THE

RADIO REