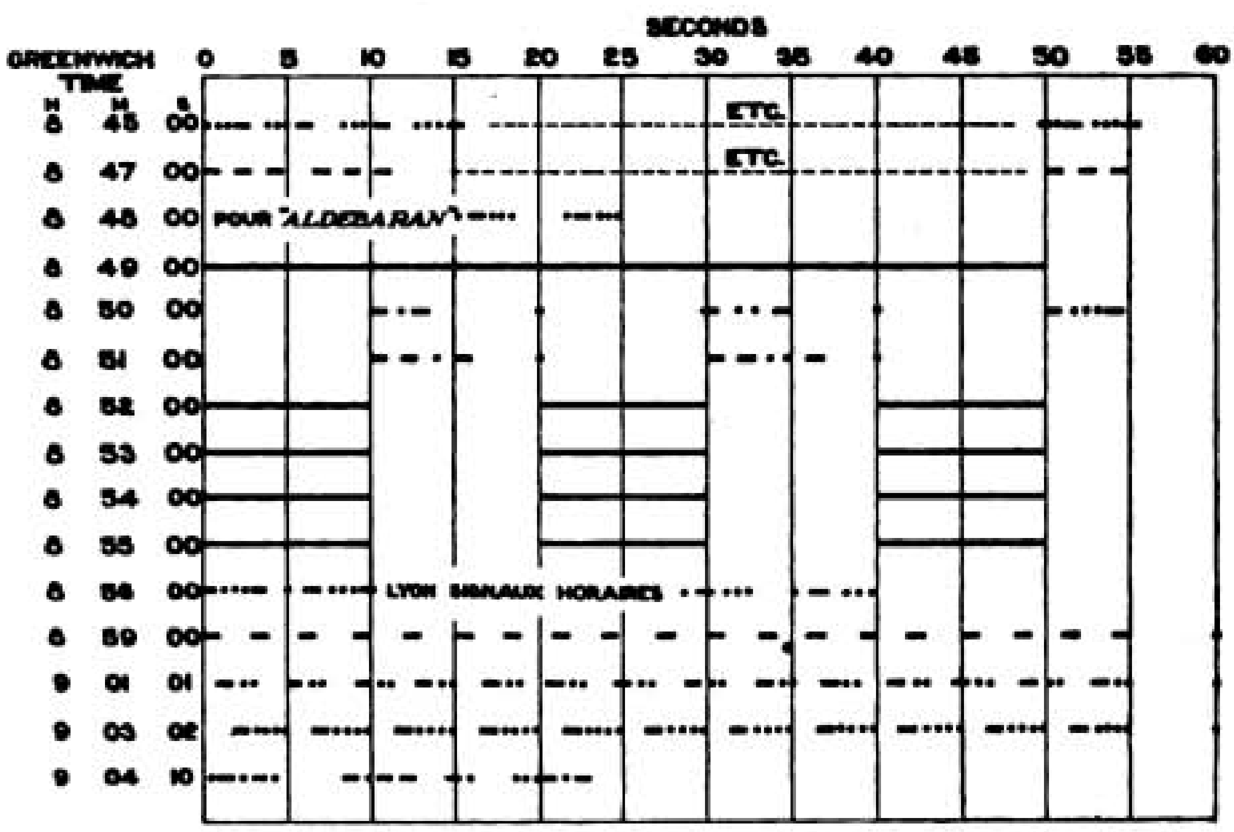


FIG. 3.

proportional to i_a for constant sound in the telephone. The experimental verification of this statement is difficult since each variation of the plate voltage introduces a considerable change in the transmitted wavelength, and consequently also in the received heterodyned beat note. This difficulty is overcome by retuning the transmitter for each value of V_p and of i_a so as to produce the loudest sounds in the receiver which is maintained at a constant adjustment. Complete silence is necessary for successful results and each measurement is obtained as a result of a large number of readings.

(*c*) Effect of number of turns n.

Assuming that the potential of the coil J is maintained constant by an earth connection the inductive effect is proportional to n. Hence if the receiver is properly adjusted (see § 2) the telephone shunt R'' (or R''') should be inversely proportional to n for a constant sound in the telephones. This may be checked for any two values of n such as n_1 and n_2 by finding the appropriate shunts R'' and R''', for constant sound. The adjustments of the coil J and of the telephone shunt should be effected simultaneously as the accuracy of the measurements depends largely on the continuity of the impressions received by the operator. These measurements which may be easily and quickly carried out should be repeated from time to time as a check on the proper adjustment of the apparatus.

Tests (*b*) and (*c*) above were carried out before the departure of the *Aldebaran* for shunts between 5 and 150 ohms, as it was thought unwise to use values outside these limits.

(4) *Tests* (*Basse Landes and Lyons*).—The station under investigation made the following transmissions (Fig. 3) :—

(*a*) Starting period during which rough adjustments of the receiver were made.

(*b*) A series of V's for fifty seconds used first for adjustment of the heterodyne and afterwards for the exact adjustment of four condensers C_A, C_S, C_1, C_2 (Fig. 1). The strength of the spacing wave was always adjusted to be less than that to be received from the local transmitter. For this purpose, at small and medium distances (probably up to 3,000 km) the local radiation was adjusted to its maximum value and the heterodyne tuned to give complete extinction of the spacing wave. The note thus obtained for the marking wave is lower than that corresponding to maximum sensitiveness of the receiver, but as the signals are very strong under these conditions no difficulty was experienced. At greater distances when the receiver signals became so weak that the auxiliary transmission and the signals could be equalised it became imperative to tune the heterodyne so as to obtain the strongest signals.

(*c*) A series of six dots each preceded by a distinctive signal for use in connection with the chronographs controlling the alternation of the dashes.

(*d*) The last four minutes were utilised for an uninterrupted series of ten-second dashes sent alternately by the station under investigation and by the local transmitter. During the first dashes the note of the auxiliary station was adjusted to equality with that of the incoming signals. The following dashes were used for equalising the strength by variation of the induction from the local transmitter and if necessary of the comparison shunts R″ and R‴. In order to avoid the variations of note which would be caused by switching on and off the filament current of the valve at the auxiliary transmitter the coil J was short circuited when it was required to stop the local radiation.

Value of the Method.

The long experience obtained in the use of this method enables us to testify to its excellence in practical operation. All the necessary operations—adjustment of tuning—starting of chronographs—equalisation of pitch and strength of sound—soon became habitual. A measurement by equalisation of two sounds is much more accurate than a measurement made by extinction of sound, since in the latter case serious errors are often made. The continued tests have shown that in the first case the personal error due to the observer should not exceed 15 per cent. The essential feature of this method is to ensure constant reliability of results in spite of variations in the sensitiveness of the ear. This renders it possible to change the operator.

Criticism of Results.

(A) ROUTE TOULON–REUNION–MELBOURNE.

During this voyage investigation was made of wave propagation over an almost entirely overland route: firstly Toulon–Reunion (9,350 km), then Toulon–Melbourne (17,200 km). The curves of the results give the type of variation of the strength of reception in terms of distance. Their examination shows:

(1) That the range at night was always greater than during the daytime; at the end of the journey Toulon–Reunion we were at the limit of daylight reception but the night signals were very easily readable in spite of storms. At the end of the Toulon–Melbourne test daytime reception was zero, night time reception very strong, and moreover each of these routes was at the time of transmission either entirely in daylight or entirely in darkness.

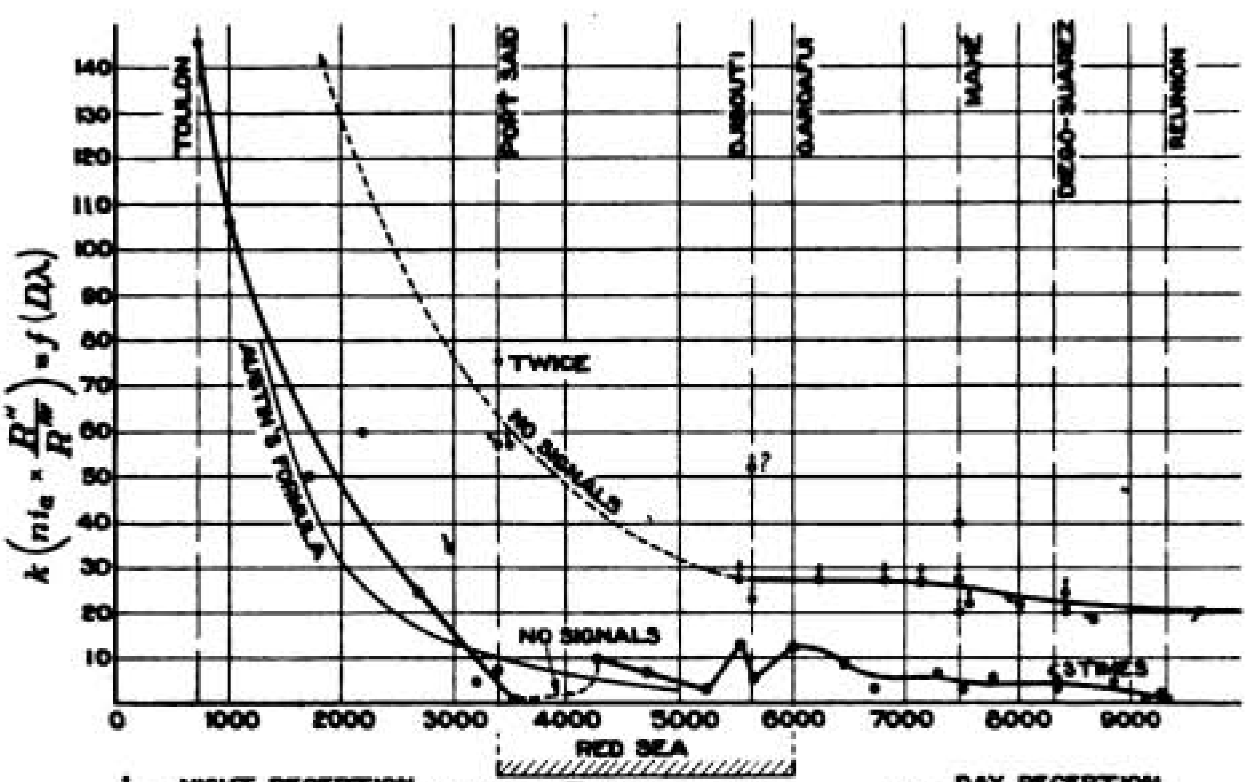


FIG. 4.—Curves of Received Signal Strengths between Toulon and Reunion. Transmission from Nantes on 9,000 m.

(2) That the variations in reception were greater by night than by day;

(3) That the signal strengths were in the order of the wavelengths—15,000, 11,000 and 9,000 metres;

(4) That the crossing of the Red Sea was accompanied by irregularities in the reception of 9,000 metre signals which were not experienced on 11,000 metres.

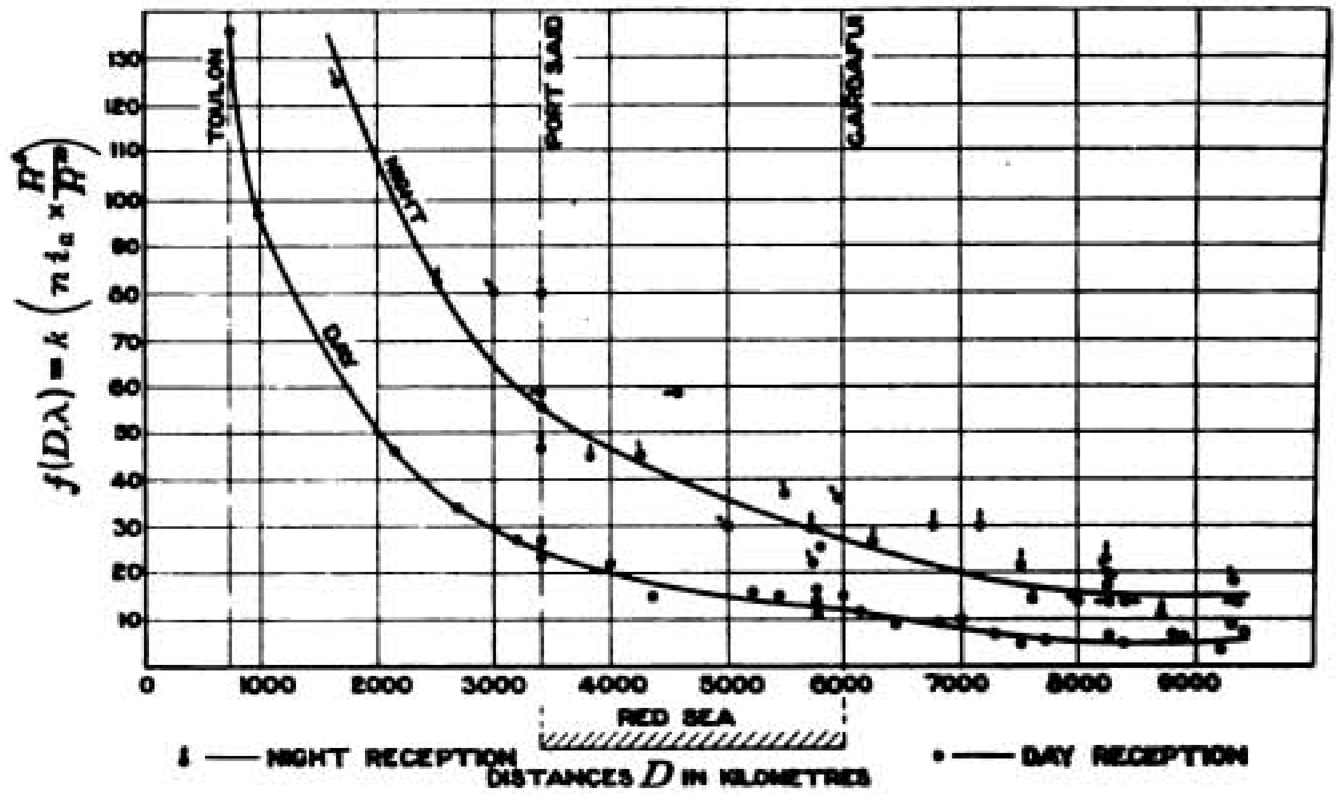


FIG. 5.—Received Signal Strengths between Toulon and Reunion. Transmission from Nantes on 11,000 m.

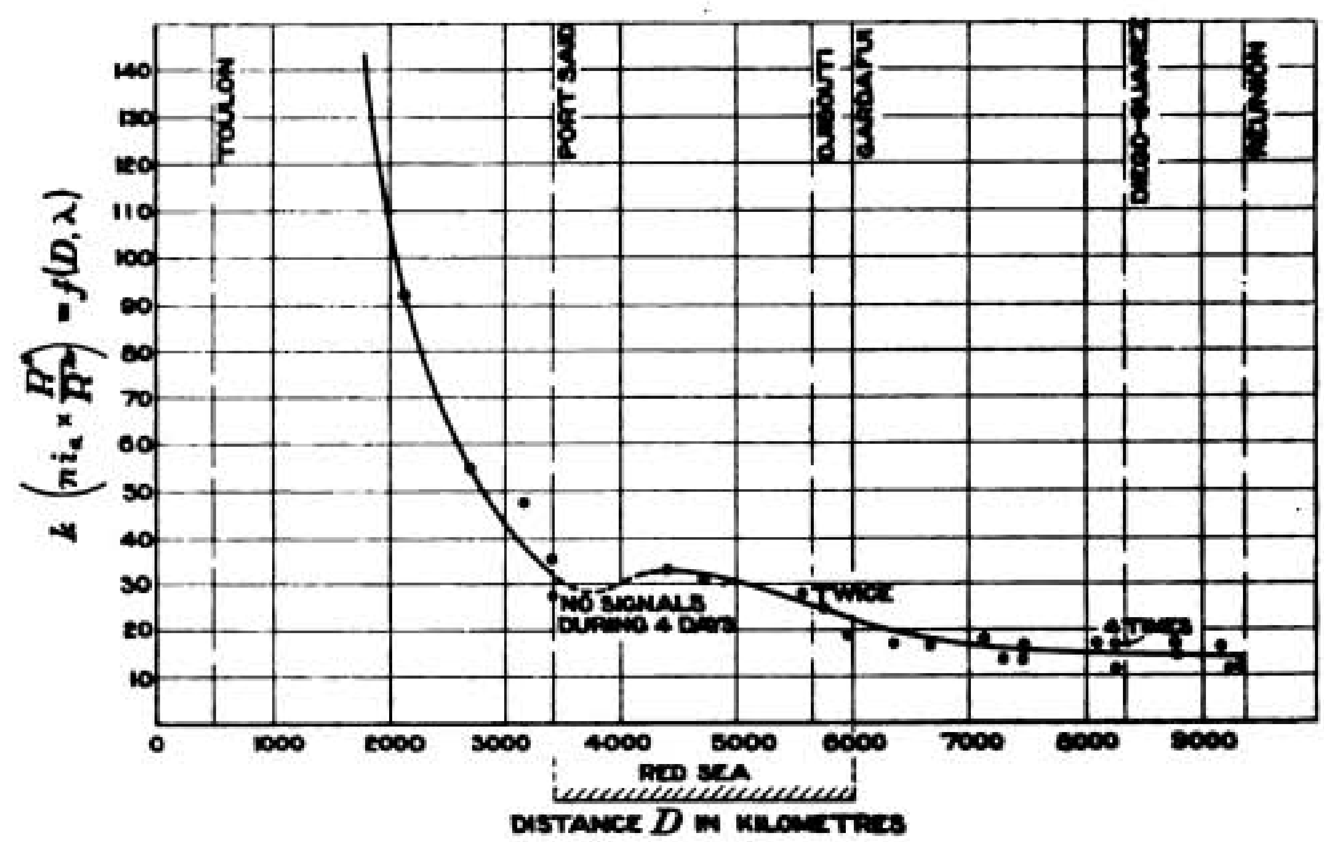


FIG. 6.—Received Signal Strengths between Toulon and Reunion. Transmission from Lyons on 15,000 m.

Alternative Graphical Representation of the Results.—The factor $f(D,\lambda)$ which is proportional to the received signal strength and which is plotted as ordinates of the preceding curves (Figs. 4—6) has the form

$$f(D,\lambda) = k\,\frac{\epsilon^{\gamma D/\sqrt{\lambda}}}{D},$$

the numerator of this fraction being the absorption coefficient. If we plot as ordinates for the curves not this function $f(D,\lambda)$ but its product by the distance D, we shall show up the variations in the absorption. On plotting these figures we obtain a series of points the separation of which indicates

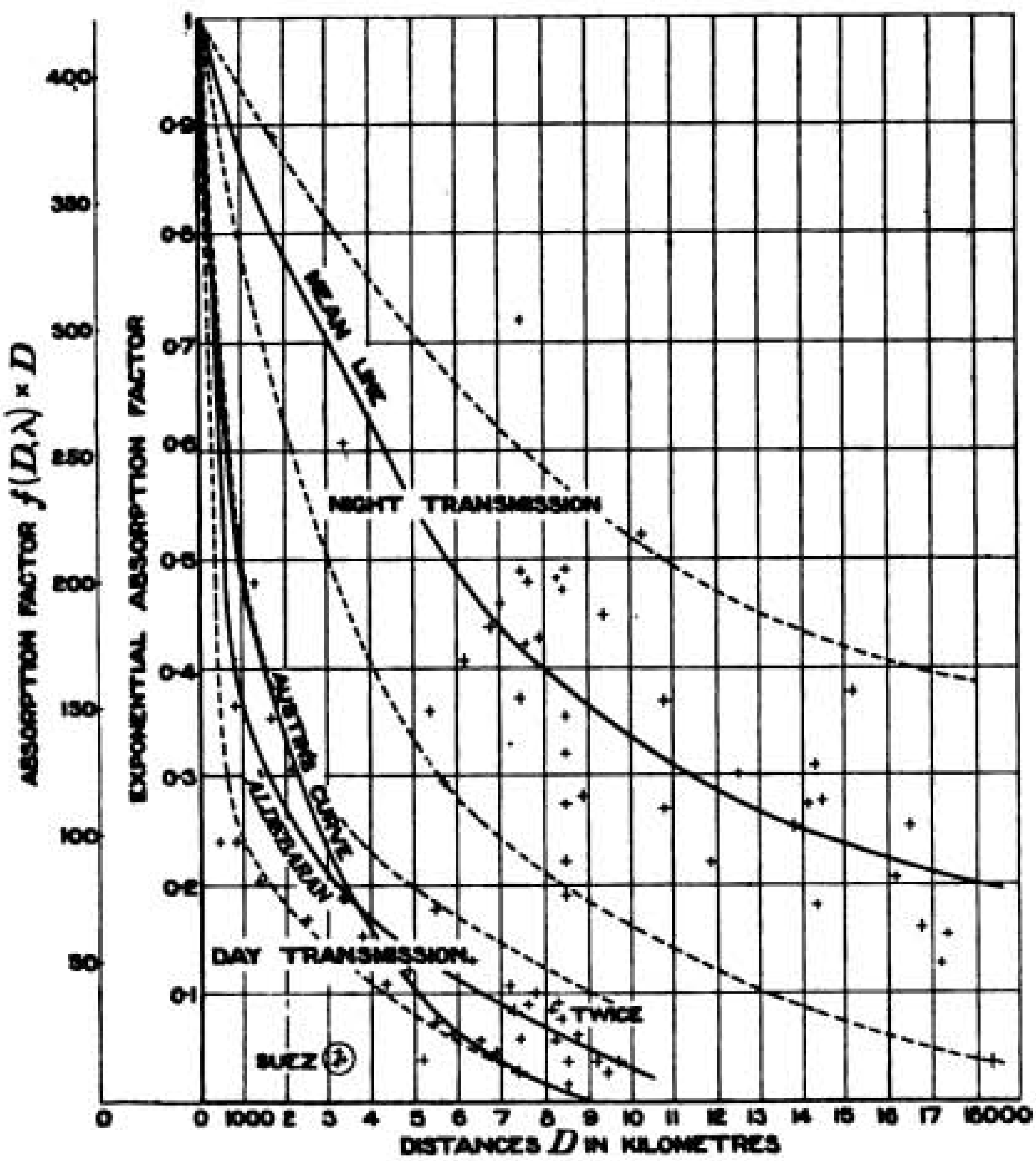


FIG. 7.—Curves for Transmissions from Nantes on 9,000 m. Absorption factors (reduced to 1,000 km) as functions of the distance.

the constancy of the transmission—a stability which can be defined by the ratio of the separation of the envelope curves of these points to the mean ordinate of those curves at any given value of D. The determination of the wavelength to be employed for communication over a given distance depends in fact on the relative and absolute values of these two factors. This method of plotting which was designed by M. de Bellescize has also the advantage of enabling a better determination to be made of the curves near their origin, since evidently at zero distance the exponential factor becomes unity, and our curves for night and day transmission should cut the axis of ordinates at this point.

Austin's Curves.—Points calculated by Austin's formula can be plotted out in a similar manner. From an examination of these curves, it is evident, apart from the above considerations:—

(1) That the absorption is less and at small distances varies less between night and day, and that at the limit of observations, the advantages of night transmission increase with the distance;

(2) That the constancy of transmission defined above is greater by night than by day;

(3) That Austin's formula gives inadequate results for ranges in excess of 4,000 km, and increasingly so the greater the wavelength;

(4) That, since at distances where it is no longer possible to count on reception, the signals still exist, although they are very feeble, the progress to be made lies rather in the direction of utilising this residual energy than in further increasing the power of the transmitting stations.

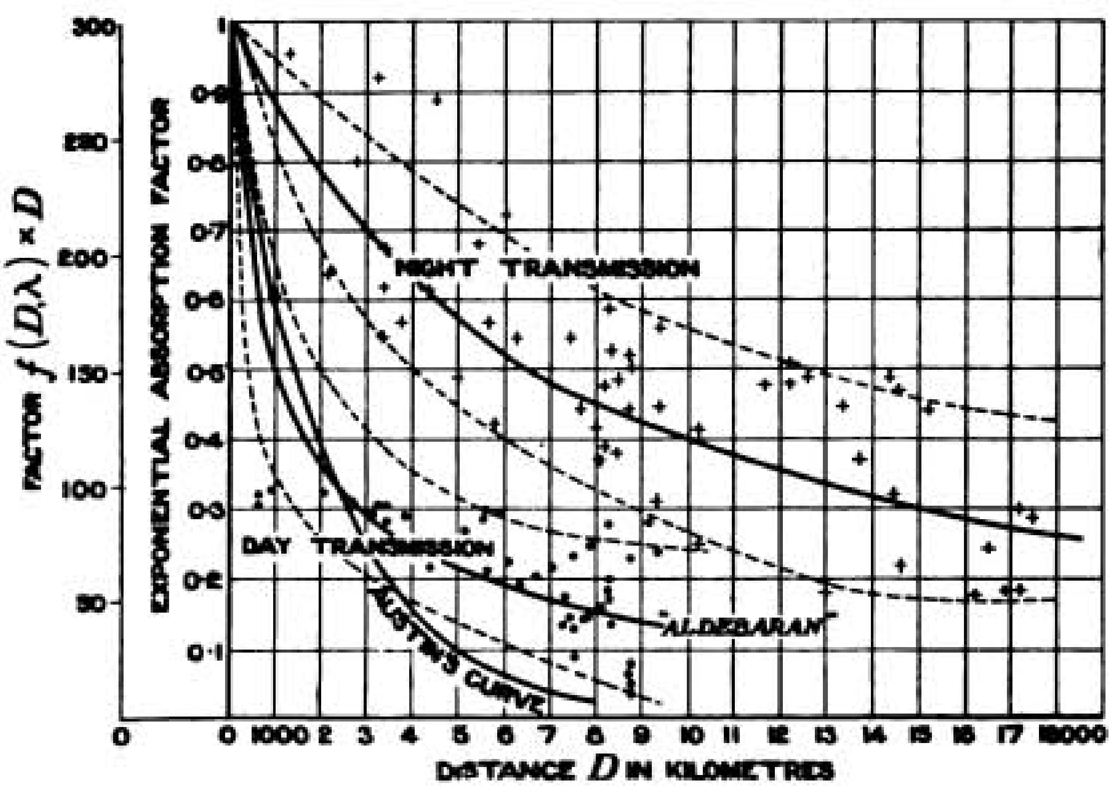


Fig. 8.—Curves for Transmissions from Nantes on 11,000 m, giving absorption factors (reduced to 1,000 km) as functions of the distance.

Experimental Results.—It does not appear that the atmospherics are uniformly stronger in tropical or equatorial regions that we have passed through than they are in our own latitudes, it is more a question of seasons and places, and in any case they were always stronger on a wavelength of 15,000 m than on those of 11,000 and 9,000 m.

On October 2nd, at Diego-Suarez (8,400 km) at 0823 G.M.T., Nantes was heard signalling to **FRI**, in spite of a slight storm. At St. Denis, Reunion (9,450 km), at 0823 G.M.T., Nantes was heard transmitting to **FRI**. These signals were readable except during storm maxima, and were verified by the log of the station. At these places the limit of daytime reception was reached and no regular service was possible using a ship's antenna, but the night reception of Nantes remained very strong. The log of signals received shows that on October 8th at 2023 G.M.T. at a distance of 9,450 km, very readable signals were received with the coupling loosened by 10 cm, in spite of a violent storm.

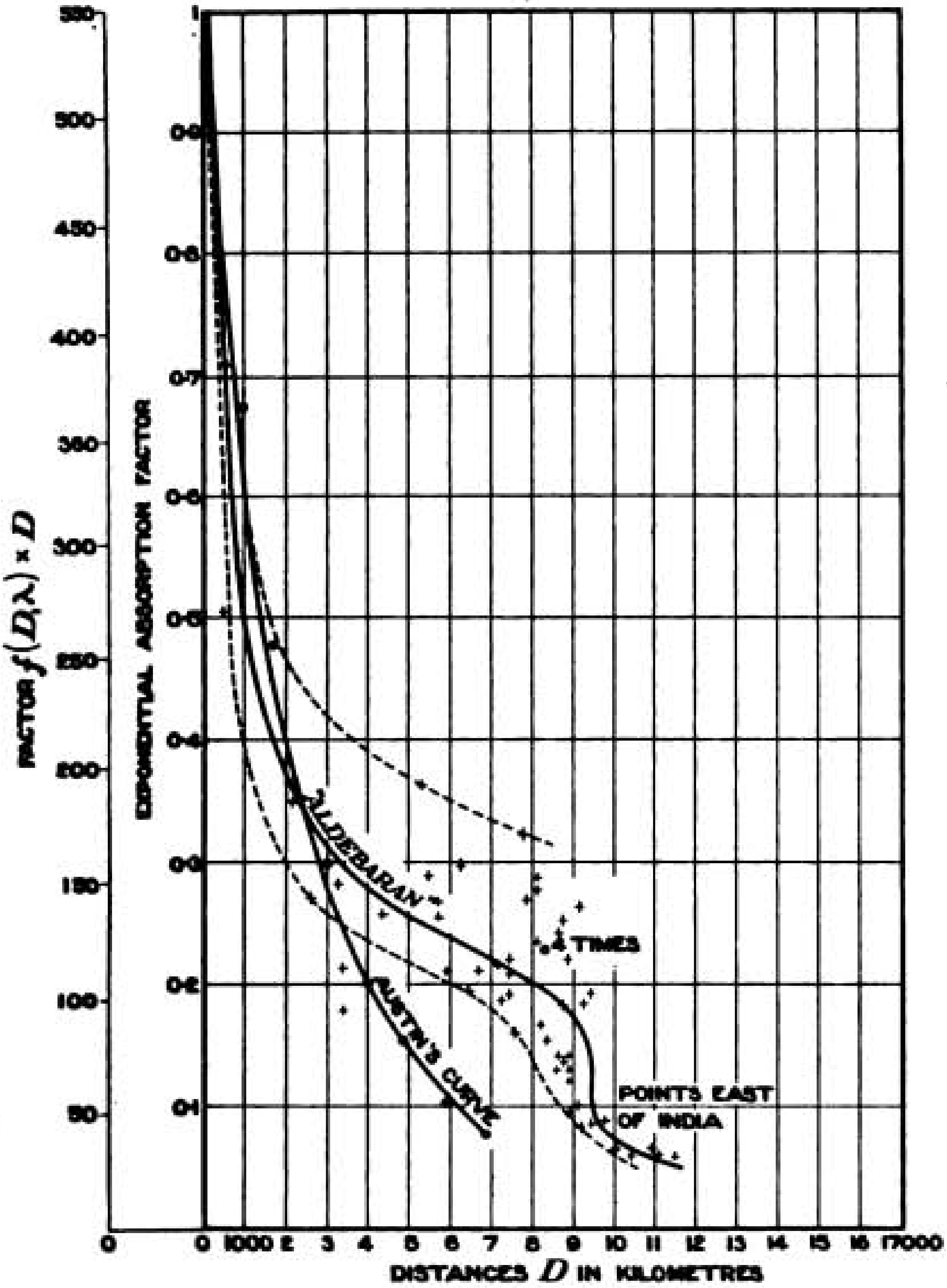


Fig. 9.—Curves for Transmissions from Lyons on 15,100 m, giving absorption factors (reduced to 1,000 km) as functions of the distance.

The reception of Lyons was excellent by day as well as by night, and at Reunion as at Diego-Suarez, communications were frequently received from this station by day or night. The messages from Lyons were read very easily at Melbourne (17,200 km) when they were sent at night.

(B) Investigation of Phenomena at the Antipodes.

The belief in an increase of potential at the antipodes has up to the present been based on formulæ, and on the particularly strong reception observed in New Zealand, and information furnished by the officers of that country indicate a much stronger reception in the south (at Awarua) than in the north (Awanui). According to Mr. Davis who has been in charge of the station at Awarua for a long time the Eiffel Tower has been heard by that station since 1917 between 6.30 and 7.30 a.m. local time, much stronger than any other European station—two to three times stronger even than Nauen. On the other hand the station at Awanui is reputed to have only mediocre reception.

The route adopted by our cruise of investigation was: Auckland, Chatham Is. (wireless station at 100 miles from the antipodes of Lyons), antipodes of Lyons; antipodes of Nantes; Bluff Harbour (a port near the Awarua radio station), Auckland.

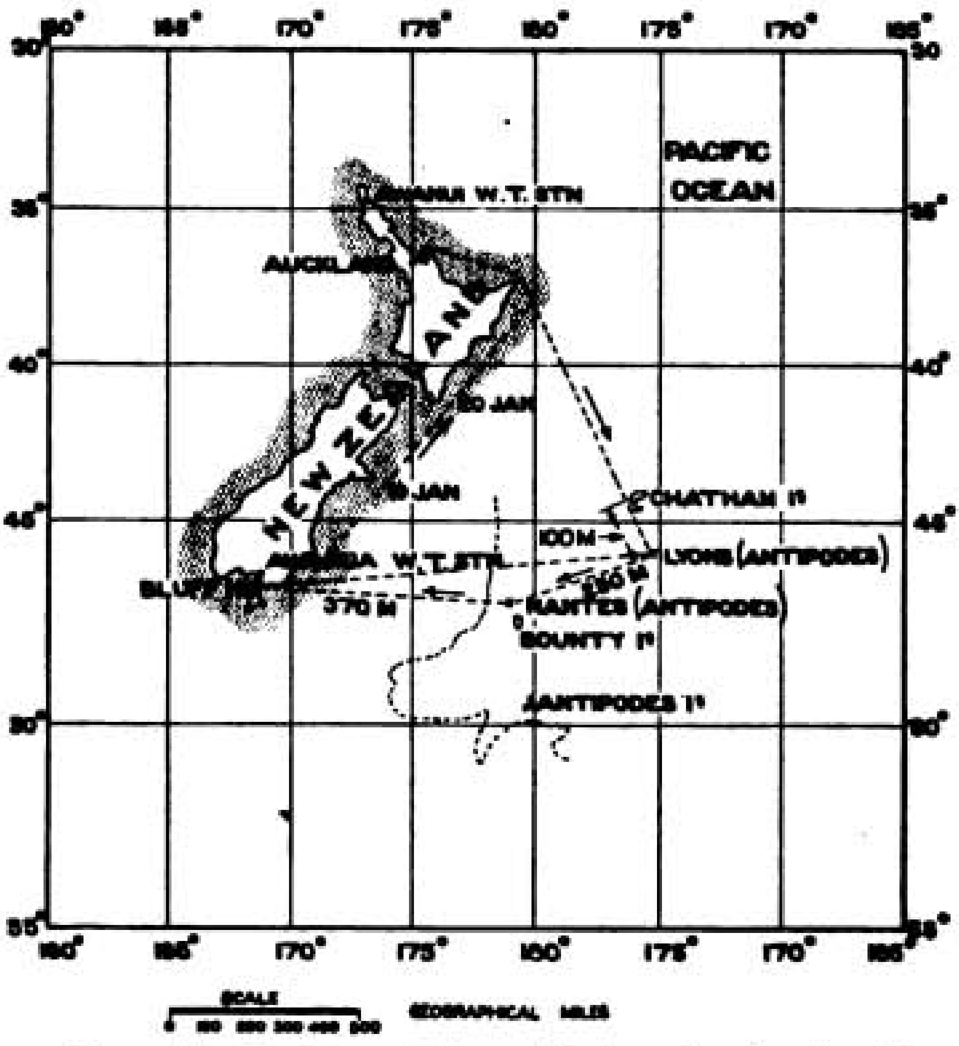


FIG. 10.—Chart showing Route followed in investigating the Phenomena at the Antipodes of the Transmitting Station.

All the figures which follow correspond to transmissions made with uniform intensity of 200 A for Nantes and 185 A for Lyons. It should be noticed that on January 2nd at Auckland the Nantes daily signals (on 9,000 metres) which had been lost after leaving Colombo, were again received; the daytime and night time signals were of very nearly identical strengths. This is easily explained, because transmissions made to the antipodes day and night at twelve-hour intervals arrive by practically the same paths (half the great circle is in darkness), one from the east and the other from the west.

The operators in the Chatham Islands state that during 1918 they often heard Lyons about two o'clock mid-day, on their T aerial 100 metres long and 45 metres high, using a valve detector without amplification.

However, at 100 miles to the north-west of the antipodes of Lyons, the *Aldebaran* only heard that station very faintly—coefficient 2·8.

On January 8th, at 0845 at the exact antipodes, in spite of rain which diminishes reception, Lyons was received with coefficient 11·5, and the message was taken down to the last letter. This strengthening only gradually diminished with increased distance to the south-west, and at Bluff Harbour, 570 miles from the antipodes, the coefficient was still 3·3, whereas it was 2·8 at 100 miles in the north-west of the antipodes.

The reception of Nantes on 9,000 metres gave rise to somewhat different phenomena.

At 120 miles to the north-west of the antipodes reception was no better than at Auckland ; at 25 miles it was 2·4.

On January 10th, at the exact antipodes, the Nantes signal at 0823 was received with strength 13·3 with very sharp tuning. But on the 11th at the same place and time this strengthening had disappeared, and the received strength was 1·9 ; in the west it diminished also, then increased at Bluff Harbour where it reached 2·8.

The bad working of Nantes on 11,000 metres prevented experiments on this wavelength.

The two wavelengths 15,000 m and 9,000 m seem to act differently, the first causing a strengthening at the antipodes, then a progressive falling off to the west, the second showing a strengthening at the antipodes and at Bluff with very weak reception between the two.

Strengthening of Nantes.—At the wireless station of Awarua (South Island) the aerial is of the Telefunken umbrella type, with one mast 140 metres high, twenty-four wires 50 metres long, having a fundamental wavelength of 1,390 metres. A single valve receiver without amplifier was used. Three consecutive nights spent at this station enable me to state that this station can easily receive the European stations ; in the evening Nantes, Lyons, Nauen and the Eiffel Tower could be heard with intensity proportional to the power of the stations sending ; but in the morning the Nantes signals on 9,000 metres could always be heard much better than any of the other signals, especially than the one from Lyons sent almost immediately afterwards.

The table of receptions drawn up by Mr. Willis, who is in charge of the station, emphasises this fact ; it is reproduced below.

The measurements made on board at the same time confirm these statements.

On leaving Bluff Harbour for Auckland, it was noticed that received strength decreased rapidly, although just at the head of Cook Straits one is nearer the antipodes than one is in the roadstead of Bluff Harbour.

Conclusions.—The phenomenon of the antipodes extends over a very restricted area (at least in the part explored) ; it is an interference phenomenon ; the position of nodes and anti-nodes ought to be constant while

RECEPTION IN NEW ZEALAND.

To Lieut. Guierre,
Aldebaran,
Auckland.

Radio Awarua,
20th January, 1920.

The following is a copy of the signals received during the visit of the French Wireless Mission to this station.

Date. 1921.	Time.	Wave-length.	Calls and Remarks.	Signal Strength.	Atmospheric Strength.
Jan. 15th	7.45 p.m.	9,000	**UA** sent routine	6	6
	8.15 p.m.	15,100	**YN** heard but X's too heavy. .	4	6
	4.40 p.m.	11,000	**UA** unheard (missed through commercial work) . . .	—	7
„ 16th	4.40 a.m.	12,600	**NNF** de **POZ** here note . .	7	6
	6.1 a.m.	4,000	**PSO** de **FL** note	6	6
	6.33 a.m.	15,100	**NFF** de **YN** messages . . .	5	6
	7.56 a.m.	9,000	**UA** sent routine and note for mission	9	6
	8.21 a.m.	15,100	**CQ** de **YN** French Press . .	5	6
	7.54 a.m.	9,000	**UA** sent routine . . .	5	5
	8.30 p.m.	15,100	**NFF** de **YN** note for **NSS** . .	4	5
	8.5 p.m.	12,000	**POZ** sending	4	6
	8.17 p.m.	15,100	**YN** sent routine. . . . :	5	7
„ 17th	4.30 a.m.	15,100	**YN** sent Press	5	7
	4.30 a.m.	12,000	**POZ** sending	7	
	6.50 a.m.	4,000	**IDO** and **FL** working . . .	7	6
	6.50 a.m.	12,000	**POZ** working **NFF**	7	6
	7.54 a.m.	9,000	**UA** sent routine. Very strong while tuning but was weaker for routine	9/8	5
	8.30 a.m.	11,000	No sign of **UA**	—	6
	7.53 a.m.	9,000	**UA** sent routine.	4	6
	8.15 p.m.	15,100	**YN** sent routine but unreadable .	3	7
	9.57 p.m.	11,000	No sign of **UA**	—	9
„ 18th	5.30 a.m.	12,000	**POZ** working	7	8
	6.15 a.m.	9,000	**IDO** de **FL** messages . . .	6	6
	7.31 a.m.	9,000	**IDO** and **FL** still working . .	6	6
	7.33 a.m.	9,000	**OSN** de **FL** remarks	6	6
	7.35 a.m.	9,000	**IDO** de **FL**. Continues working .	6	6
	7.50 a.m.	9,000	**UA** tuned but did not send routine	5	5

Signals are computed on the scale 1 to 9.

Yours faithfully,
A. L. M. Willis.

the wave remains the same, but the signal strength evidently depends on atmospheric conditions and on the distribution of land masses on the different routes. It is an unstable phenomenon, since what I observed for Nantes alone at Awarua has been observed at other times for the Eiffel Tower—and also at the Chatham Islands for Lyons.

FIG. 11.—Route followed by the *Aldebaran*. The figures marked give the distances in kilometres from Nantes.

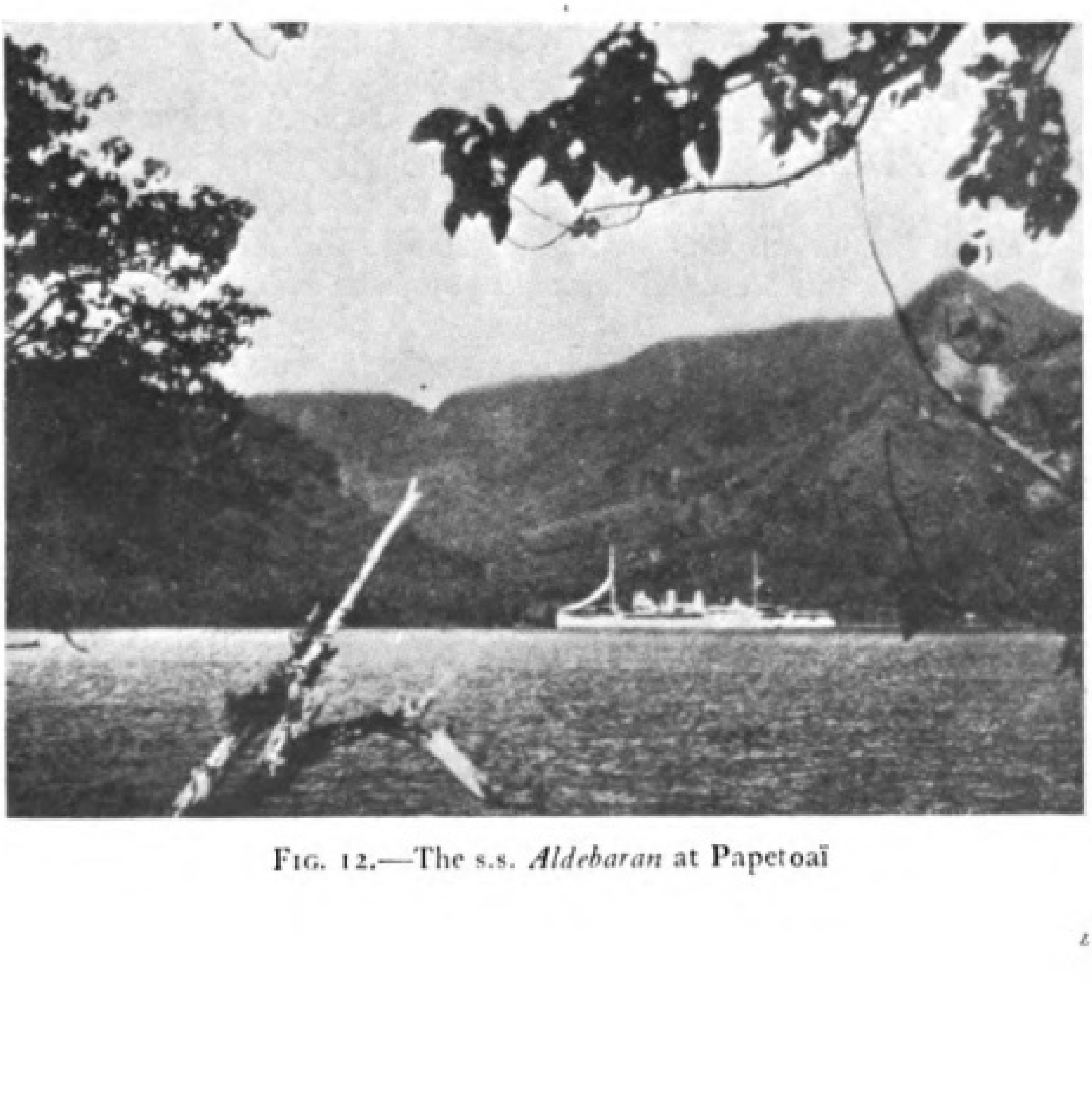


FIG. 12.—The s.s. *Aldebaran* at Papetoaï

A detailed investigation of this phenomenon ought to be of great scientific interest.

Measurements taken at the same time on land and on board ship enable us to state that the minimum reception on board corresponds to a readable reception on a commercial station of average size. We may conclude that a station like Lyons, which we heard right up to the antipodes (without being able to read it between Melbourne and Auckland) should be able to maintain a service by day and night with all the places on our route.

Reception of other European and American Stations.

Between the Antipodes of Nantes and Bluff Harbour.—**NPM, NPN** strong, and **POZ** very strong at 1600h.; good at 2137h., G.M.T.; **NSS** good at 1400h. Lyons strong at 1845h. and 2100h. G.M.T.

At Bluff Harbour.—Heard **POZ** very strong (value of shunt for silence = 8) at 1700h.; **NSS** good at 1200h.; **NFF** very strong at 1200h.; **POZ** good at 1345h. (all G.M.T.).

Between Bluff Harbour and Auckland.—**NPM** very strong at 0145h.; **NSS** good at 1000h.; **NFF** good at 1050h.; **POZ** good at 1445h.; Lyons very strong (value of shunt for silence = 5) at 1530h., 1715h. and 2000h. At 2145h. heard **IDO** Rome calling **FL** feeble. At 2010h. heard **POZ** calling **NFF**—good transmission (value of shunt for silence = 20). **POZ** is often heard.

At 0610h. heard Rome feebly. **POZ** strong at 1230h., **IDO** readable at 1810h., **NSS** very strong at 1125h.

Between Auckland and Noumea.—**NSS** (Annapolis) good at 1400h., feeble at 0700h. Lyons **(YN)** strong at 2000h., fairly strong at 0300h. **PKI** strong at 2130h. Heard **PKI** calling **PCG** at 2200h. and **PKX** calling **AAP**. **POZ** is frequently heard, although feebly except at 2000h.

At Noumea (receiver in bad condition) heard **POZ** strong at 1500h., fairly good at 1800h. Lyons strong at 2000h. and fairly good at 0900h. Near New Zealand and New Caledonia, Lyons and Nauen were heard more than any other station.

Near Tahiti.—Heard only the American stations, even on those days when reception was very good.

Reception between Noumea and Tahiti.—From North Cape (North Island, New Zealand) we lost all contact with Nantes—Lyons could be heard but unreadable.

At Noumea we were obliged to add an amplifier to take down the Lyons message; that was 17,200 km from France—the same distance as Melbourne, where the night time sigs were very strong.

There is a difference of longitude of 1 h 30 m between these two points; and whereas in one case the whole of the route was in darkness, part of the other was in daylight; now in the preceding measurements, the sudden way in which we lost the night signals to the east of Melbourne, shows the tremendous influence of the position of the sun on transmission; to eliminate this factor it is necessary to change the time of transmission as the receiver moves.

As the observer travels eastward the Nantes signals which travel towards him by the shorter of the two arcs of the great circle will have a route partly in daylight and partly in darkness. That is to say that at these distances they would not have been heard even had the atmospheric conditions been favourable. Now two cyclones having occurred within fifteen days, the humidity of the air caused two faults to appear—one in a coupling transformer which was soon repaired, the other in a telephone transformer, which we unsuccessfully attempted to rewind.

Reception between Noumea and Tahiti was therefore very weak, but at Tahiti itself a transformer lent by the local radio station was put in place and the sensitiveness of reception was re-established, since the standardisation transmitter could be heard with two turns and 16 volts. However, Lyons could not be heard at any time; Tahiti is 15,800 km from Paris and the local time is ten hours behind the French time, so that the 0845h. signals traversed a path which was two thirds in darkness; it is very surprising that even with the arrangement used at Noumea (amplifier Type 3^ter^) we were never able to receive these signals at Tahiti.

Conclusions.

In spite of the limitations imposed by the bad condition of the receiving station, the fact that the standardisation transmitter could be heard with two turns, makes it seem probable that the signals are weaker in the Pacific than in the Indian Ocean. A report received from the *Aldebaran* on June 17th, has turned this probability into a certainty.

Moreover, why should the distribution of the waves be symmetrical round a sphere of such little homogeneity? Has not the phenomenon experienced at the antipodes given us a similar surprise? Not only should the law of attenuation of the energy over land and over sea be studied, but rather a world map of the distribution of the radiated energy. To this end regular transmissions could be arranged from a European high power wireless station which could be received by all ships, and their reports—like the meteorological reports—could be grouped together and thus furnish a quick solution of the problem.

Institution of Electrical Engineers Wireless Section.

At a meeting of the Section on November 9th, Dr. G. W. O. Howe delivered his address as Chairman of the Section.

After reviewing the highly successful work of the Section since its inception Dr. Howe took as the subject of his address the effective inductance and resistance to self-capacity of coils. He pointed out that the formulæ usually given for the inductance of portions of conductors could not be strictly so called and that the inductance of a portion of a circuit was difficult if not impossible to define. He described a new method of calculating the natural frequency of a coil and showed that the self-capacity was independent of the frequency if the current were assumed to have a sine distribution along the coil. This is dealt with more fully in the Editorial Notes, as is also a reference to some interesting results obtained by Mr. S. Butterworth in his work on the high-frequency resistance coils.

Some Dutch Wireless Apparatus.

A description of the new Dutch marine type receiver manufactured by the Nederlandsche Radio Industrie was published in the July issue of the RADIO REVIEW. Details of other wireless apparatus of the same manufacture are illustrated and described in this article.

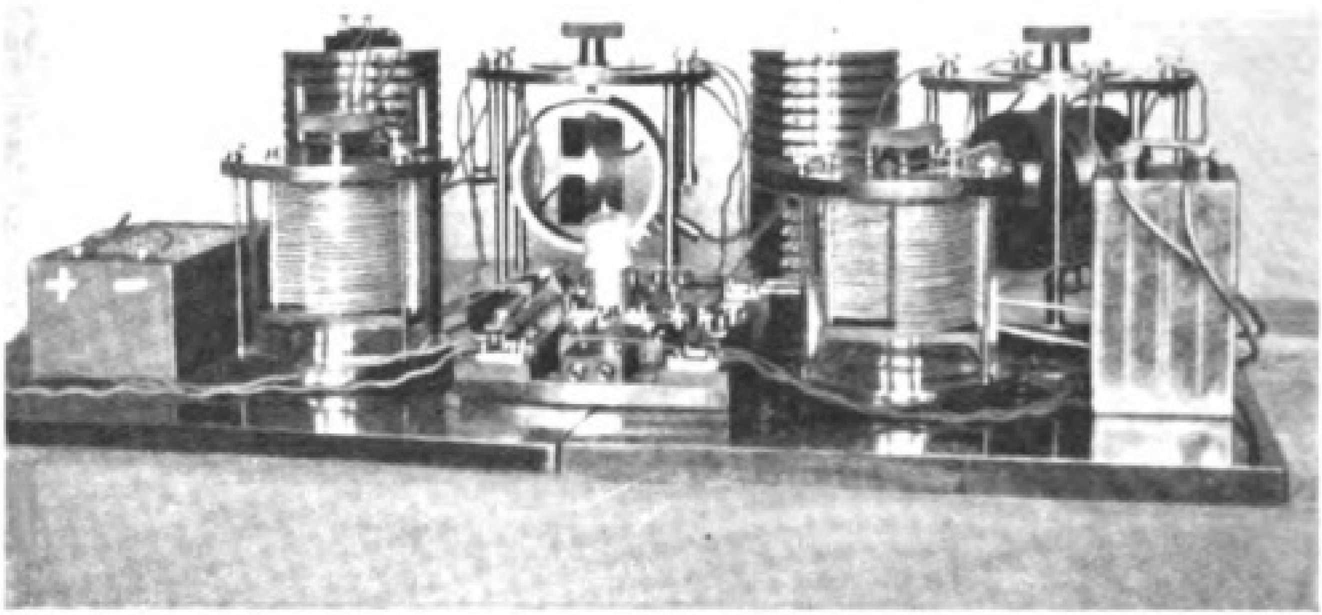


FIG. 1.—Receiver Type "T.K.A."

Combination Receiver Type "T.K.A."—This set shown in Fig. 1 is for use on wavelengths of from 400 to 20,000 metres and is specially constructed with universal plug contacts for experimenting on all kinds of diagrams. It can be used either as a simple combination, a short-wave receiver, a standard variable range receiver or it may be calibrated and used as a wavemeter.

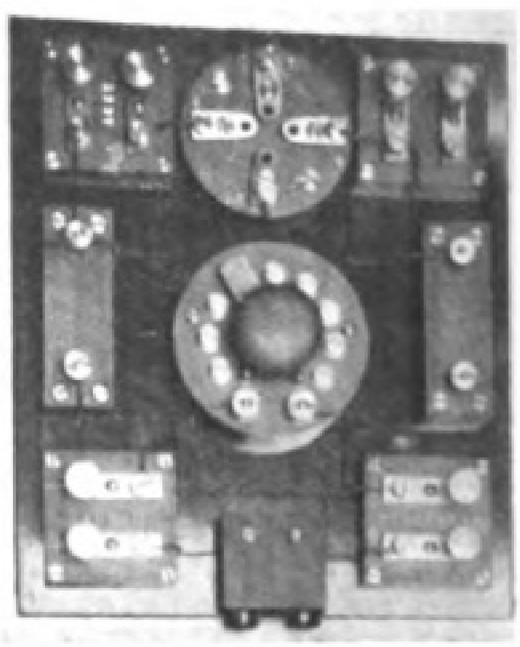


FIG. 2.—Type "A" Control Panel

A special feature of this set is the control panel, type C.S., of which there are two models "A" (Fig. 2) and "B," the "B" type panel having an extra in the form of a grid potentiometer. It is only necessary with the use of these panels to connect up three sets of terminals to put the receiver in action.

Other notable features of this set are the variable condensers, type "AM" of 0·00125 μF, coupling variometeis, type "KV" model "H," inductances, type

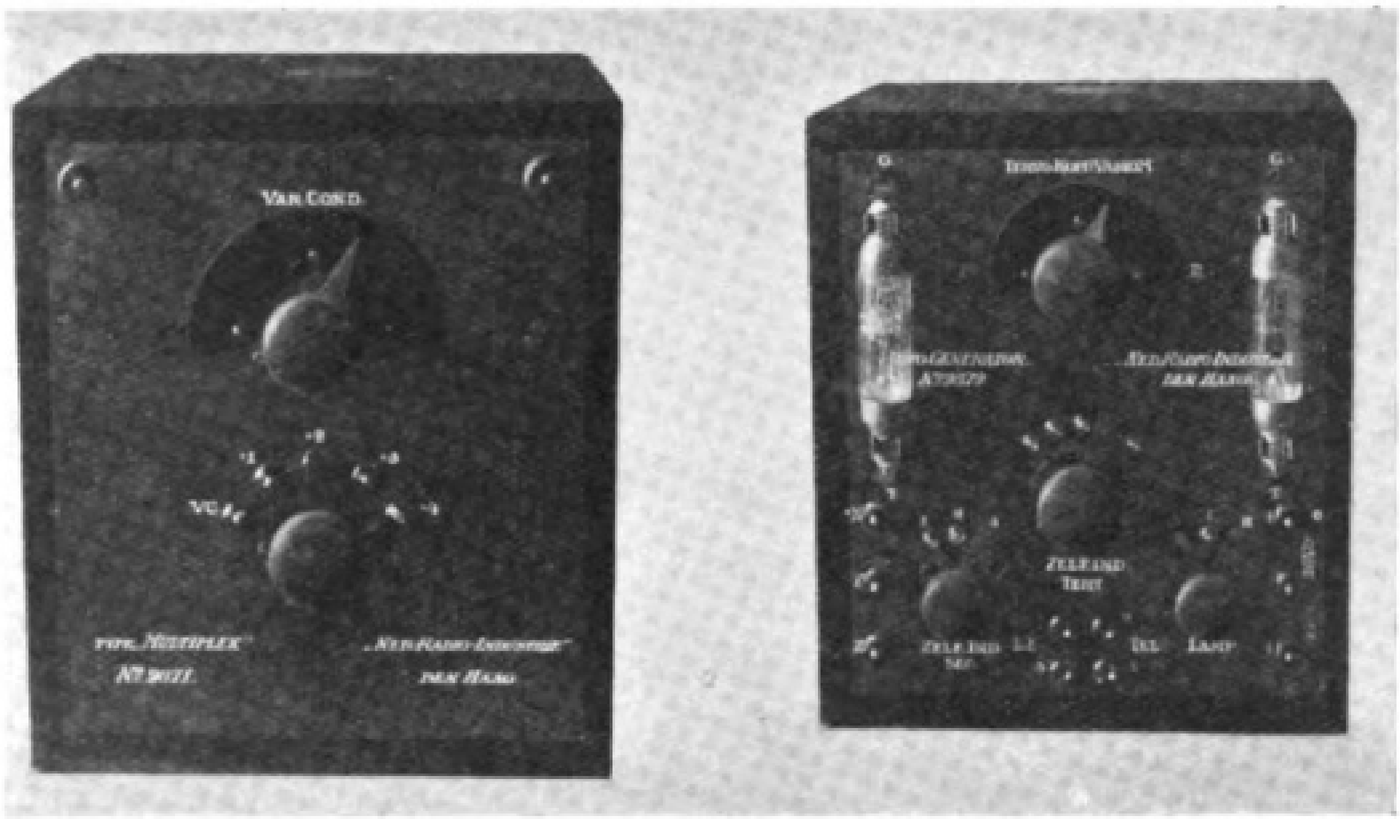


FIG. 3.—Parts of Loop Aerial Receiver.

" R 16," of the ring coil form, which latter the manufacturers claim hold advantages over honeycomb coils in that they have smaller self-capacity and high-frequency resistance, less liability to bad contacts, finer coupling if using variometers, only a portion of the circuit being coupled instead of the whole inductance and changing over is performed quicker and easier by their use.

Loop Aerial Receiver.—This consists of two sets (Fig. 3), a multiplex

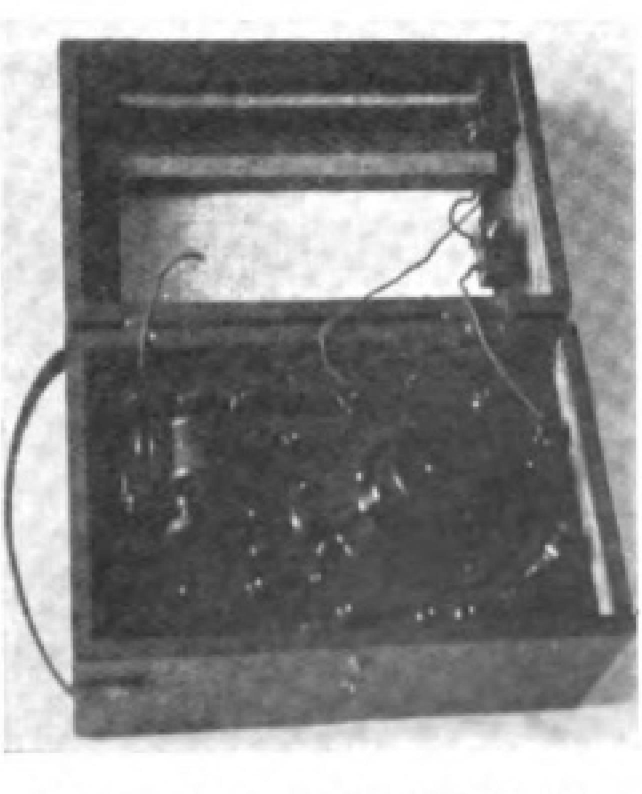


FIG. 4.—Decremeter Type " Delta."

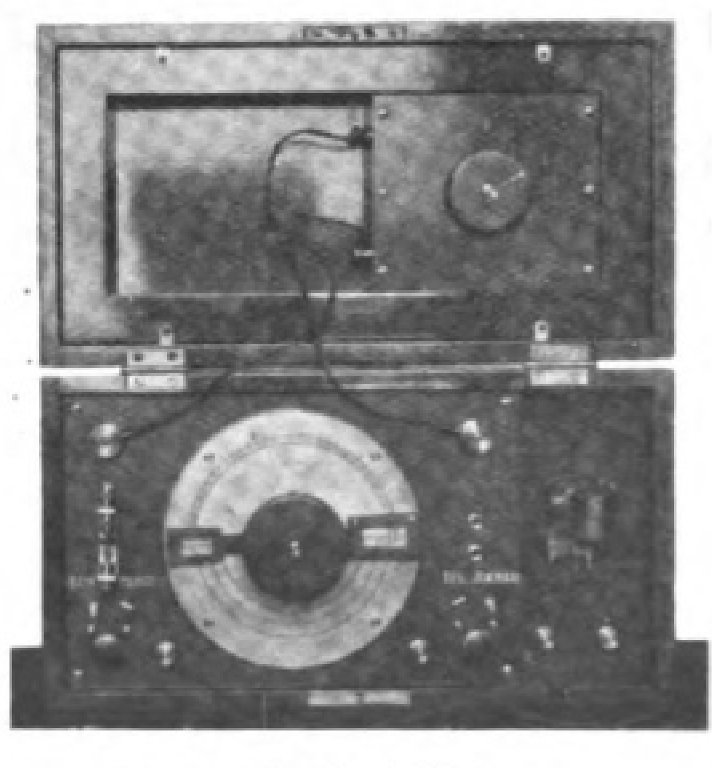


FIG. 5.—Standard Wavemeter.

variable condenser and an autodyne generator. The condenser can be shunted in successive progression by four fixed condensers by means of a switch with dead end contacts. The autodyne generator is a reactance variometer using one or two valves in parallel and can be made suitable for any wavelength or loop aerial. Both reactance coils can be lengthened by a self-inductance.

Each piece of the receiver is mounted in a polished wood box with an ebonite top on which are mounted the valves, terminals and controls.

Decremeter Type "Delta."—This is a direct reading instrument (Fig. 4) which can be used as a wavemeter if desired. It is made up in portable form with carrying straps.

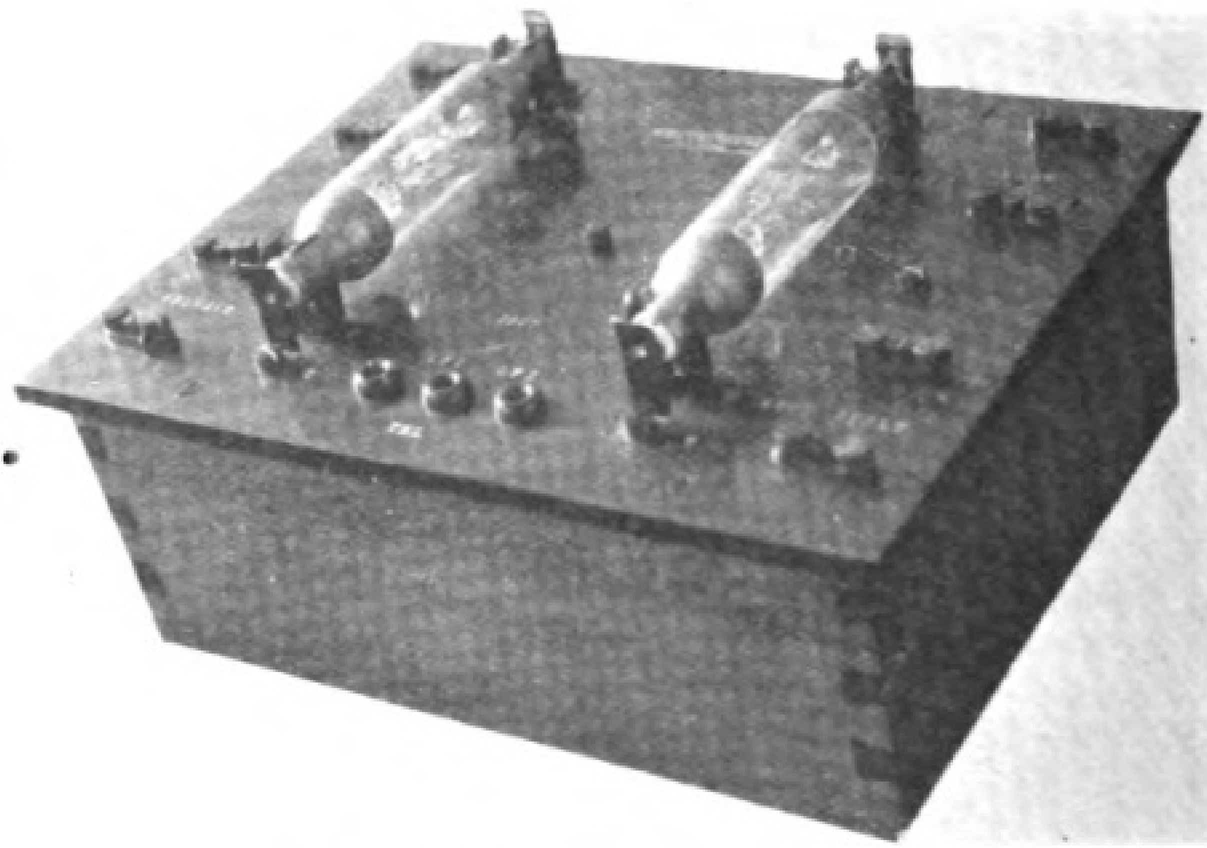


FIG. 6.—Two-valve Low-frequency Amplifier.

The translation of the reading on the scale is provided for by a curve which with a diagram of the set is fastened conveniently in the lid of the case.

Wavemeter Type "Standard."—This wavemeter shown in Fig. 5 consists of a variable condenser fitted with a precision reading pointer, an inductance of three ranges 200 to 800 metres, 500 to 1,800 metres and 1,200 to 3,600 metres wavelengths, a high note buzzer and a crystal detector.

The set is made up in portable box form with the inductance mounted in the lid. A patented feature is involved in the set, the inductance being wound free from capacity and the wiring such that the whole inductance is in use for all ranges.

Low-frequency Amplifiers.—The amplifiers are of three types, "LFA,"

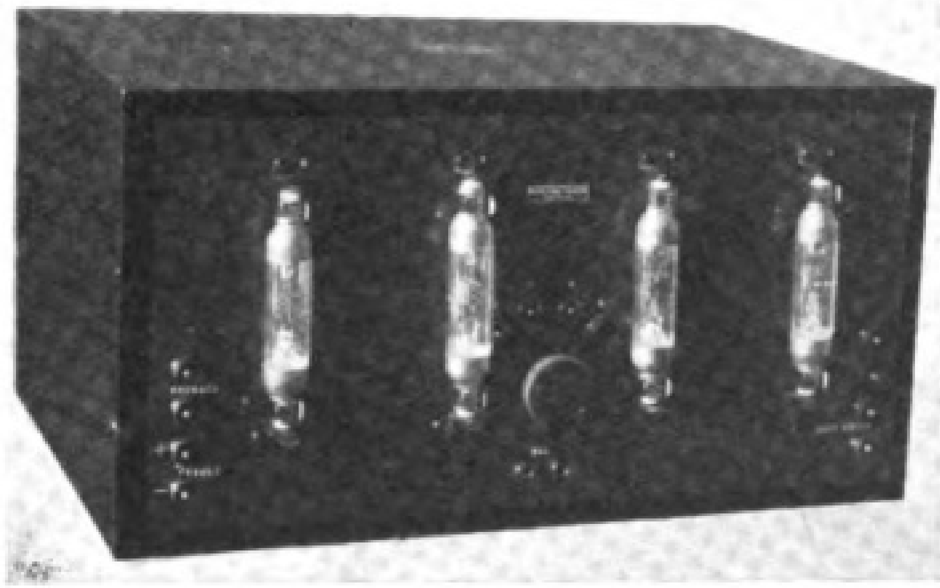


FIG. 7.—Four-valve Low-frequency Amplifier.

"LFB" and "LF." Type "LFA" is a single-valve amplifier and type "LFB" (shown in Fig. 6) a two-valve amplifier. They are fitted with a fixed potentiometer tapped correctly for Philips valves, this potentiometer being mounted in the box portion, while the whole of the rest of the fittings and connections are mounted on the top ebonite panel.

Type "LF" shown in Fig. 7 is of similar construction and detail and is designed in particular for use after the "Marine" type receiver. It is of the same dimensions as that set but has four valves and a dead end switch situated in the centre of the panel which puts into operation one, two, three or four valves without plugging over the telephones.

Short Wave Receiver Type "Torpedo."—This receiver (Fig. 8) is designed for wavelengths of 400 to 3,000 metres and is specially suitable for telephony

FIG. 8.—Short Wave Receiver.

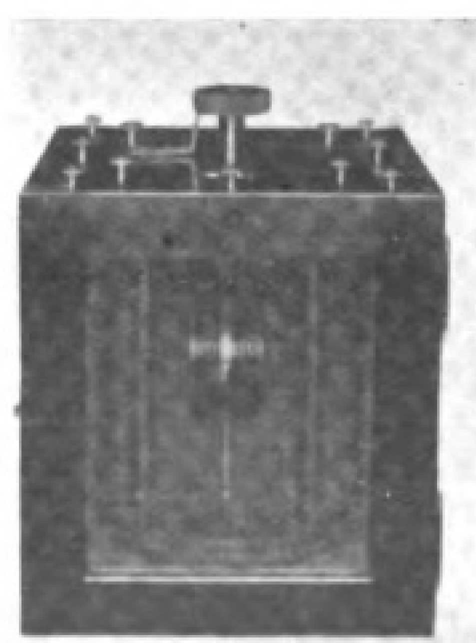


FIG. 9.—Direction Finder.

reception. The various pieces are mounted on an ebonite panel sunk into a polished wood box. A variable condenser is supplied exterior to the set.

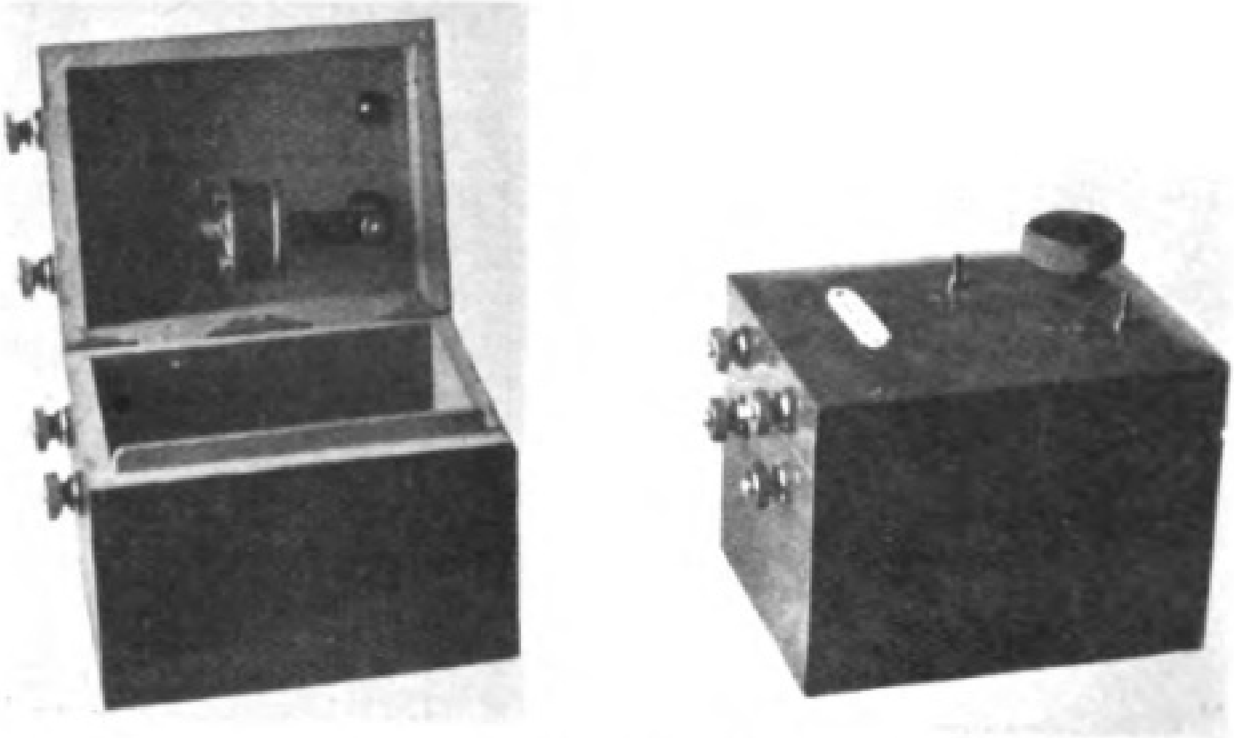


FIG. 10.—High Note Buzzer.

Direction Finder.—The Dutch military authorities employed this type of direction finder during the war (Fig. 9). It is constructed as a separate unit in a polished wood case with a glass front giving clear vision of the search coil the handle of which together with the necessary pointer and terminals are mounted on the top of the instrument.

High Note Buzzer.—Designed to form a constant high note buzzer this set contains an induction coil mounted in the lid and the circuit is made *via* this induction coil, the telephones and key in such a manner that the operating knob interrupts the induced currents while the buzzer is continuously in operation. Its current consumption is very small.

Fig. 10 shows the set with the lid both open and closed.

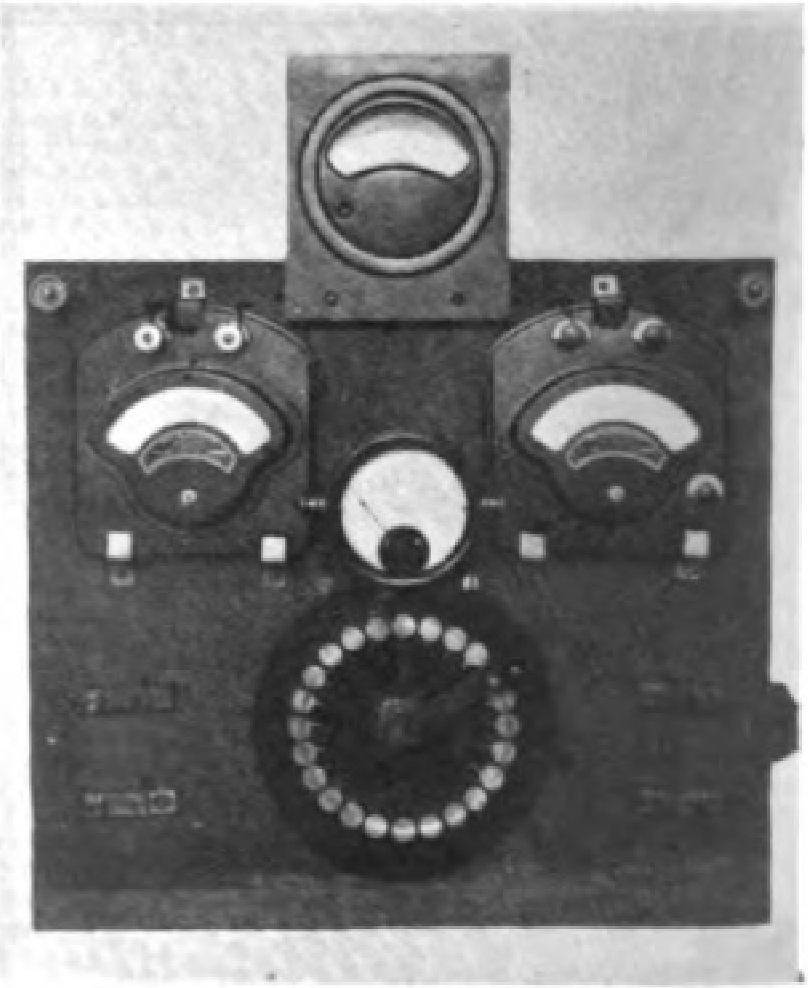


FIG. 11.—Small Telephone Transmitter.

Small Telephone Set.—At present only in the experimental stage this set will be fitted up in a polished mahogany case with an ebonite front panel on which all the necessary connections and controls will be fitted. Fig. 11 shows the various components of the set which will consist of a variometer for the grid and plate circuit, coupling variable condenser, filament resistance,

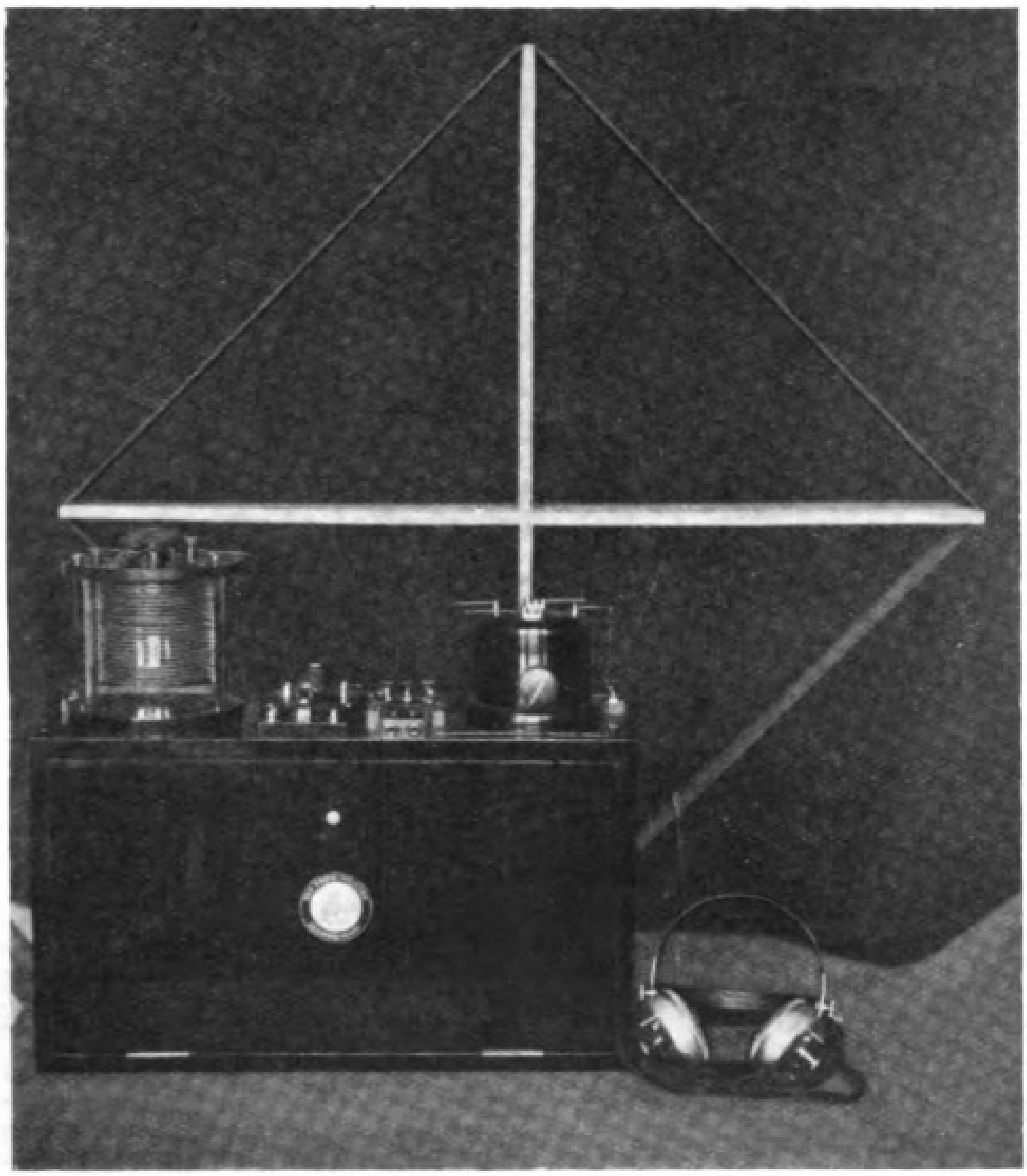


FIG. 12.—Loop Receiver.

valves 30 to 50 watt, aerial ammeter, plate milliammeter, filament voltmeter, earth aerial, high- and low-tension terminals and suitable contacts for a microphone or key.

Loop Receiver Type "Tijdsein."—This set shown in Fig. 12 is specially constructed for the use of watch and clock makers for taking time signals and controlling and adjusting electric clocks, etc. It is suitable for wave-lengths up to 3,000 metres.

The accumulator, anode battery and telephones can be packed up in the case, the lid of which is suitable for use as a writing desk.

Carborundum and its Rectification Effect.

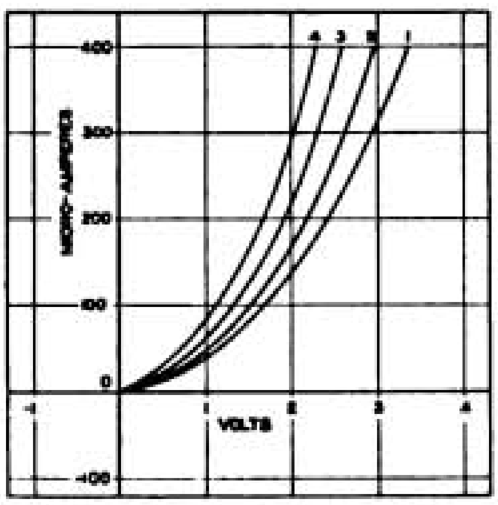
By H. M. DOWSETT, M.I.E.E., F.Inst.P.

(*Concluded from page* 594.)

(13) The following experiment which is related to the one just described was carried out at a later date using a plain solder-mounted crystal.

Current was passed through the steel spring to heat the point contact to various temperatures. The characteristic and the signal strength were taken for various temperatures of the steel spring up to 200° C.—the current then passing through the spring being 37 amperes.

The characteristic became steeper (Fig. 10) and the signal strength increased as the temperature rose and these changes were shown to depend solely on the temperature and not on the heating current as the signal strength only fell off in intensity as the crystal cooled down.



Curve.	Temperature of Contact Spring.
1	19° C.
2	60° C.
3	100° C.
4	200° C.

FIG. 10.—Effect of Temperature on Characteristic of Crystal mounted in Solder.

The audibility increased four times for an increase in temperature from 19° C. to 200° C.

(14) What happens when a carborundum detector loses its sensitivity due to heavy induction in the receiver circuit ?

If a sufficient D.C. voltage not exceeding 20 volts is applied to a crystal detector the current flowing through the point will heat it up, the internal resistance of the crystal will fall and there will be a progressive increase in current. When it exceeds 1 ampere the point will be red-hot. A suitably mounted crystal was heated up in this way, the minimum voltage being used for the purpose (see Fig. 11B). It was found on re-test when the crystal was again cool that its sensitivity as a detector had remained unimpaired, although the characteristic had altered as shown in Fig. 11A from A_1 to A_2.

In this case the working current—which usually does not exceed 5 micro-amps—had been increased 250,000 times without burning the point or breaking it down.

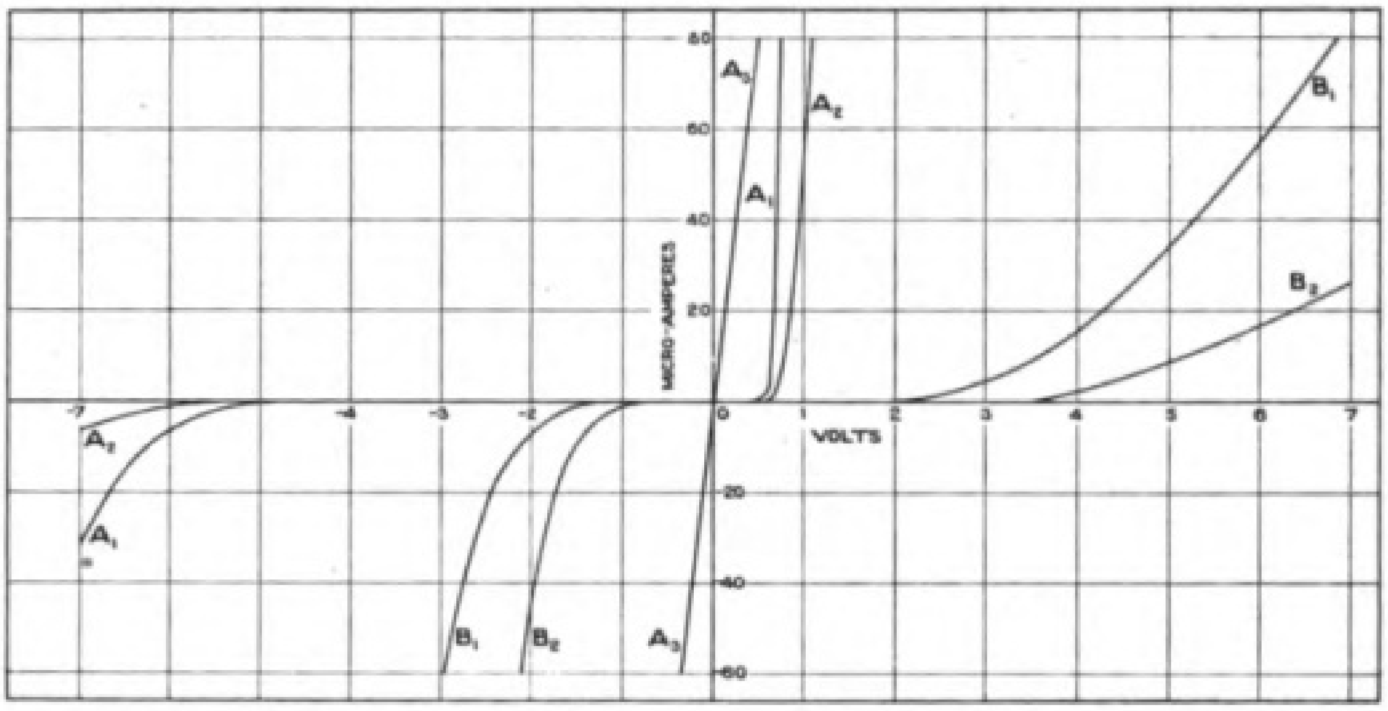


FIG. 11A.—Effect of passing Strong Currents through Carborundum Crystal.

GREEN CARBORUNDUM.

Curve A_1 = Characteristic before heating.
Curve A_2 = First test—Characteristic after heating to a dull red by current of 1·25 amps at 18 volts in the positive direction.
Curve A_3 = Second Test—Characteristic after again heating to a dull red by current of 1·25 amps at 24 volts in the negative direction.
After first test point of contact appeared unaffected by the heat.
After second test point of contact appeared slightly burnt.

BLACK CARBORUNDUM.

Curve B_1 = Characteristic before heating.
Curve B_2 = Characteristic after heating with 4·0 amps at 20 volts in the negative direction.

A further application of 24 volts in the reverse direction did succeed in destroying the point with signs of burning, but this only shows that the current required to produce breakdown by burning is so extremely high that no induction effect would have sufficient magnitude to produce it. As shown in Fig. 11A, A_3, the damaged point ceased to rectify and became conducting.

The effect of heating up a negative crystal is also shown in this figure. The characteristic was altered from B_1 to B_2 but the crystal still remained a good rectifier even when 4 amps had passed through the point contact.

But the momentary application of high voltage from a low-current source will often destroy the sensitivity of a detector. Thus various crystals broke

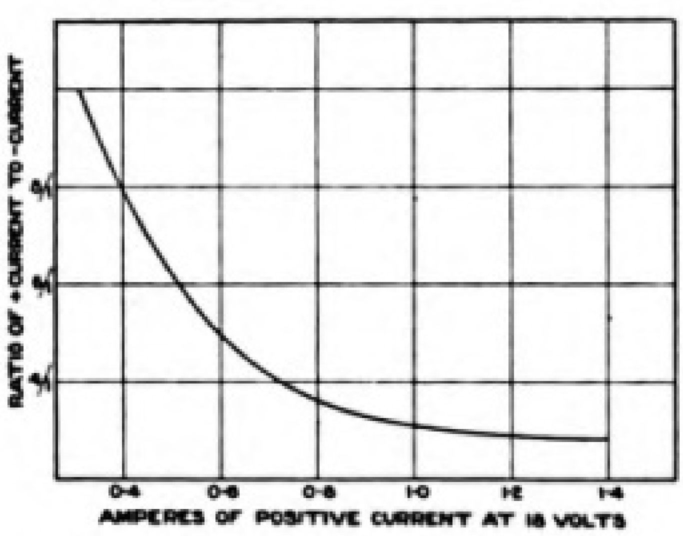


FIG. 11B.—Curve showing Ratio of Positive Current to Negative Current taken during First Heating Test on Green Carborundum Crystal.

down after being flashed several times from a dry battery at voltages ranging from 60 volts to 200 volts, and also on the momentary application of 60 volts high frequency (see Figs. 12 and 13). In these cases the maximum current was within the values 0·01 to 0·04 ampere.

Under the microscope the damaged points either appeared to be fractured with no signs of burning, or the crystal had lost its lustre or become discoloured, and in a few cases there were signs of burning.

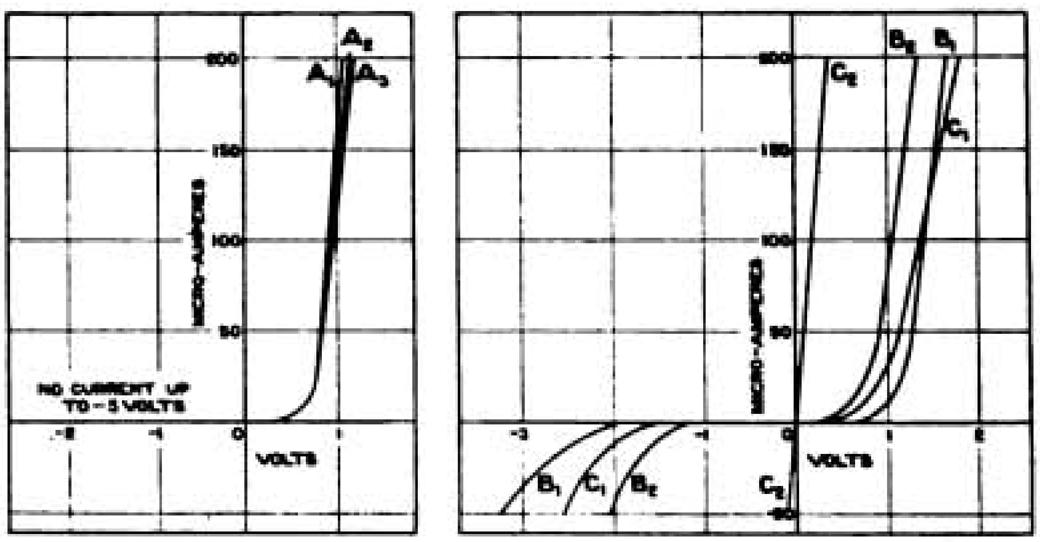


FIG. 12.– Effect of application of High Voltages to Crystal.

CRYSTAL WITH STEEL TIP AND MOUNTED IN SOLDER.

A_1 — Original characteristic.
A_2 — After application of 200 volts (dry battery) from plate to crystal opposing rectification.
A_3 — After application of 200 volts from crystal to plate assisting rectification.

CRYSTAL MOUNTED IN SOLDER ONLY.

B_1 and C_1 = Original characteristic.
B_2 — After application of 200 volts opposing rectification.
C_2 — After application of 200 volts assisting rectification.

The potential gradient is greatest at those parts of the layers of the crystal which enter into the rectification effect, and in the cases just quoted with the crystals still cold this gradient was unquestionably very high, so that there is little doubt that the manner of these breakdowns was by electrostatic disruption of the rectifying layers, which was followed in a few cases by burning owing to the sudden rise of current resulting from the great fall in effective resistance, and the possible presence of impurities.

(15) In all the experiments just described a large group of irregular crystals has been employed as a detector, but the conclusion has been reached that the only part concerned in rectification is contained within the thickness of the first crystal to which the point contact is made.

To carry the investigation further it would be useful to examine the behaviour of a single crystal.

It is practically impossible to separate out and mount a single crystal but we can arrive at a similar result by employing a group of regular crystals layered evenly one on the other and by making our contacts all on the same crystal of the layer.

One part of it must be steel tipped to ensure a stable low-resistance contact of reference, or a piece of carborundum may be chosen which has the layered crystal grafted well into another single group to which the tipping process can be applied and the results will be equally good.

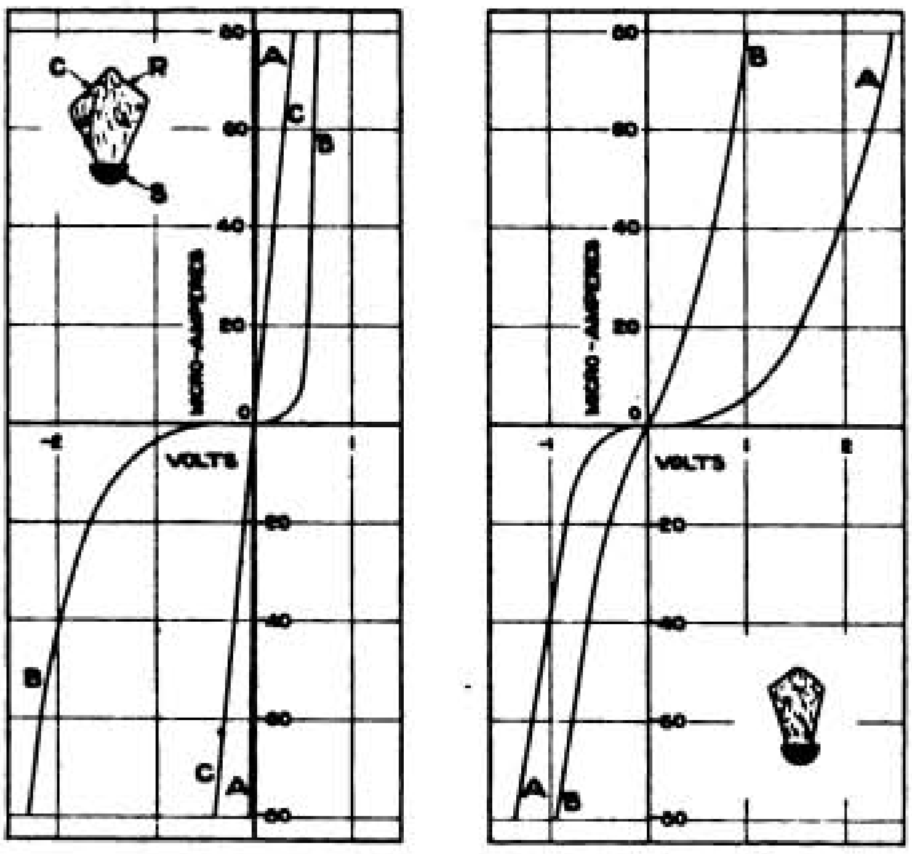


FIG. 13.—Effect of application of High Voltages and High-frequency Currents.

BREAKDOWN VOLTAGE FROM C TO R = 60 VOLTS D.C. FROM DRY BATTERY IN NEGATIVE DIRECTION.

Curve A = C to S before and after breakdown.
Curve B = R to S and R to C before breakdown.
Curve C = R to S and R to C after breakdown.

BREAKDOWN VOLTAGE = 60 VOLTS (APPROX.) HIGH FREQUENCY (WAVELENGTH = 600 METRES).

Curve A = Before breakdown.
Curve B = After breakdown by induction.

Using such a crystal having a width of face of about $\frac{3}{8}$ inch the first facts which can be established are that every perfect part of the crystal rectifies, and rectifies in the same sense. The rectification voltage and the effective resistance are lowest at a point and highest on a face. As much as 20 volts may be required to be applied at some places on a face to produce a detectable current while the nearest crystal point on this face may not require more than 0·2 volt.

It can also be shown that the internal resistances of crystals is inversely proportional to their size, the resistances measured from natural neutral points on green positive carborundum to the steel-tipped base of the large crystal formation having values between 200 ohms and 2,000 ohms and the small crystal formation having values 5,000 ohms to 10,000 ohms.

Also for black negative carborundum and large crystal formation 400 ohms to 1,000 ohms and small crystal formation 2,000 ohms to 10,000 ohms.

Neutral points produced by electrical breakdown covered a range that had a lower minimum and a much higher maximum than any value mentioned above.

The next fact which is illustrated by Fig. 14A is one of considerable interest.

C_1 and C_2 are two neutral points at different distances from R the rectifying point and from S the steel-tipped base. The resistances through the crystal from C_1 to C_2, C_2 to S, and C_1 to S are all different, yet either of these three neutral contacts gives the same characteristic with R.

The same result was obtained with many other large crystals, the neutral points used being preferably natural to the crystal or were made artificially if required at a particular spot by fracturing the crystal.

The exceptions all gave higher resistance characteristics than that between the rectifying point and the steel-tipped base, as shown in Fig. 14B.

The only explanation one can offer of this effect is that when a rectifying point is being used and a certain intimacy of neutral contact is obtained, the crystal can be considered as having no internal resistance other than at the rectifying part.

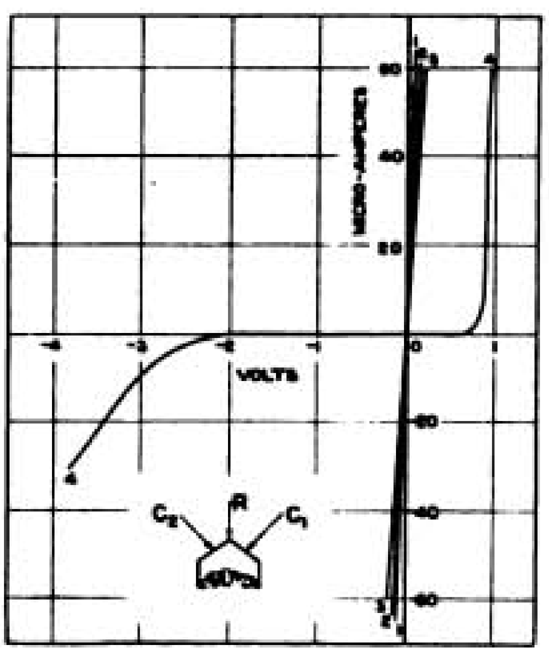


FIG. 14A.

Curve 1 = C_1 to S.
Curve 2 = C_2 to S.
Curve 3 = C_1 to C_2.
Curve 4 = { R to S. / R to C_1. / R to C_2.

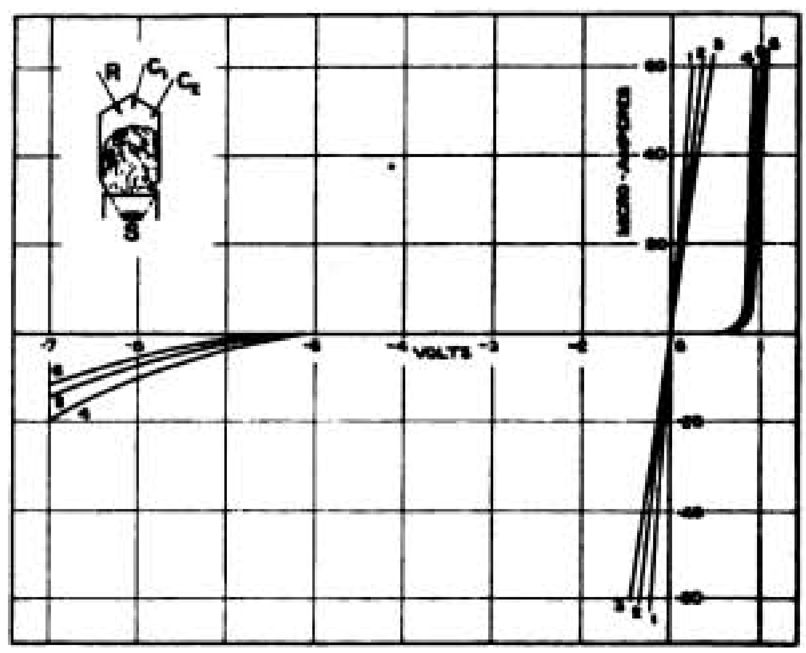


FIG. 14B.

Curve 1 = C_1 to S.
Curve 2 = C_2 to S.
Curve 3 = C_1 to C_2.
Curve 4 = R to S.
Curve 5 = R to C_2.
Curve 6 = R to C_1.

If this is so then it should follow that a change in contact pressure which is capable of making a considerable alteration in the resistance between two neutral contacts on a crystal, if applied to one of these contacts when it is being used with a rectifying point should make very little difference to the characteristic.

This was confirmed. Pressures varying from less than 100 grammes up to 2,500 grammes caused a change in resistance measured through the crystal of 500 ohms down to 100 ohms in one case, but there was no corresponding effect on the characteristic.

The effect noted in section (5), that the steel tip could be removed and replaced by solder and the original solder characteristic could then be reproduced is obviously related to the phenomena just described.

Also it is because of these results one must conclude, as intimated in section (9), that it is not entirely because the steel has a better mechanical grip on the crystal than the other metals employed that it gives the best results.

A further case of interest which may be quoted is that of a large green crystal on the face of which a rectifying point contact had been established instead of at an edge.

The application of 200 volts slightly altered the characteristic but did not destroy the rectification effect. A certain amount of heat developed however which caused a flow of fluid between the outer crystal layers and the crystal became more transparent. This fluid would necessarily consist of the constituents of low melting point, the impurities, and as the rectification effect remained still good the conclusion is that these impurities have no useful function near the point contact.

It would also appear from this result that the presence of certain kinds of impurity does not prevent the formation of a perfect carborundum crystal, and if iron when applied in the molten state to the crystal finds its way between the layers without fracturing them, this would provide the most reasonable explanation of the improvement which results from steel tipping.

With this crystal the blue glow which can often be seen when the applied voltage is high enough, started at a short distance from the point contact, was fan shaped, and also appeared to be located between the layers.

These effects would appear to indicate that there is an easier molecular and electric flow parallel to the faces of the crystal than normal to them.

(16) All the phenomena described are consistent with the following theory of the rectification effect as exhibited by carborundum.

Normal conductivity takes place parallel to the faces of the crystal so that for a non-rectified current flow from any point A to the base B (Fig. 15) the

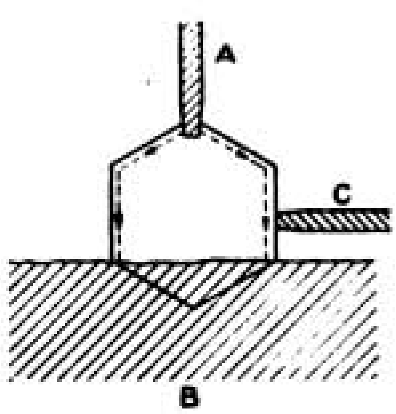


FIG. 15.

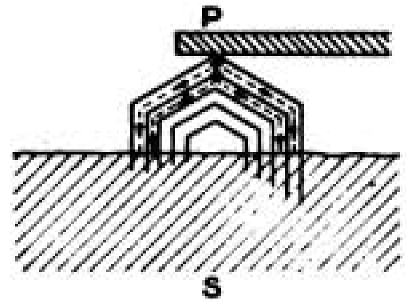


FIG. 16.

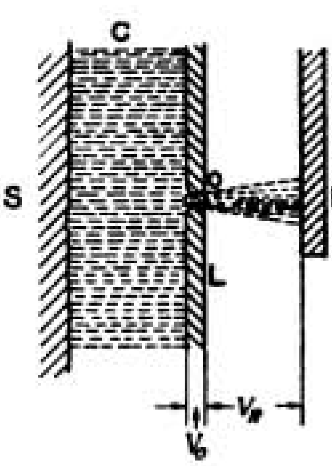


FIG. 17.

crystal edge must be broken at A to establish a connection in line with the direction of flow, a condition which is attained at B by establishing an intimate contact of wide area.

But a current cannot flow through the crystal from a contact C normal to a face without the molecules forming the crystal being strained apart at this contact in order to provide an opening to introduce or extract the necessary electrons. When the applied E.M.F. reaches a certain value the equivalent of an orifice is opened into one or more of the outer layers of the crystal against an opposing elastic pressure resisting distortion which is felt throughout the crystal, in the same way that mechanical pressure is felt throughout an incompressible fluid, so that no matter how far or how near the neutral contact may be to the rectifying point, the effective resistance through the crystal and therefore the characteristic will be the same.

If the elastic disturbance is not carried to an extreme the orifice closes and the crystal recovers as soon as the applied E.M.F. driving the current is removed.

A contact at a perfect edge or still more at a perfect point of a crystal requires a smaller applied E.M.F. to strain an opening into the crystal structure than a contact on a face.

The first flow of current takes place through the outer crystal layer only (Fig. 16); then as the applied E.M.F. is increased an entry is forced into one or more inner layers until with a sufficient further increase of applied E.M.F. the whole crystal conducts.

It is the successive layers coming into circuit which cause the bend in the characteristic, the straight part being obtained when they are all conveying current.

Because the smaller crystals have fewer layers their resistance is higher than that of larger crystals.

Crystals which have a high rectification voltage have many layers through which an elastic opening must be made before the layer is reached which is in good electrical contact with the base electrode. For this reason the small crystals from the base of a block of carborundum which are practically all faulty, on the average have a higher rectification voltage than the more perfect large ones from the top. A crystal ceases to grow as soon as it becomes fatlty, and most of the impurities are found at the base of the block.

In Fig. 17 the plate on the rectifying point of the crystal is represented by P, the rectifying layers by L through which an orifice O is opened into the elastic electrostatic and magnetic fields of the crystal C by the application of the E.M.F. V_0.

This allows a current to flow from the steel-tipped base S to P as indicated by the jet LP which will have a value depending on the size of the orifice representing the number of crystal layers tapped, the specific resistance of the crystal for normal currents, and the applied E.M.F.

Owing to the elastic pressure existing in C, for every electron taken in or expelled at O another leaves or enters at S and there is no resistance loss therefore in conveying the current from O to S or *vice versa*, provided the crystal structure is only strained and not broken at O. The whole potential drop in the crystal due to resistance therefore occurs in the rectifying layers and can be represented by V_R.

If V_0 and V_R represent the total absorption of E.M.F. in the crystal there is nothing to prevent the current being subject to Ohm's law, and if these two values can be separated we can write $I = \frac{V_R}{R}$.

(17) Much additional information can now be obtained from the current voltage characteristic, such as curve A, Fig. 18, which is the working or positive half as given by a positive crystal.

It may be divided into three distinct sections. In the first the E.M.F. applied to the crystal can be increased up to a certain value without current flowing, the crystal behaves in fact like a very small condenser having a capacity which is however too small to measure, and the whole of the E.M.F. is applied in straining the crystal.

In the second section there is a flow of current the rate of increase of which becomes greater as more crystal layers open, and the applied E.M.F. is divided in varying proportions between straining the crystal and driving the current through the layers. The third section of the characteristic begins when all the layers are open so that the E.M.F. straining the crystal has reached a constant value and the characteristic has therefore become perfectly straight, the increase in current being proportional to the increase in applied E.M.F.

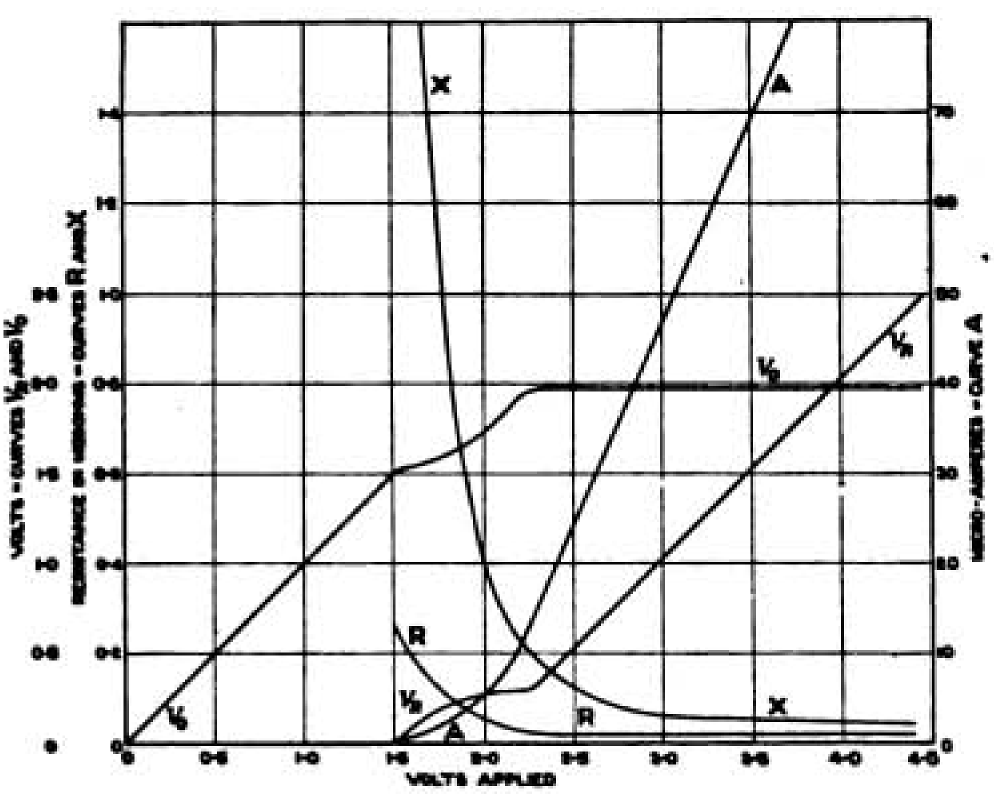


Fig. 18.—Positive Portion of Characteristic of Positive Crystal with Calculated Resistance Curves.

From the slope of the characteristic at every point we can then calculate the true resistance of the crystal.

This is shown by the curve R, which may be compared with curve X giving the apparent resistance obtained by dividing the applied E.M.F. by the resultant current, and which never reaches a constant value.

The E.M.F. expended in driving the current through the crystal V_R, is given by the product of the current I and the true resistance R at that current, and the values obtained are plotted in curve V_R.

The difference between the applied E.M.F. and V_R is V_0 the E.M.F. used in straining the crystal and these values are plotted in curve V_0.

3 A

If it is required to separate V_0 from V_R without working out the actual values of R it can be done in a very simple manner as follows :—

For any value of applied E.M.F. draw the tangent to the characteristic at the corresponding point, then where it cuts the abscissa it will divide the applied E.M.F. in the required manner, the part towards zero being the orifice voltage V_0 and the remainder V_R.

The most interesting portions of the curves V_0 and V_R are the peculiar bends which take place during the process of straining open the crystal. Usually the last layers, those at the centre of the crystal, appear to open with a rush as the final rise of V_0 to its steady value becomes fairly steep, and this causes the E.M.F. driving the current to stop increasing or even to fall as shown in curve V_R, Fig. 19.

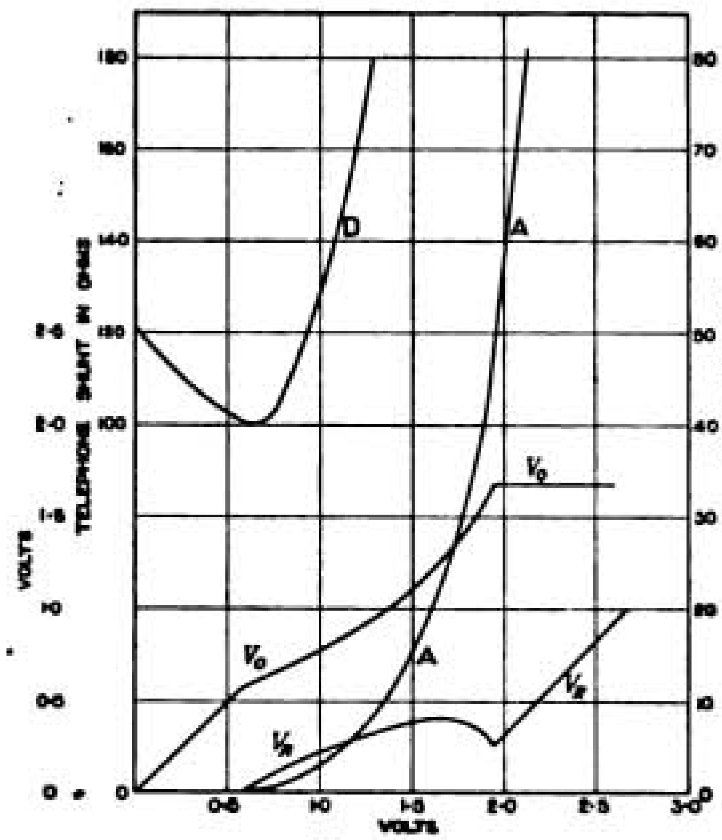


FIG. 19.

Curve V_R = Resistance component of voltage.
Curve V_0 = Valve component of voltage.
Curve A = Characteristic.
Curve D = Telephone shunt for just audible signals.

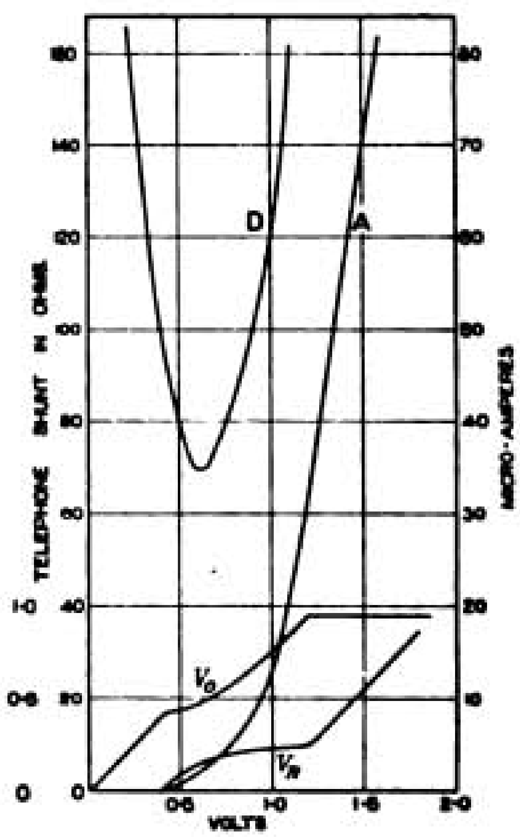


FIG. 20.

Curve V_R = Resistance component of voltage.
Curve V_0 = Valve component of voltage.
Curve A = Characteristic.
Curve D = Telephone shunt for just audible signals.

The best rectifying point as shown by the shunted telephone method (see curves D, Fig. 19 and Fig. 20) occurs near the commencement of these bends and apparently where the increment of E.M.F. divides more or less equally between V_0 and V_R as the curves at this point are approximately parallel.

The crystals vary in the number of layers and the critical voltage per layer, so that for different crystals these curves differ considerably in detail although they all have the same general form.

(**18**) There remains finally to picture a structure of the atoms and molecules forming the carborundum crystal which will be consistent with all the experimental results described and with the theory of the rectification effect as put forward in section (**16**).

If possible this structure should explain why the crystals are electrically polarised so that they act as normal conductors having a few hundred ohms resistance for currents flowing parallel to the crystal faces, whereas at right angles to these directions an E.M.F. has to be applied to force an elastic opening into the path or paths parallel to the crystal faces, which opening has a very high resistance (of the order of 250,000 ohms down to 20,000 ohms) until its elastic limit is exceeded.

An explanation is also required of the second polarisation effect, why all the crystals of green carborundum find it easier to receive electrons than to give them up, and all the crystals of black carborundum find it easier to give up electrons than to receive them. And, finally, some definition is necessary of the nature of the elastic medium which is active when the crystal is rectifying, but quiescent when a normal current is passing between neutral points.

As regards the first query, the arrangement of atoms in crystals can be determined by the method of X-ray analysis so ably developed by the Braggs.

Carborundum has not yet been submitted to this process but from the general results obtained with other hexagonal crystals we know that the carbon and silicon atoms must be symmetrically placed relative to each other on some form of hexagonal space lattice structure, but no experimental method has yet succeeded in showing how these atoms are bonded together.

If current flows without much difficulty along the layers but has to be forced through them, it seems probable that in the first case the current is carried by electrons which are under very little constraint, whereas in the second case they have to be displaced from tied positions such as are held by bonding electrons.

As regards the second point we start from the facts that the crystal as a whole is electrically neutral, and that silicon is electrically positive to carbon.

The work of the Braggs already referred to has shown the agreement which exists between the close packing of spheres and the positions of atoms in crystals, and may therefore be accepted as evidence that the external shape of the atom is either spherical or spheroidal.

Rutherford has shown that the seat of all the measurable positive charge, and therefore of practically the whole atomic mass, occupies only a very small space at the centre of this spheroid.

In a neutral molecule, then, the essential parts or nuclei of the two ions are as far apart as the centres of two touching spheres so that when an electron current—that is a stream of negative ions—flows through such a molecule it will enter the positive ion first.

We may therefore conclude that in the positive crystal the electron current finds it easiest to leave the steel plate and enter the carborundum crystal through a silicon atom, and in the case of the negative crystal the electron current finds it easiest to leave the carborundum for the steel plate by way of a carbon atom.

It may be suggested that the negative charge of the carbon does not completely satisfy the silicon in the first case, and more than satisfies it in the second, but this would cause the two types of crystal to have resultant charges whereas they are perfectly neutral.

Or again it may be suggested that the silicon is nearest to the crystal surface in one case and carbon in the other, but the probability is that they are more or less equally scattered over it.

The most reasonable view is that conductivity depends on the orientation of the molecules, that normally the conducting axes of the molecules are all in the planes of the crystal faces, and that when a current flows through a rectifying point the axes of the nearest molecules have been deflected through a small angle with the silicon ends up in order to receive it in green carborundum, a similar change in orientation taking place but with the carbon ends up when the black carborundum transmits an electron current to the steel plate.

(19) To answer the last question we must examine the particular structure of atoms and molecules.

Although many different models of the atom have been suggested, the collective opinion of physicists at the present time is not definitely in favour of any one of them.

There is a distinct leaning towards that developed by Lewis and Langmuir, but this model is too incomplete to be helpful in the present case.

It deals with the possible arrangements of electrons surrounding the positive charge, but it is not concerned with the electrostatic and magnetic fields which, until we have definite proof to the contrary, must be assumed to accompany them and to play a very active part in the life of the atom. These fields necessarily must occupy the greater part of the space in the atomic volume, and we must look to them to provide the elastic medium in the crystal of which the rectification effect gives evidence.

The model described below is an attempt towards a more complete presentation of the atom based on the electromagnetic theory.

The nuclear part of it was outlined by the author during the discussion of Mr. S. Evershed's paper on "Permanent Magnets" read at the Institution of Electrical Engineers in May last year.*

(*a*) The positive electricity at the centre of the atom has the form and nature of a single vortex ring (P, Fig. 21), somewhat similar to the Kelvin ether vortex atom. It is built up of a number of units corresponding to the atomic number of the element concerned.

(*b*) Surrounding this ring are one or more dense shells of electrons (N, Fig. 21) also in vortex motion. The individual electrons in the shells move always so as to approach the positive electricity, if the ring moves clockwise round its axis the electron shell or shells move counter-clockwise, if the twist of the ring vortex motion is clockwise the vortex motion of the electron shell or shells will be counter-clockwise, so that the motions of the two kinds of electricity are therefore in opposite sense.

(*c*) The charge of the positive ring is utilised partly in balancing the mutual repulsion exerted by all the shell electrons and partly in constraining them to move in vortex motion round the ring.

* *Journal of the Institution of Electrical Engineers*, 58, p. 827, September, 1920.

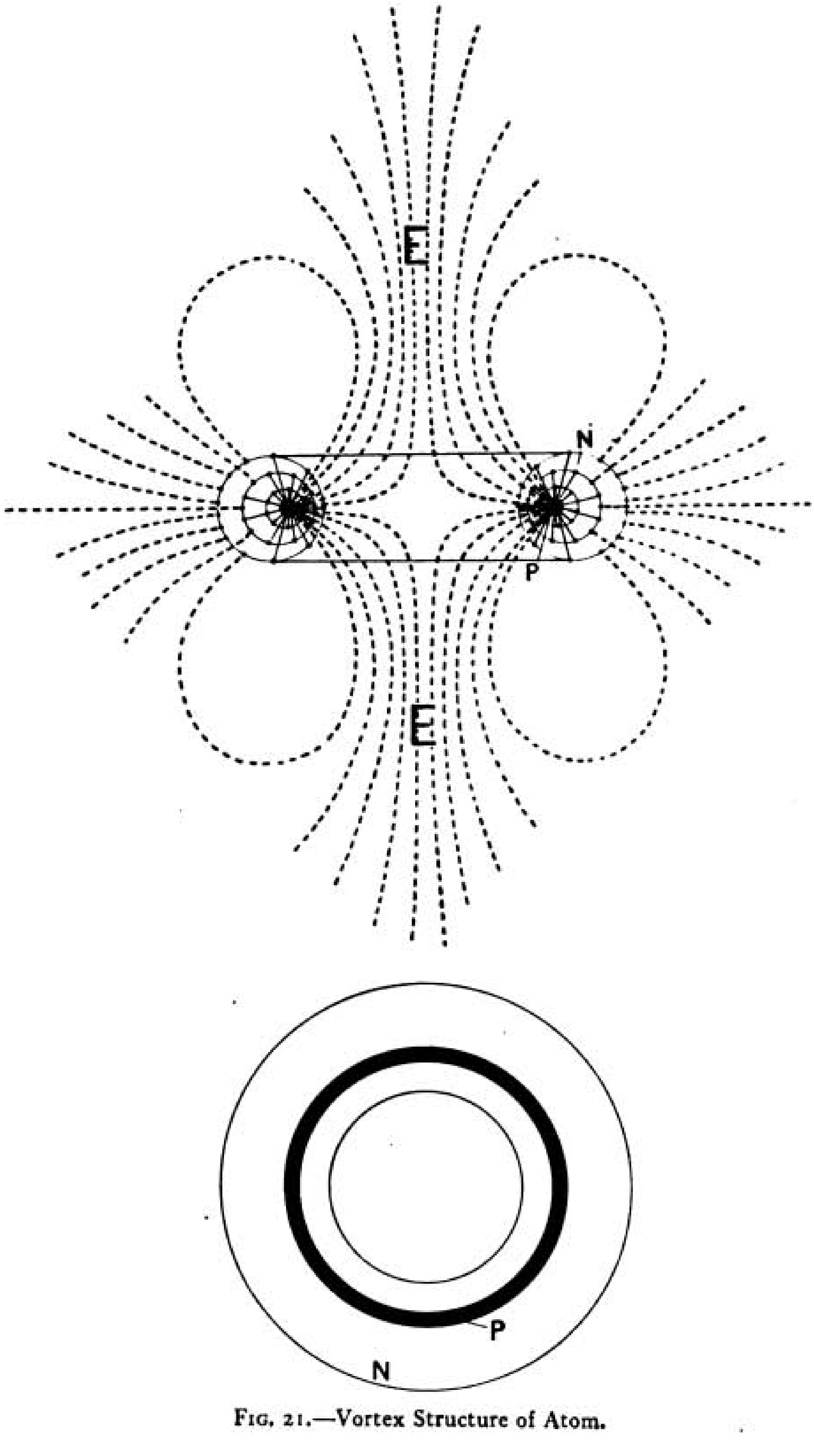


FIG. 21.—Vortex Structure of Atom.

(*d*) The positive ring is not in the true centre of the electron shells. Normally it is nearest to the shell electrons as they pass through the

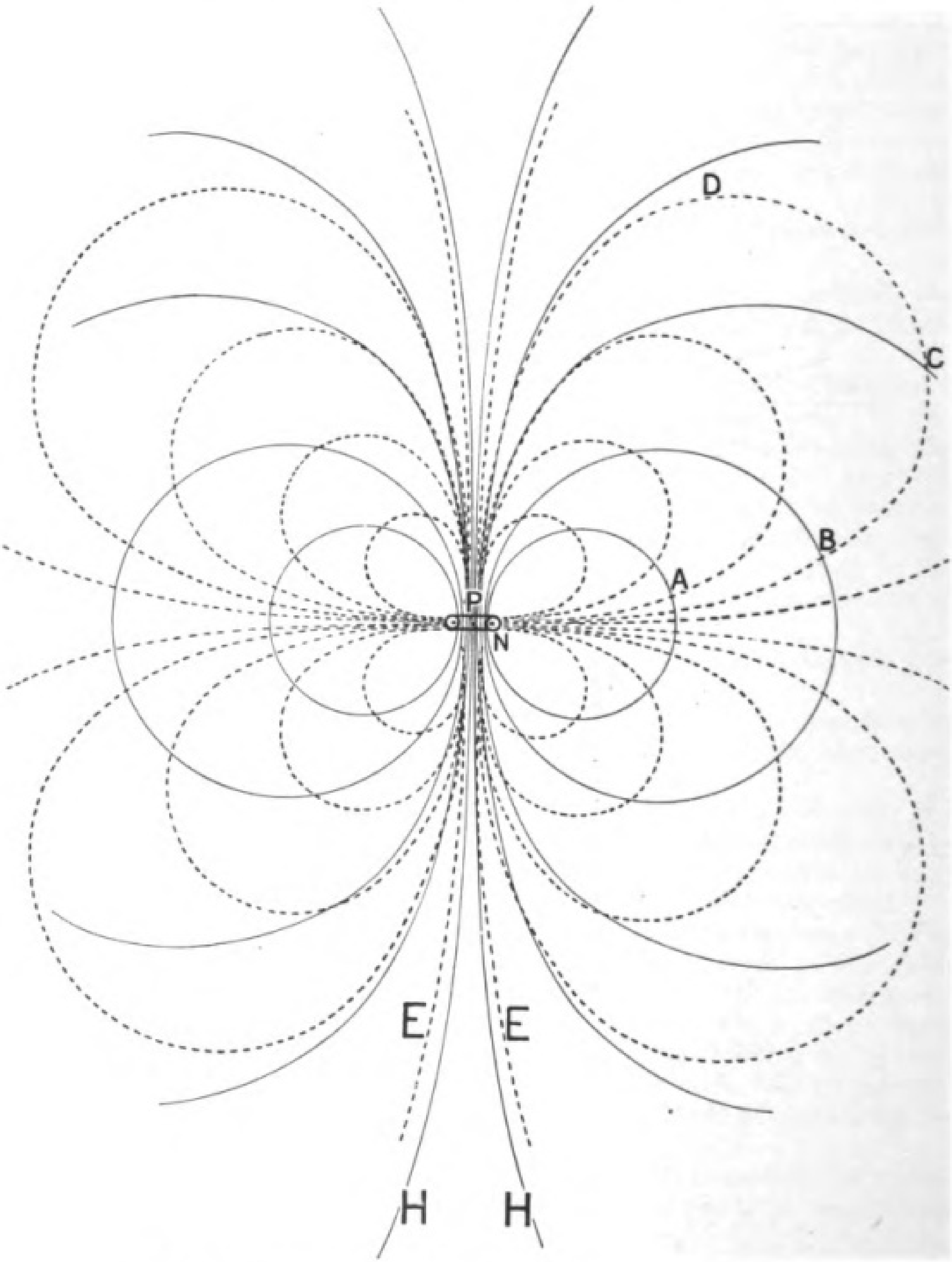


FIG. 22.—Magnetic and Electrostatic Fields round Vortex Atom.

aperture of the system. As a result these inside electrons speed up and open out, while the outside electrons slow down and close up, so that on the extreme diameter one shell tends to screen the next outside it from the direct action of the field from the positive ring.

This field (E, Fig. 21) therefore leaks out towards the atomic axis and links up externally with the weakly held electrons from which it is partially screened internally, so that the ring system core of the atom is enveloped in an extensive and re-entrant electrostatic field, and the shape of the atom as a whole therefore approximates to a spheroid.

(*e*) The strength of the electrostatic leakage field (E, Fig. 22) is proportional to the atomic number of the element, and is the positive charge which is measured on the atom. For distances near the core its intensity falls off according to the inverse square law in agreement with the experimental results of Rutherford and Chadwick.

(*f*) The vortex motion of the positive ring produces an internal magnetic field which is balanced by the opposite vortex motions of the electron shells. Also the external magnetic field produced by the revolution round its axis of the positive ring, is counterbalanced by the revolution in the opposite sense of the electron shells, so that the system as a whole tends to have no resultant magnetic field in space.

With most of the elements this magnetic balance is not perfect so that the atom has a small resultant magnetic field in space (H, Fig. 22).

(*g*) The effect of the compound electrostatic-magnetic field surrounding the core on any stray electron is to draw it towards the core. But its progress there will not be direct. The magnetic field will cause it to spiral, and at certain positions on its path the resultant of E and H may even give it a fixed orbit.

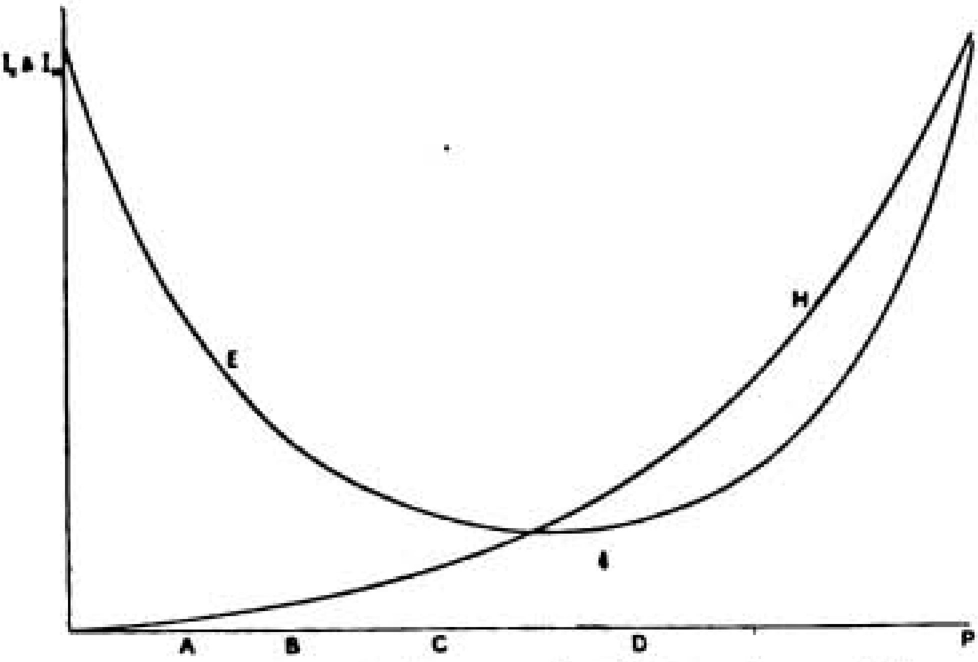


FIG. 23.—Variation of Magnetic and Electrostatic Fields acting on Electron in various positions round Vortex Atom.

Imagine a free electron to travel from the outside of the atomic core towards the core aperture following the path NABCDP (Fig. 22). Then the intensities of the E and H fields through which it will pass are roughly indicated in Fig. 23.

From N to some point B the intensity of the electrostatic field commences high but steadily falls, and the magnetic field is so weak that it only introduces a very small component of motion at right angles to the directions of both fields, which will carry the electron out of the plane of the paper to some position normal to it.

From B to a point about midway between C and D the electrostatic field falls to a minimum while the intensity of the magnetic field steadily increases.

This means that the component of motion in a plane normal to the paper becomes relatively much stronger, and the deviation may be so considerable that the electron is carried a negligible distance nearer to P for a complete circuit round the atom.

About the region CD while the electrostatic pull is almost constant, the deviation effect of the magnetic field increases the nearer the electron is to P so that there exists hereabouts a tendency for the electron to be given a permanent orbit.

While the electron is in orbital motion in the region CD it is a "valency" electron, capable of being held by the fields of two neighbouring atoms and by the same means assisting to hold the two atoms together. In such a position when necessary it may even be stationary relative to the two atomic axes, but it will still be in relative movement to both atomic cores owing to their rotation.

Tetravalent atoms like carbon and silicon have two such electrons at each pole.

(*b*) The E curve becomes steeper than the H curve near the atomic axis, and the two fields gradually become more parallel, so that should the balance be disturbed which keeps the electron within the orbital region, on passing D it will be sucked into the aperture of the atom at P, where, if there is room for it, it will remain spiralling in and out.

There are then two positions of stability for the electron in the atom : (1) in a valency orbit, (2) in the aperture, and every neutral atom is accompanied by a definite complementary number of loose electrons divided between these two positions. The elements in group 0 have no valency electrons.

A current flows when either a valency electron or an aperture electron is displaced and its position is taken by another one, and as the aperture electron is under very little constraint from the magnetic field it can be moved by the application of a smaller E.M.F. than is required to displace a valency electron.

(*c*) When two atoms of different elements which each have a resultant magnetic field, unite to form a molecule, they will come together as do permanent magnets in such a way that these fields assist each other. But the leakage electrostatic fields must oppose each other.

The molecular fields will then have the general form shown in Fig. 24; they will intersect at right angles where the atomic electrostatic fields meet, and the valency electrons will have their orbits in this plane.

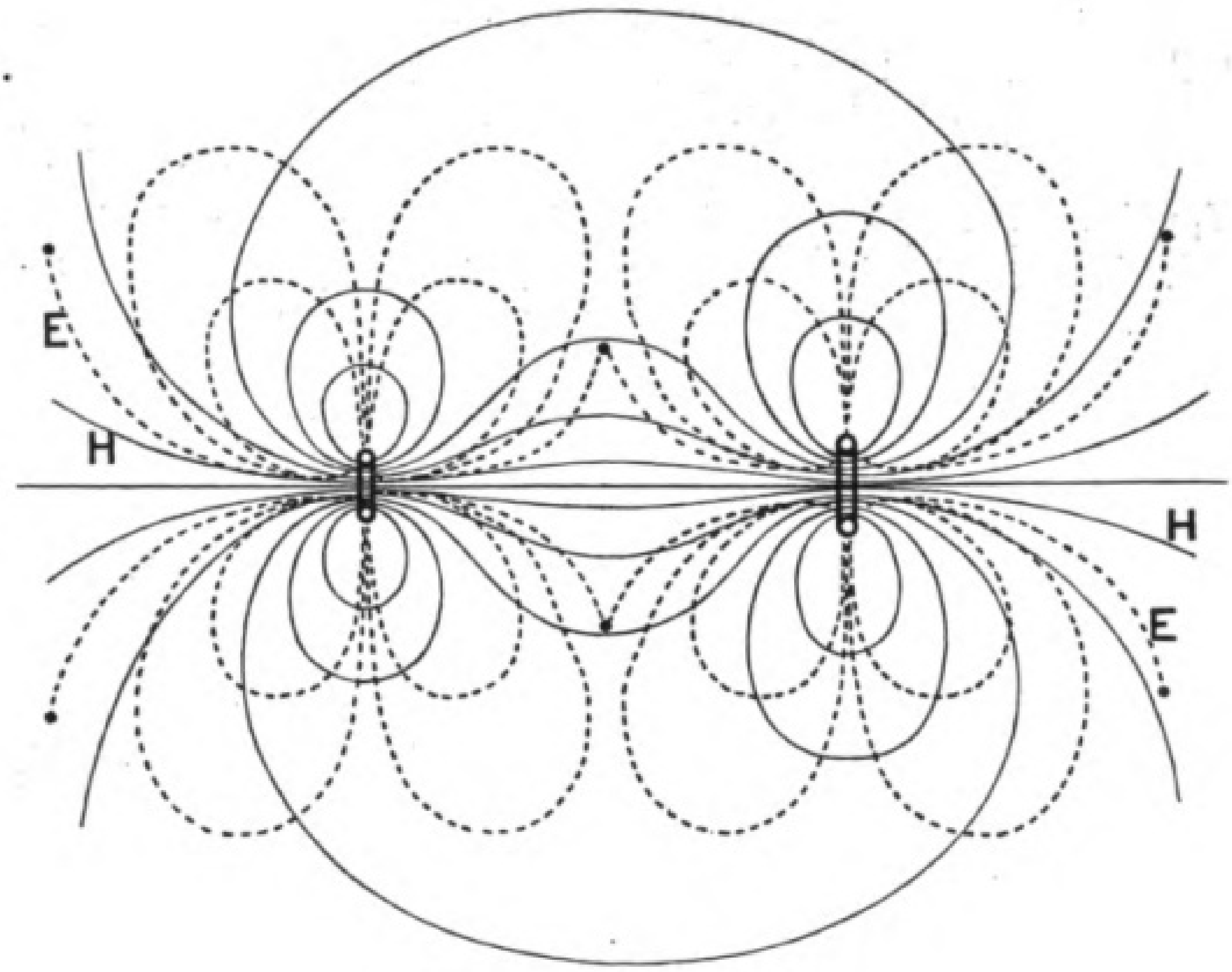


FIG. 24.—Molecular Fields.

In the production of the carborundum molecule **CSi** (Fig. 25) two electrons have been given up; there are two electrons in a common orbital region which are shared between the two atoms and two at each end orbital region. In this figure the diameters of the two elements have the same relative values as the atomic diameters given by W. L. Bragg.*

(j) In the process of crystal structure many molecules form chains of various types, positive ion of one to negative ion of another, and the two end valency electrons of one carborundum molecule share their fields with other carborundum molecules so that the molecules become bonded together.

In the complete crystal then there are sufficient valency electrons to provide for the independent existence if necessary of each molecule, but there are not sufficient to provide for the separate existence of

* *Philosophical Magazine*, 40, p. 180, August, 1920.

each atom. The bonding therefore between the molecules will be much weaker than between the atoms.

It is not necessary for our present purpose to follow this theory further. It is clear that on the application of an E.M.F. a molecule having the form described will pass an electron current from X to X_1 without any difficulty by drawing on the aperture electrons; but if the E.M.F. is applied from Y to Y_1 no current can pass until the imposed electrostatic field has reached such a value as to disturb the stability of the valency electrons.

For the reason given above it is the valency electrons between the molecules such as those at Z and not those at the centre of the molecule in the plane YY_1 which will be the less difficult to displace, and in effecting this displacement and the loosening of the crystal bonding the imposed field must unquestionably alter the orientation of some of the molecules.

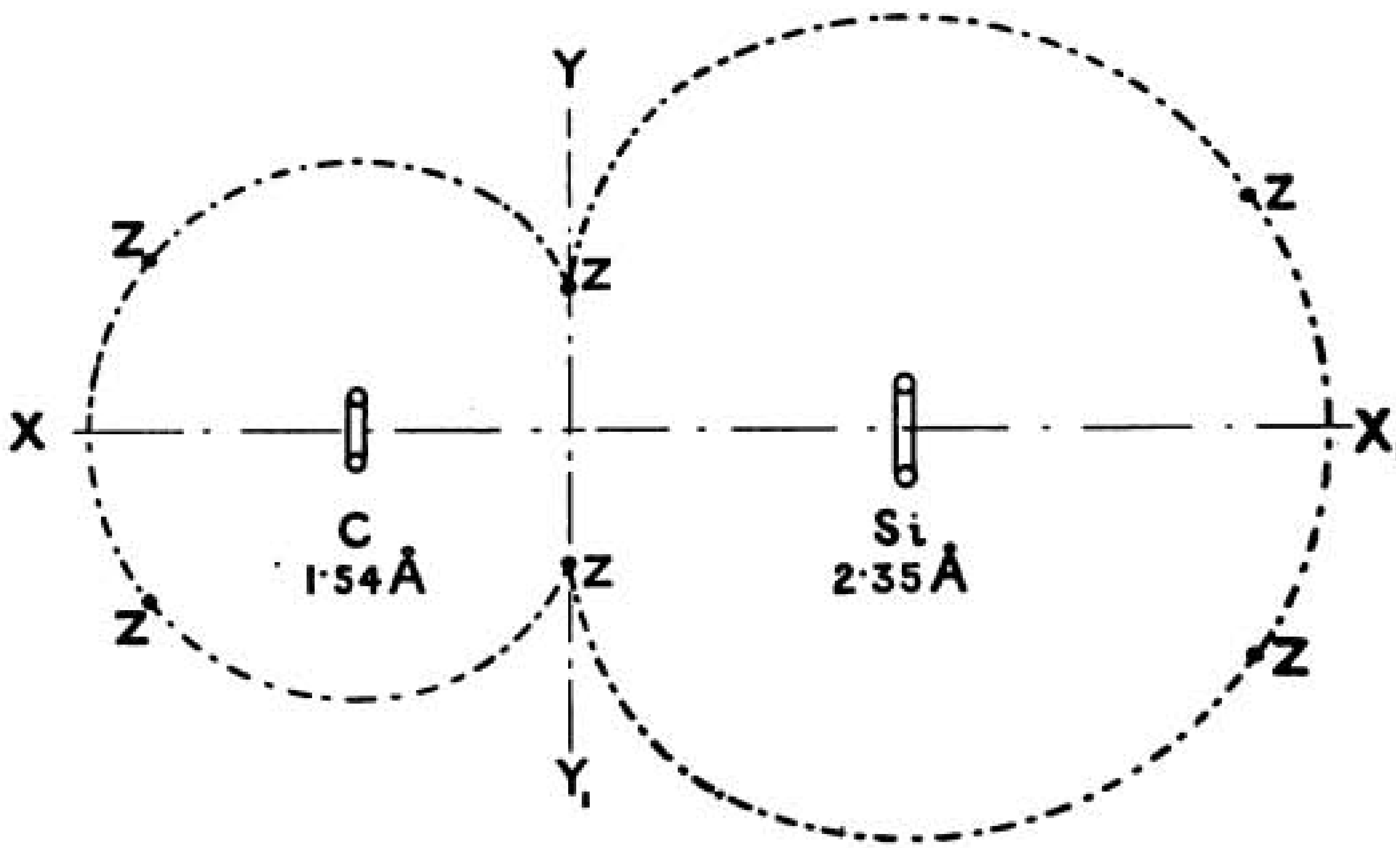


FIG. 25.—Structure of Carborundum Molecule.

Also it is clear that the displaced valency electrons will tend to travel along the XX_1 axis instead of along YY_1 if the two paths finally join, and as the orbital stability in **C** and **Si** is not necessarily the same, and it must be affected by the form of the space lattice structure, it is reasonable to expect that the applied E.M.F. will always establish conductivity more easily through the carbon end of the molecule in one type of crystal, and more easily through the silicon end of the molecule in another type of crystal, the disturbance changing the orientation of the molecule as a whole, however, not only of one or other atomic part.

Further, this molecular distortion involves the stability of the crystal as a whole and is resisted by the combined magnetic and electrostatic molecular fields as a whole, so that when stability is yet more disturbed by forcing electrons in or taking them out at a rectifying point, an elastic pressure due to these fields is felt throughout the crystal, and electrons will be forced out or sucked in at any other point without energy being lost between the points of ingress and egress.

A current which passes between two neutral points on a crystal involves aperture electrons only and no change in the orientation of molecules, so that there is no reaction in the crystal tending to neutralise the internal absorption of energy.

The principle on which the rectification effect in carborundum appears to be based has now been stated.

To follow out its operation in greater detail requires a more complete knowledge of the space lattice structure of the two principal forms of crystal than we at present possess.

All the experiments described in this paper have been carried out at various dates in the testing laboratories of Marconi's Wireless Telegraph Company at Chelmsford, and in this connection the careful work of Mr. M. F. Willis, B.Sc., deserves special mention.

Notes.

Personal.

Dr. Lee de Forest, for many years the head of the de Forest Radio Telephone and Telegraph Company, resigned on September 26th as its active head. For the next few years he intends to reside in Germany. **Mr. Chas. Gilbert**, who has been treasurer of the company since 1915, has been elected its president and general manager. He will be assisted by **Mr. R. M. Keator**, who will have charge of sales and manufacture. **[4368]**

Dr. G. W. O. Howe, D.Sc., M.I.E.E., head of the Department of Standards and Measurements at the National Physical Laboratory, Teddington, has been appointed to the newly-founded James Watt Chair of Electrical Engineering in the University of Glasgow. **[4252]**

"Sir Charles Bright and Partners" is the style of a new firm of consulting engineers which has recently been formed, its members comprising Sir Charles Bright, F.R.S.E., M.Inst.C.E.; Mr. A. Hugh Seabrook, M.I.Mech.E., M.I.E.E.; Mr. A. J. Stubbs, M.Inst.C.E., M.I.E.E., and Lieut.-Colonel H. W. Woodall, C.I.E., M.Inst.C.E. **[4237]**

Commercial and General.

AN ITALIAN MARCONI COMPANY.—We have been informed that the notices that have appeared in the technical press recently with regard to the formation of an Italian Marconi Company are without foundation, as no such company has been formed. **[4234]**

CHINESE-AMERICAN WIRELESS AGREEMENT.—The American Minister in Peking has notified the State Department of the signing of a supplementary agreement between the Federal Wireless Company and the Chinese Government. The agreement relates to the issue of bonds for financing the project. **[4322]**

RADIOTELEPHONY BETWEEN FINLAND AND SWEDEN.—The directors of Sodra Finlands Interurbana Telefon A.B., of Helsingfors, have made application to the Finnish Ministry for Communications for the grant of a concession for the establishment of a system of radiotelegraphy between Finland and Sweden for general public use. According to the company's statement, it is proposed to form a separate company, in which the Finnish State would have the opportunity of being represented, for the execution of the scheme. **[4408]**

NEW BELGIAN WIRELESS STATION.—A powerful wireless station is to be erected at Ruysselde in Belgium; the tower is to have a height of 325 metres. **[4420]**

IMPERIAL WIRELESS CHAIN.—H.M.S. *Raleigh* arrived at St. John's, N.F. recently on a visit of inspection of the Admiralty wireless station with a view to its utilisation as a link in the Imperial Wireless Chain. [4235]

NOTES ON WORKING OF ARC SETS ON S.S. "CARONIA" AND "SCYTHIA."—The *Caronia* is fitted with a 10 kW arc set, and the *Scythia* with a similar 5 kW installation. Power is derived from a motor generator set mounted on the upper deck and controlled from the wireless cabin.

After difficulties of adapting these sets to conditions of working on board ship had been overcome, both have given extremely satisfactory service. Very little difference has been experienced in the ranges obtained in working coast stations due to the fact that the *Caronia* is limited in her performance to the ranges of the stations with which she works, as they have not sufficient power to transmit to her as far as they can receive her. Reports indicate that good signals have been received from the *Caronia* at a range of 3,500 miles.

Traffic is handled with ease at 2,200 miles both with Devizes and stations on the American side, whilst traffic has been worked at ranges of 2,500 miles with Bar Harbour, Maine, U.S.A. Traffic can be dispatched very rapidly at these extreme ranges on account of the fact that signals are sufficiently strong to permit of batches of as many as twenty messages being sent. Although it takes approximately sixteen seconds to start up the arc, working assumes a higher rate of messages in a given period over valve sets of less power, which, through necessity of sending messages singly or in small batches due to weaker signals, lose the advantage of more rapid change over from send to receive. [4453]

WIRELESS TELEGRAPHY IN ITALY.—The first meeting of the Commission recently nominated by the Associazione Elettrotecnica Italiana to study questions related to telegraphy, telephony, and radiotelegraphy was held in July, when the use of wireless telegraphy by industrial companies possessing electric plant was discussed as one among several means of extending the employment of wireless telegraphy generally. In Italy hitherto wireless telegraphy has been limited to the naval and military services and to a few shipping concerns. To carry out the Association's plans three sub-committees have been appointed, whose duty will be to find out the machines best suited for wireless purposes, to fix standards for the various parts, to ascertain what dielectric rigidity is required, to settle the earth insulations of dynamos and transformers, the choice of a direct-current type of machine able to work with sudden and frequent changes of load, the tendency of short-circuiting and sparking at the collector, the insulation of conductors, protection against lightning, safeguarding of neighbouring networks against disturbance, etc. [4157]

Review of Radio Literature.

1. Abstracts of Articles and Patents.*

(F.) Thermionic Valves, and Valve Apparatus.

(6) APPLICATION OF VALVES TO OSCILLATION GENERATION (including Valve Transmitting Apparatus).

2674. **B. Rosenbaum** [E. F. Huth Gesellschaft]. Wireless Transmitting Apparatus. (*British Patent* 149216, July 12th, 1920. Convention date July 21st, 1917. Patent not yet accepted.)

* Particulars of the U.S.A. Patents abstracted in this section have been supplied by Mr. John B. Brady, Patent Lawyer, Ouray Building, Washington, D.C., U.S.A.; and those of the French Patents by Messrs. J. E. Raworth & Moss, Patent Agents, 75, Victoria Street, London, S.W.

In a system for the transmission of undamped oscillations, feeble independently generated oscillations are impressed upon and amplified by one or more power valves before transmission to the aerial.

2675. **Gesellschaft für drahtlose Telegraphie.** Wireless Telephone Transmitter. (*British Patent* 158901, February 8th, 1921. Convention date February 9th, 1920. Patent not yet accepted.)

An addition to *British Patent* 154181.

2676. **Gesellschaft für drahtlose Telegraphie.** Wireless Transmitting Apparatus. (*British Patent* 159463, February 21st, 1921. Convention date February 28th, 1920. Patent not yet accepted.)

In a thermionic valve transmitter the grid potential is derived solely from the aerial current and is not influenced directly by the field of the plate inductance. The grid and anode connections are taken to tapping points on the aerial tuning inductance, so that the power output may be easily varied by changing the tapping point of the grid lead without changing the aerial tuning.

2677. **E. F. Huth Gesellschaft.** Thermionic Oscillation Generators. (*British Patent* 157928, January 10th, 1921. Convention date July 24th, 1919. Patent not yet accepted.)

In order to overcome the interference effects that normally occur when two or more thermionic oscillation generators are connected with their output circuits in parallel, each valve is caused to influence the other reciprocally by appropriate intercouplings.

2678. **L. Lévy.** Thermionic Valve Oscillation Generators. (*British Patent* 160799, March 24th, 1921. Convention date March 29th, 1920. Patent not yet accepted.)

Relates to an arrangement of two valves having retroaction provided by capacities and resistances only as used for the generation of large number of harmonics. A definite fundamental frequency with few harmonics may be generated by including a tuned loop in one of the valve circuits.

2679. **Gesellschaft für drahtlose Telegraphie.** Thermionic Oscillation Generators. (*British Patent* 160819, March 30th, 1921. Convention date March 31st, 1920. Patent not yet accepted.)

Relates to the use of A.C. of high audible frequency to supply the anode circuit of an oscillating valve.

2680. **W. H. Eccles** and **J. H. Vincent.** Generating High-frequency Oscillations. (*British Patent* 162067, January 21st, 1920. Patent accepted April 21st, 1921.)

Mechanical means are provided so that the filament current is adjusted when the reaction coupling is altered to ensure constancy of the generated frequency.

2681. **Société anonyme pour l'Exploitation des Procédés M. Leblanc-Vickers.** Converting Electric Currents. (*British Patent* 155784, December 23rd, 1920. Convention date December 23rd, 1919. Patent not yet accepted.)

Relates to a valve filled with an inert gas or vapour and having an incandescent cathode, one or more anodes and a grid electrode. Its applications to oscillation, generation and frequency changing are dealt with in the specification.

2682. **L. A. Hazeltine.** Producing Electric Oscillations. (*British Patent* 155789, December 23rd, 1920. Convention date November 28th, 1919. Patent not yet accepted.)

Relates to means for improving the efficiency of valve oscillation generators and for eliminating harmonics by the use of two or more valves simultaneously.

2683. **C. L. Farrand** [Marconi's Wireless Telegraph Company]. Valve Transmitters and Receivers. (*British Patent* 145039, June 14th, 1920. Convention date June 14th, 1919. Patent accepted July 14th, 1921.)

The grid circuits of valve used for transmission or reception are supplied from independent sources of H.F. of frequency generally differing from the wave frequency. For transmission a modulation method similar to the " choke control " method is described but using a transformer between the two plate circuits in place of a common choke coil, and having the grid circuit control or L.F. amplifying valve also supplied with a H.F. E.M.F. derived from a coil coupled to the aerial.

2684. **C. L. Farrand** [Marconi's Wireless Telegraph Company]. Wireless Transmitters. (*British Patent* 145040, June 14th, 1920. Convention date June 14th, 1919. Patent accepted May 12th, 1921.)

Relates to valves having two grids and two plates so arranged that when the current is a maximum in one plate circuit it is a minimum in the other. The maximum emission from the filament can thus be used at all times.

2685. **Gesellschaft für drahtlose Telegraphie.** Producing Electric Oscillations. (*British Patent* 148445, July 10th, 1920. Convention date October 25th, 1918. Patent not yet accepted.)

In oscillation generators using a number of thermionic valves in parallel, inductances are inserted in the parallelling connections to prevent the generation of undesired frequencies.

2686. **Gesellschaft für drahtlose Telegraphie.** Producing Electric Oscillations. (*British Patents* 148447 and 148523, July 10th, 1920. Convention date September 9th, 1918. Patent not yet accepted.)

To suppress an undesired frequency in a valve oscillator an auxiliary condenser, inductance or resistance is inserted into one of the oscillation circuits.

2687. **H. J. Round.** Thermionic Telephone Transmitters. (*British Patent* 148632, April 28th, 1919. Patent accepted July 28th, 1920.)

Relates to radiotelephone transmitters of the "quiescent aerial" type in which the high D.C. voltage for supplying the oscillating valve is obtained by rectifying the alternating speech currents obtained from a microphone and step-up transformer.

2688. **Société Française pour l'Exploitation des Procédés Thomson-Houston.** Wireless Telephone Transmitting Apparatus. (*French Patent* 509304, March 31st, 1920. Published November 6th, 1920.)

Electric oscillations for wireless telephony are produced and controlled by an electron valve in which the grid circuit is connected to a second electron valve, the potential of the grid in the second valve being varied by a telephone transmitter. For further particulars, see *British Patent* 7367/15.

2689. **H. de F. Arnold** [Western Electric Company]. Wireless Telephonic Apparatus. (*British Patent* 146881, July 6th, 1920. Convention date December 1st, 1915. Patent not yet accepted.)

A wireless transmitter with a resonant circuit to suppress one of the resultant modulated frequencies $N + n$, N, or $N - n$; preferably the carrier frequency N is eliminated.

2690. **W. C. White** [British Thomson-Houston Company]. Producing Electric Oscillations, (*British Patent* 146946, June 17th, 1920. Convention date July 8th, 1919. Patent not yet accepted.)

Two thermionic valves in cascade with the output of the second reacting back on the grid circuit of the first.

2691. **R. Whiddington.** Producing High-frequency Electric Oscillations. (*British Patent* 150516, August 9th, 1919. Patent accepted September 9th, 1920.)

A valve containing traces of gas or vapour is adjusted to oscillate with a frequency determined by the grid potential, the dimensions of the valve, and the molecular mass and ionic charge of the contained gas.

2692. **H. J. Round.** Wireless Transmitting Apparatus. (*British Patent* 150037, May 21st, 1919. Patent accepted August 23rd, 1920.)

In order to reduce energy losses due to internal heating valve generators are supplied with a square form voltage, and filter circuits are instituted to reject the harmonics in the output.

2693. **A. K. Macrorie, H. Morris-Airey** and **G. Shearing.** Thermionic Oscillation Generators. (*British Patent* 163117, February 11th, 1920. Patent accepted May 11th, 1921. *Engineer*, 131, p. 681, June 24th, 1921—Abstract.)

The retroactive connection between the aerial and the grid circuit of a generating valve is made through an intermediate circuit tuned to the aerial frequency. This arrangement is claimed to produce approximately the optimum phase relation of 90 degrees between the oscillatory grid potential and the aerial current.

2694. **A. K. Macrorie** and **G. Shearing.** Thermionic Oscillation Generators. (*British Patent* 163118, February 11th, 1920. Patent accepted May 11th, 1921.)

Two or more valves are connected with their anode circuits in series or series parallel, and with their grid circuits highly insulated from one another and separately coupled to the aerial circuit. By this means the inductance in the aerial circuit between earth and the anode tapping point may be much greater than with the usual parallel arrangement of the valves.

2695. **M. K. Akers** [Western Electric Company]. Wireless Transmitters. (*British Patent* 156159, December 31st, 1920. Convention date December 31st, 1919. Patent not yet accepted.)

In a thermionic valve oscillation generator, the effects of parasitic oscillations are overcome, and the power output is made constant for any wavelength by various means, such as a small variable condenser shunted across grid and plate of the valve, or across the anode inductance. The constructional arrangement of special variometers for these circuits is also given.

2696. **Gesellschaft für drahtlose Telegraphie.** Wireless Telephony. (*British Patent* 157405, January 10th, 1921. Convention date December 11th, 1919. Patent not yet accepted.)

In a wireless telephone valve transmitter an amplifier valve controlled by the microphone currents influences the degree of coupling of grid or anode or both.

2697. **H. Fassbender** and **E. Habann** [Deutsche Telephonwerke Gesellschaft]. Wireless Telephony. (*British Patent* 157303, January 10th, 1921. Convention date August 29th, 1918. Patent not yet accepted.)

In a system for telephony using H.F. oscillations, energy is transferred to the line or aerial only when speech is in progress.

2698. **Société Indépendante de Telegraphie sans Fils.** Valve Oscillators. (*British Patent* 153259, October 28th, 1920. Convention date October 28th, 1919. Patent not yet accepted.)

The oscillations are set up in an inductance shunting the grid and plate of the valve, the interelectrode capacities forming the condenser of the oscillation circuit.

2699. **Gesellschaft für drahtlose Telegraphie.** Thermionic Oscillation Generators. (*British Patent* 147849, July 9th, 1920. Convention date September 28th, 1917. Patent not yet accepted.)

2700. **Gesellschaft für drahtlose Telegraphie.** Thermionic Valve Oscillators. (*British Patent* 147850, July 9th, 1920. Convention date December 22nd, 1917. Patent not yet accepted.)

Relates to means for filtering out the harmonics in the oscillations generated by a valve.

2701. **Gesellschaft für drahtlose Telegraphie.** Thermionic Valve Transmitters. (*British Patent* 147851, July 9th, 1920. Convention date January 9th, 1918. Patent not yet accepted.)

Relates to the use of two tubes connected in opposition so as to avoid loss of efficiency due to grid currents.

2702. **Gesellschaft für drahtlose Telegraphie.** Thermionic Valve Oscillators. (*British Patent* 147854, July 9th, 1920. Convention date October 25th, 1918. Patent not yet accepted.)

Inductances are inserted in series with the anode of each valve of a series of valve oscillators in parallel to prevent the generation of undesired frequencies.

2703. **H. E. Bussey.** A Radiophone employing A.C. and a Chemical Rectifier. (*Q.S.T.* 4, pp. 17—18, June, 1921.)

2704. **A. K. Macrorie** and **G. Shearing.** Wireless Transmitting Apparatus. (*British Patent* 163458, February 16th, 1920. Patent accepted May 17th, 1921.)

Relates to valve oscillators in which a variable condenser is placed across the grid coupling coil, and comprises means for minimising the rise in the current in the grid circuit and for giving a visual warning (such as by a lamp) should the grid current be excessive owing to incorrect adjustment.

2705. **D. S. Basin.** A Tube Transmitter using A.C. on the Plate. (*Radio News*, 2, p. 863, June, 1921.)
Gives constructional details.

2706. **P. R. Coursey.** Experimental Wireless Telephony. (*Wireless World*, 9, pp. 127—144, May 28th, and pp. 164—167, June 11th, 1921.)
A paper read before the Wireless Society of London. See RADIO REVIEW, 2, p. 481, September, 1921, for Abstract.

2707. **M. Latour.** Wireless Transmitting Apparatus. (*British Patent* 164009, July 3rd, 1920. Convention date December 8th, 1915. Patent not yet accepted.)
An arrangement of a transmitting circuit where the plate and grid of a thermionic valve are connected to either end of the aerial tuning inductance. The transmitting key is inserted in the filament connection or aerial circuit.

2708. **W. Schäffer.** Radiotelephony with Triode Transmitters. (*Tijdschrift van het Nederlandsch Radiogenootschap*, 1, pp. 35—67, March, 1921.)
A paper read at Delft in November, 1920. The author is apparently associated with the Telefunken Company. The paper gives a very full and clear explanation of the application of the triode to radiotelephony, with many excellent diagrams of connections, including one ascribed to Krafft-Kolpitz.

2709. A New Continuous Wave Type Transmitter. (*Radio News*, 2, p. 285, November, 1920.)
An illustrated description of a three-valve transmitting set.

2710. **H. M. Pruden.** A Vacuum Tube Transmitter operating on a Six-volt Storage Battery. (*Radio News*, 2, p. 286, November, 1920.)

2711. **J. Bethenod.** Continuous Wave Transmitter. (*French Patent* 511933, May 26th, 1916. Published January 7th, 1921.)
The electric oscillations are generated by a three-electrode valve in which the anode and the incandescent cathode are connected by two circuits in parallel, one consisting of an oscillating circuit comprising an inductance and a capacity and the other a supply circuit. See also *British Patent* 107581.

2712. **R. V. L. Hartley.** Vacuum Tube Amplifiers in Parallel. (*Proceedings of the Institute of Radio Engineers*, 9, pp. 250—254, June, 1921.)
The general theory of the power output of a number of similar vacuum tubes in parallel is outlined assuming that the current-voltage characteristics are linear.

2713. **Physikalisches Institut der Universität Jena.** Thermionic Valves. (*British Patent* 165096, June 20th, 1921. Convention date June 18th, 1920. Patent not yet accepted.)
Relates to an arrangement of reaction coupling for oscillation valves, in which the grid circuit of the valve is coupled both to the plate circuit and to a secondary circuit coupled to the plate, with the object of preventing the production of a double wave. A suitable short circuiting switch to one or other of the couplings permits the production of either of the wavelengths.

2714. **M. B. Sleeper.** A B-Battery Telephone Set. (*Radio and Model Engineering*, 1, pp. 1—4, May, 1921.)
Gives details of construction.

2715. **R. E. Lacault.** A Radiophone and C.W. Set. (*Science and Invention*, 9, p. 645, September, 1921.)
An illustrated description of a six-valve set.

(7) AND (8) MISCELLANEOUS APPLICATIONS OF TWO- AND THREE-ELECTRODE VALVES.

2716. **Cutler-Hammer Manufacturing Company** [Igranic Electric Company]. Electric Supply Systems. (*British Patent* 162961, June 21st, 1920. Patent accepted May 12th, 1921.)
Relates to the application of two- and three-electrode thermionic valves to power transmission systems for controlling the speeds of motors, etc.

2717. **A. W. Hull.** Electron Tubes Soon in Heavy Power Service. (*Electrical World*, 77, p. 1263, May 28th, 1921.)

An abstract of a lecture before the American Institute of Electrical Engineers at its Annual Meeting in New York on May 20th and dealing with the possible future applications of high power two- and three-electrode vacuum tubes. A new tube termed a Magnetron was also described. In this tube the control of the electron current is effected by means of a magnetic field and a tube built on these lines and capable of an output of 5 kW was exhibited.

2718. **W. H. Eccles** and **F. W. Jordan.** Converting Electric Currents. (*British Patent* 155854, April 17th, 1918. Patent accepted January 6th, 1921. *Engineer*, 131, p. 167, February 11th, 1921—Abstract.)

Relates to the use of triode valves for maintaining the vibrations of a tuning fork or the rotation of a small motor or similar mechanism.

2719. **J. Malassez.** The Use of a Three-Electrode Valve for the Measurement of Ionisation Currents. (*Comptes Rendus*, 172, pp. 1093—1094, May 2nd, 1921. *Revue Scientifique*, 59, p. 255, May 14th, 1921—Abstract.)

The grid of the valve is connected to a condenser plate in the ionisation chamber and is initially charged to a potential of — 40 volts, and then insulated. The positive ions attracted to this plate raise the potential of the grid and so vary the plate current of the tube.

2720. **T. W. Case.** Photoelectric Effect in Oxide-coated Audion Bulb. (*Electrical World*, 77, p. 894, April 16th, 1921; p. 1175, May 21st, 1921. *Electrical Review*, 88, p. 687, May 27th, 1921.)

It has been observed that the oxide-coated filament in a high vacuum valve shows a slight photoelectric effect both when heated and when cooled. When the plate is kept positive an increasing action is found. The active material appears to be a brownish deposit on the plate. The effect is immediately destroyed if a trace of oxygen is admitted to the bulb.

2721. **E. Merritt.** Photoelectric Phenomenon in Coated Filament Audion Bulbs. (*Physical Review*, 17, pp. 525—526, April, 1921.)

Experiments are described similar to those made by T. W. Case on this subject (see preceding abstract.) Photoelectric emission was also found from the deposit on the plate. The photoelectric current measured with the filament warm was considerably greater than that obtained from the Elster and Geitel platinum-hydride cell arranged to give maximum effect although the area illuminated in the latter case must have been a hundred times greater than the area of the valve filament. The phenomenon is also connected with the effects of secondary emission in such tubes.

2722. **F. Breisig.** Converting Electric Currents. (*British Patent* 144720, June 11th, 1920. Convention date March 11th, 1919. Patent not yet accepted.)

The power supplied from a C.C. source over a long line is converted to A.C. by means of cathode tubes.

2723. **Siemens and Halske.** Telegraphic Receiving Apparatus. (*British Patent* 146122, June 23rd, 1920. Convention date September 27th, 1918. Patent not yet accepted.)

Deals with the application of a three-electrode valve as an amplifier for line telegraphic reception.

2724. **Bosch Akt. Gesellschaft.** Internal Combustion Engines. (*British Patent* 158270, January 19th, 1921. Convention date January 19th, 1920. Patent not yet accepted.)

Deals with the employment of thermionic valves in place of interrupters in ignition systems of internal combustion engines.

2725. **J. J. Dowling.** Direct Reading Ultra-Micrometer. (*Proceedings of the Dublin Royal Society*, 16, pp. 185—188, March, 1921. *Science Abstracts*, 24A, p. 313, Abstract No. 737, May 31st, 1921—Abstract.)

Refers to an earlier paper, RADIO REVIEW Abstract No. 2125, August, 1921. The present paper describes improvements in the apparatus which render it more suitable and reliable.

2726. **A. Pflüger.** Measurement of Small Angular Movements. (*Physikalische Zeitschrift*, 22, p. 73, February 1st, 1921. *Science Abstracts*, 24A, p. 313, Abstract No. 758, May 31st, 1921.)

The valve method described is similar in principle to that used by Whiddington.* The variable condenser used consists of a fixed plate and a movable one capable of rotation about an axis coincident with one edge, the plates being initially parallel.

2727. **O. Bothe.** Apparatus for receiving and reproducing Sound. (*British Patent* 161979, April 20th, 1921. Convention date April 20th, 1920. Patent not yet accepted.)
The application of a thermionic valve to the amplification of photoelectric currents.

2728. **E. C. Hanson.** Telephones. (*British Patent* 154536, November 23rd, 1920. Convention date June 11th, 1919. Patent not yet accepted.)
The use of valve amplifiers for apparatus for use by deaf persons.

2729. **A. van T. Day.** Railway Signals. (*British Patent* 148381, July 9th, 1920. Convention date October 18th, 1916. Patent not yet accepted.)
Relates to the application of valve amplifiers to railway track circuit signalling.

2730. **J. H. Smart** and **J. Tucker.** Valve Receiving Systems. (*British Patent* 152190, September 23rd, 1919. Patent accepted October 14th, 1920.)
The use of a thermionic valve amplifier for line telegraphic reception.

2731. **E. Waltz** and **H. Meusser.** Transmitting and reproducing Motion and Sounds. (*British Patent* 153300, November 1st, 1920. Convention date November 1st, 1919; 157124, January 8th, 1921. Convention date December 2nd, 1919. Patents not yet accepted.)
Deals with the application of thermionic valves to a species of electrostatic gramophone in which the variations in the record vary the capacity of one of the valve circuits.

2732. **J. Engl, J. Marsolle** and **H. Vogt.** Sound-recording Apparatus. (*British Patents* 157440, 157441, 157443, all of January 10th, 1921. Convention dates June 2nd, 1919, June 3rd, 1919, April 5th, 1919, respectively. Patents not yet accepted.)
Arrangements for producing a photographic record of sound waves a thermionic tube supplying the source of illumination the said tube being controlled by the receiving microphone.

2733. **L. Duverger.** Electric Signalling Systems. (*British Patents* 157386, 157387, and 157388, January 10th, 1921. Convention dates January 15th, 21st, and May 8th, 1919. Patents not yet accepted.)
Additions to *British Patent* 157385 (RADIO REVIEW Abstract No. 2602, November, 1921) dealing with the applications of the special valve amplifier there described.

2734. **I. Langmuir** [British Thomson-Houston Company]. Thermionic Amplifying Apparatus. (*British Patent* 147806, July 9th, 1920. Convention date February 5th, 1914. Patent not yet accepted.)
Deals with various applications of thermionic valves—such as to amplifying photoelectric currents, regulating the voltage of a generator, etc.

2735. **C. A. Briggs** and **R. F. Yates.** Measuring One Five Hundred Thousand Millionth of an Inch. (*Popular Science Monthly*, 99, pp. 64—65, July, 1921.)
Describes an elaboration of the ultramicrometer. (See RADIO REVIEW Abstract No. 1629, March, 1921.)

2736. **B. van der Pol.** Some Physical Applications of the Triode. (*Physica*, 1, pp. 97—100, July, 1921.)
An experimental lecture delivered at Utrecht in April, dealing with various applications, *e.g.* production of short waves on Lecher wires and the detection by a two-stage beat method of the change in specific inductive capacity of the air by sucking out some of the air from an enclosed air condenser, the change in frequency being 1 in 10^5.

2737. **F. W. Meyer.** The Applications of Thermionic Devices to the Control of Electrical Machinery. (*Elektrotechnische Zeitschrift*, 42, pp. 689—693, June 30th; pp. 725—728, July 7th, 1921.)
A lecture delivered at Essen dealing in a general way with the possibilities of employing

* RADIO REVIEW Abstract No. 1629, March, 1921.

thermionic devices with their absence of inertia and friction, rapidity of action, extreme sensitiveness, etc., for the accurate control of large amounts of power, without the disadvantages of hunting, etc. Diagrams of connections are given showing the field regulation of dynamos and motors to give constant voltage or speed.

2738. New Uses for the Audion. (*Experimental Science*, 1, p. 165, July, 1921.)

Deals with its use in connection with measurements of solar radiation, measurements of small diameters, measurements of high temperatures, stellar photometry and magnetic permeability measurements.

2739. **Cutler-Hammer Manufacturing Company** [General Electric Co., Ltd., London]. Thermionic Regulating Apparatus. (*British Patent* 164924, April 22nd, 1920. Patent accepted June 23rd, 1921.)

Relates to the application of thermionic valve apparatus for the controlling of electric motors, etc., by arrangement of the anode circuit of the valves in series with the field circuit of the motor.

(9) VALVE MANUFACTURE.

2740. **G. Holst** and **E. Oosterhuis** [Naamlooze Venootschap Philips' Gloeilampenfabrieken]. Removing Gases from Vacuum Apparatus. (*British Patent* 151611, September 22nd, 1920. Convention date September 23rd, 1919. Patent not yet accepted.)

An alloy of alkaline metals is used for removing inert gases, etc.

2741. **I. Langmuir** [British Thomson-Houston Company]. Vacuum Tubes. (*British Patent* 147822, July 9th, 1920. Convention date October 16th, 1913. Patent not yet accepted.)

In a process for removing ionisable gas from the anode of a vacuum tube, the anode is subjected to prolonged electron bombardment.

(10) SPECIAL TYPES OF VALVES.

2742. **T. Meyenburg.** Thermionic Tube. (*German Patent* 317920, October 28th, 1915. Patent granted December 31st, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 16, pp. 310—311, October, 1920—Abstract.)

A tube in which the cathode is maintained incandescent not electrically but by means of an external source of heat.

2743. **Q. A. Brackett** [Metropolitan-Vickers Electrical Company]. Thermionic Valves. (*British Patent* 149349, July 21st, 1920. Convention date August 5th, 1919. Patent not yet accepted.)

Describes a special form of thermionic detector which utilises the interference between two independent streams of electrons. The secondary winding L_2 of the receiving circuit A L_1 E is connected to the two electrodes P_1P_2 of the output and the centre point of this winding is joined to the filament F_1. On the receipt of the signal two streams of electrons are set up between F_1 and P_1 and P_2. These streams interfere with the flow of electrons between F_2 and P and hence produce a sound in the telephones T connected in this circuit.

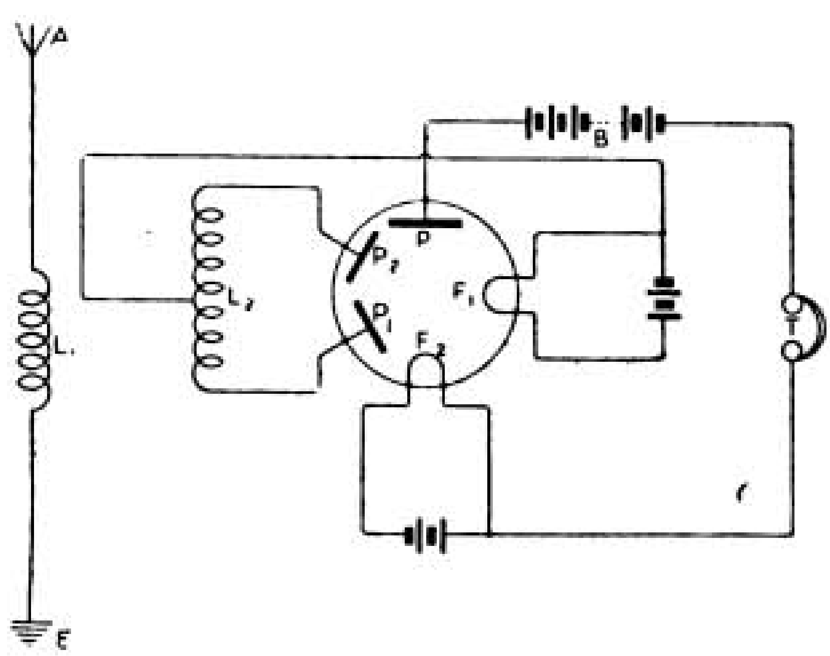


FIG. 1.

2744. **J. A. Fleming.** Thermionic Valve Apparatus. (*British Patent* 149422, May 12th, 1919. Patent accepted August 12th, 1920.)

See RADIO REVIEW, 2, pp. 38—40, January, 1921, for description of the apparatus covered by this specification.

2745. **A. H. de Voogt.** Double-Grid Valves. (*Radio Nieuws*, 4, pp. 99—104, April, 1921.)
A non-mathematical explanation of the action of these valves.

2746. **J. Corver.** The Use of Double-Grid Valves. (*Radio Nieuws*, 4, pp. 104—107, April, 1921.)
A brief description of some simple detecting and amplifying circuits employing these valves.

2747. **K. Rottgardt** [E. H. Huth Gesellschaft]. Thermionic Valves. (*British Patent* 149014, July 12th, 1920. Convention date July 7th, 1917. Patent not yet accepted.)
Thermionic valves for generating or receiving oscillations have two or more grids and an oscillatory circuit connected between each grid and the filament, one of the oscillatory circuits being also connected to the plate.

2748. **H. M. Dowsett.** Thermionic Valves. (*British Patent* 159564, November 22nd, 1919. *Engineer*, 131, p. 337, March 25th, 1921—Abstract. Patent accepted February 22nd, 1921.)
The cathode of the valve, which is of the three-electrode type, is formed by a crystal which is refractory and a bad electrical conductor—such as carborundum, bornite, zincite or silicon.

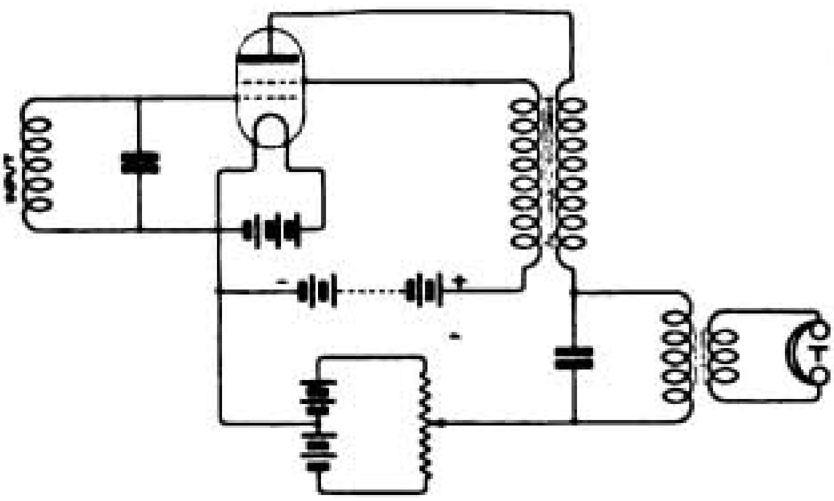


FIG. 2.

2749. **H. J. Round.** Thermionic Amplifiers and Detectors. (*British Patent* 159984, December 9th, 1919. Patent accepted March 9th, 1921.)
Relates to thermionic valves having more than one grid. The input circuit is connected to one grid, and couplings are arranged between the other grids and the plate circuit for further amplification. Suggested connections for valves using two and six grids respectively are shown in Figs. 2 and 3.

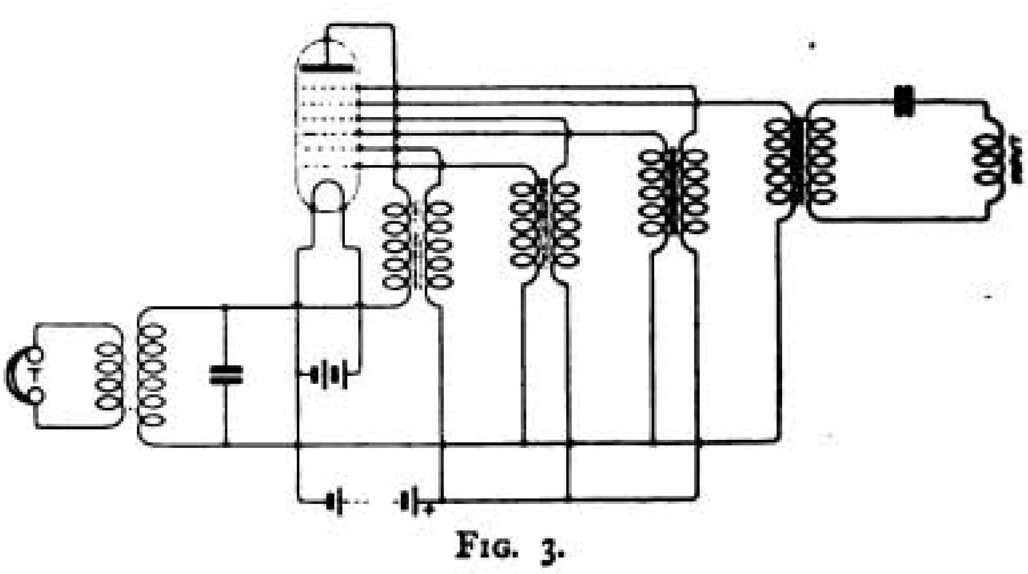


FIG. 3.

2750. **J. Massolle, H. Vogt,** and **J. Engl.** Thermionic Valves. (*British Patent* 157706, January 10th, 1921. Convention date December 2nd, 1919. Patent not yet accepted.)

A thermionic valve having a filament cathode, a control grid, and two anodes which are connected together through a resistance, so that one of them is maintained at a higher potential than the other.

2751. **A. W. Hull** [British Thomson-Houston Company]. Wireless Receiving Apparatus. (*British Patent* 147150, July 7th, 1920. Convention date June 5th, 1916. Patent not yet accepted.)

Describes the "pliodynatron" and its applications to wireless reception.

2752. **R. Hesketh.** Thermionic Valves. (*British Patent* 147252, April 5th, 1919. Patent accepted July 5th, 1920.)

An arrangement of valve using two electrodes (connected to the receiving circuits) so as to set up a transverse electric field to deflect the main electron stream from the anode. These electrodes may take the form of plates, or of two interleaving spiral grids in a valve of the ordinary cylindrical type.

2753. **S. Loewe.** Electron Discharge Apparatus. (*British Patent* 152311, July 12th, 1920. Convention date April 20th, 1918. Patent not yet accepted.)

A thermionic vacuum tube utilises the interference between two or more independent electron streams. The arrangement may be used as a detector, amplifier, or relay, or as an oscillation generator.

2754. **J. Massolle, H. Vogt,** and **J. Engl.** Thermionic Amplifiers. (*British Patent* 157435, January 10th, 1921. Convention date December 2nd, 1919. Patent not yet accepted.)

A valve having multiple anodes and grids and one common filament is employed for multiple amplification.

2755. **Western Electric Company.** Telegraphic Repeating Apparatus. (*British Patent* 153357, July 24th, 1919. Patent accepted October 25th, 1920.)

Thermionic valve repeating apparatus having means for restoring a distorted signal to its original form.

2756. **I. Langmuir** [British Thomson-Houston Company]. Electron Discharge Devices. (*British Patent* 148133, July 9th, 1920. Convention date October 29th, 1913. Patent not yet accepted.)

A valve with two or more control electrodes.

2757. **A. W. Hull** [British Thomson-Houston Company]. Electron Discharge Devices. (*British Patent* 148134, July 9th, 1920. Convention date December 29th, 1913. Patent not yet accepted.)

An additional electrode is used to neutralise the space charge, and a magnetic field is provided to control the position of the electron stream.

2758. **H. de A. Donisthorpe.** The Thermagnion. (*Model Engineer*, 45, pp. 37—38, July 14th, 1921.)

A description of the new type of thermionic valve referred to in RADIO REVIEW Note No. **3367**, August, 1921. Details are given of the winding for producing the magnetic field used with this valve.

2759. **H. Oort.** Two- and Three-Grid Valves as High Frequency Amplifiers. (*Radio Nieuws*, 4, pp. 133—135, May 1st, 1921.)

A short theoretical discussion with a circuit diagram of a three-grid valve amplifier.

2760. **J. Corver.** Double-Grid Valves. (*Radio Nieuws*, 4, pp. 200—203, July, 1921.)

A simple account of the valves devised by Schottky and also of Scott-Taggart's method of using double-grid valves.

2761. **R. A. Weagant** [Radio Corporation of America]. Vacuum Valve Detector. (*U.S. Patent* 1379706, March 10th, 1917. Patent granted May 31st, 1921.)

2762. **R. A. Weagant** [Radio Corporation of America]. Vacuum Valve Detector. (*U.S. Patent* 1380206, March 10th, 1917. Patent granted May 31st, 1921.)

2763. **A. W. Hull** [General Electric Company]. Electron Discharge Apparatus. (*U.S. Patent* 1385873, June 5th, 1916. Patent granted July 26th, 1921.)

Electron discharge apparatus, in which a charge controlling member in proximity to the cathode is provided and by varying the potential between this member and the cathode, the effective emission of primary electrons is varied, that is, the number of primary electrons which will reach the co-operating electrode is varied. When this is done the number of secondary electrons produced and the negative resistance of the device are also varied, and the current in an external circuit between the cathode and the co-operating electrode is varied accordingly.

2764. **A. W. Hull** [General Electric Company]. Electron Discharge Device. (*U.S. Patent* 1387985, November 13th, 1916. Patent granted August 16th, 1921.)

Electron discharge device, which is controlled by a magnetic field set up about the tube. The stream of electrons from the cathode to the third electrode produces from the third electrode an emission of secondary electrons sufficiently to give the device a negative resistance characteristic. The variable magnetic field controls the stream of electrons thereby varying the number of primary electrons which can reach the third electrode.

(12) THERMIONIC VALVES AS NEGATIVE RESISTANCES.

2765. **M. Latour.** Thermionic Valves. (*British Patent* 148995, July 12th, 1920. Convention date December 16th, 1918. Patent not yet accepted.)

Relates to a thermionic tube system intended to create the effect of a negative resistance. The arrangement is similar to that illustrated on p. 472 of the June, 1920, issue of the RADIO REVIEW.

2766. **A. W. Hull** [General Electric Company]. Negative Resistance. (*U.S. Patent* 1387984, August 30th, 1915. Patent granted August 16th, 1921.)

A negative resistance, or a device of the Dynatron type, in which the current will decrease as the potential applied thereto increases in contradistinction to the ordinary resistance devices in which an increase of potential is accompanied by an increase in current.

(L.) Radio Wave Transmission.

(1) GENERAL E.M. THEORY.

2767. Long-distance Wireless Transmission. (*Electrical Review*, 88, pp. 739 and 742, June 10th, 1921. *Electrician*, 86, pp. 718—719, also p. 709, June 10th, 1921.)

Abstract of discussion at the Institution of Electrical Engineers opened by **Mr. C. F. Elwell.** (See RADIO REVIEW, 2, p. 373, July, 1921, for Abstract.)

2768. **L. B. Turner.** Optimum Wavelength and Atmospherics. (See pp. 524—534 in October issue; also p. 505 for editorial notes.)

2769. Discussion on Long-distance Wireless Transmission. (*Journal of the Institution of Electrical Engineers*, 59, pp. 677—692, June, 1921.)

See RADIO REVIEW, 2, p. 393, July, 1921, for Abstract.

2770. **T. Carlbaum.** Electromagnetic Oscillations in Slightly Heterogeneous Media. (*Archir für Mathematik Astronomik och Fysik Stockholm*, 15, pp. 1—24, 1921. *Science Abstracts*, 24A, p. 575, Abstract No. 1461, August 31st, 1921—Abstract.)

A mathematical article dealing with the theory of electromagnetic wave propagation in special media.

2771. **H. Bateman.** Notes on Electrical Theory. (*Bulletin of the American Mathematical Society*, 27, pp. 217—225, February, 1921.)

2772. **K. F. Lindman.** The Velocity of Propagation of Electric Waves in Air and along Wires. (*Öfversigt of Finska Vetenskaps-Societetens Förhandlingar*, 58, 1915—1916. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 18, pp. 48—49, July, 1921—Abstract.)

Various experimenters have found discrepancies between the velocity of waves along wires and the velocity of light. The author finds that with very careful experiments the difference lies within the range of experimental error in the determination of the velocity of light.

(2) TRANSMISSION TESTS AND MEASUREMENTS.

2773. **J. Williamson.** Physical Features and Wireless Transmission. (*Wireless World*, 8, pp. 389—395, August 21st, 1920. *Technical Review*, 7, p. 29, October 12th, 1920—Abstract. *Scientific American*, 123, p. 571, December 4th, 1920—Abstract.)

A paper dealing with observations on the fading of signals in the area of the Persian Gulf and Aden; a large amount of data is supplied with maps and diagrams. Finally, the conclusion is put forward that, as far as ordinary ranges are concerned the intercepted wave does not pass to a considerable height (probably not more than one or two miles) and that the maximum height attained increases with the distance.

2774. **M. Guierre.** Hertzian Exploration between Toulon and Tahiti. (*Bulletin Société Française des Électriciens*, 10, pp. 247—268, July, 1920. *Science Abstracts*, 23B, pp. 551—552, Abstract No. 1047, November 30th, 1920—Abstract. *Technical Review*, 8, p. 214, March 1st, 1921—Abstract. *Revue Générale de l'Électricité*, 8, p. 66, July 17th, 1920—Abstract.)

See pp. 618—634 in this issue.

2775. **G. Vallauri.** Measurement of Radiation from Wireless Aerials. (*L'Elettrotecnica*, 8, pp. 213—218, April 5th; and pp. 233—237, April 15th, 1921. *Technical Review*, 9, p. 158, June 7th, 1921—Abstract. *Science Abstracts*, 24B, p. 314, June 30th, 1921—Abstract. *Radioélectricité*, 1, p. 125D, May, 1921—Abstract.)

See RADIO REVIEW, 2, pp. 77—85, February; pp. 138—143, March; and pp. 179—187, April, 1921.

2. Books.

THE ALEXANDERSON SYSTEM FOR RADIOTELEGRAPH AND RADIOTELEPHONE TRANSMISSION. By Elmer E. Bucher. (New York: *Wireless Press, Inc.*; London: *The Wireless Press, Ltd.* 1920. Pp. 55. 10¾" × 8". Price 10s. 6d. net.)

This publication collects together in handy form a considerable amount of information about the Alexanderson high frequency alternator, and its electrical characteristics when used for radio transmission, which has previously appeared in American periodicals. The term "Alexanderson System" is used to cover high power radio transmitting equipment, using the Alexanderson alternator, the Alexanderson magnetic amplifier, and a multiple tuned antenna, and each of these are discussed in turn. Detailed illustrations are also given of the complete machines and apparatus and of their component parts.

P. R. C.

APPAREILS ET INSTALLATIONS TÉLÉGRAPHIQUES. By E. Montoriol, with a Preface by M. Blondel. (Paris: *Librairie J. B. Baillière et Fils.* 1921. Pp. 625, with 440 figures. 9" × 6". Price 40 fr.)

A comprehensive text-book setting out the present position of telegraphy in France and other countries, and giving detailed descriptions of the various apparatus employed. After the introduction, chapters are devoted to the following branches of the subject:—Morse Apparatus; Sounders; Modified Morse Systems; Printing Apparatus; Telegraphic Writing Apparatus ("Telautographs"); Means for Increasing the Carrying Capacity of the Lines (Overhead and Submarine); Automatic Transmitting Apparatus; Multiplex Systems; Batteries, Accumulators, etc.; Auxiliary Apparatus and Station Equipment. Good diagrammatic illustrations are given of all the apparatus described.

P. R. C.

DAS DEUTSCHE BUCH. Monatsschrift für die Neuerscheinungen deutscher Verleger. Leipzig. Kreuzstr. 3b. (A monthly bulletin issued by the German Association for the Export Book Trade in Leipzig.)

In addition to the classified catalogue of recent books, each monthly number deals with some special branch or subject and contains three or four short articles from the pens of well-known authorities on the special subject. The current number, which is No. 8 of the series, is devoted to children's books; the subjects dealt with during the past months have included, Relativity, Eucken, Scandinavian literature. As may be expected the bulletin is well produced; each number contains one or two illustrations.

Radiotelefonia. By Domenico Ravalico. (Turin and Genoa: *S. Latter & Co.* Pp. vii + 219. $6\frac{1}{4}'' \times 4\frac{1}{2}''$; with 83 figures. Price 14 lire.)

A description in simple non-mathematical language of the principles of telephonic communication and of the various methods that have been used for wireless telephony, including the modulated searchlight with selenium receiver. Descriptions are given of the work of Fessender., Slaby and Arco, Collins, Ruhmer, Poulsen, Colin and Jeance, and Majorana. The last two chapters are devoted to the thermionic valve and the recent advances made in radiotelephony.

G. W. O. H.

De Internationale Organisatie van het Radio-Electrische Verkeer. By G. F. van Dissel. (Leiden: *A. W. Sijthoff's Uitgeversmaatschappij.* Pp. 48. $9\frac{3}{4}'' \times 6\frac{1}{2}''$.)

This pamphlet consists mainly of a translation, edited by G. F. van Dissel, of lectures delivered by Commandant Brenot before the École Supérieure d'Électricité during the Session 1920—21. These have been printed in French in *Radioélectricité* (August and September, 1920—Radio Review Abstract No. 1858, May, 1921).

Correspondence.

A NEW DESIGN OF AERIAL INSULATOR.

To the Editor of the "Radio Review."

Sir,—In the Radio Review for October there appears a letter from Mr. E. W. Sawyer claiming priority for the Ohio Brass Company and a number of American engineers as the original investigators of the low capacity type of aerial insulator described on p. 198 of your issue for April.

Mr. Sawyer probably does not know that the need for low capacity aerial insulators has long been recognised in this country and it is difficult to say who were the original investigators of the type. Porcelain rods, some 2 feet long, have been used for small aerials since February, 1906. Since then the length and mechanical strength have been steadily increased as the demand arose, and as our porcelain makers have been able to overcome the very considerable manufacturing problems. For instance, insulators being made at the present time require a straight and perfect porcelain rod or tube nearly 6 feet long, capable of standing up to a routine proof test of $4\frac{1}{2}$ tons in tension.

The only date which Mr. Sawyer gives is October, 1920; rather late in the development of these insulators!

A claim for novelty of type would, among wireless engineers in this country, be absurd. The design which has been described in these columns is merely the result of a courageous and skilful development along well-known lines; the only novel point being the provision of three drip rings, due to Major R. J. P. Briggs. Under heavy rain a stream of water flows along the under side of low capacity or "candle" insulators hanging about 20° from the horizontal. Major Briggs found by experiment that carefully placed drip rings broke up the stream and very greatly reduced leakage and flash-over. The rings are separate pieces and they do not destroy the uniformity of the tube.

I am confident that Mr. Sawyer will find the insulators we are making in this country to be more efficient than those he mentions, and if he cares to have further details I shall be glad to supply them.

B. Mittell,
Director, C. F. Elwell, Ltd.

London, W.C. 2.
October 25th, 1921.

ERRATUM.

Page 602, Abstract No. 2564, the author's name should be: **J. Nienhold.**

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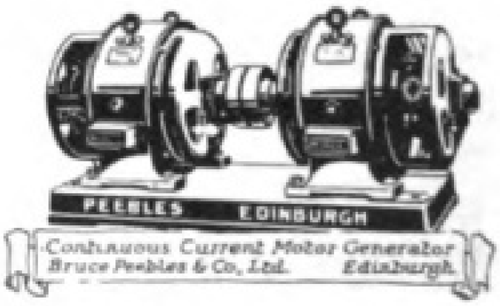

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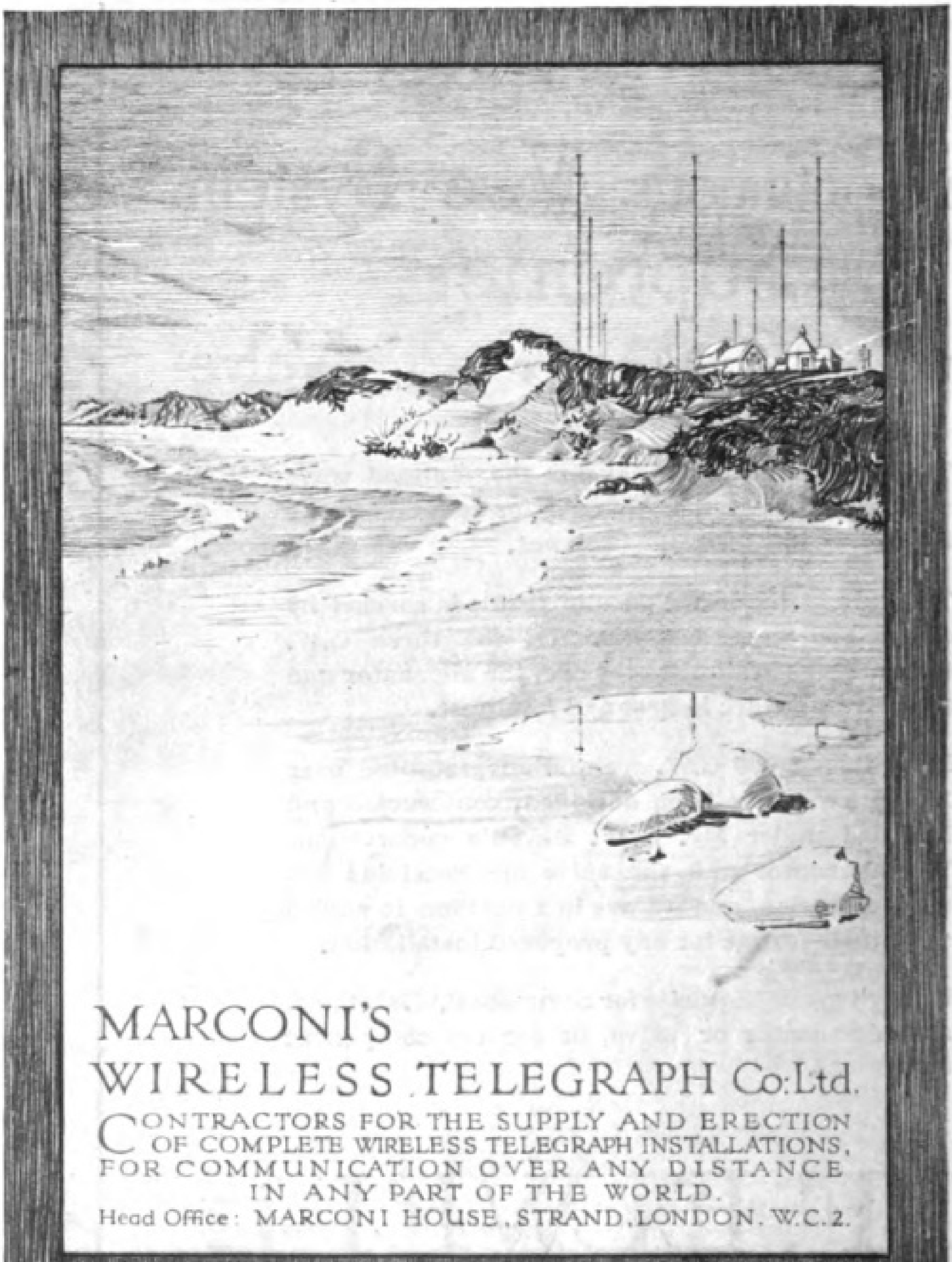
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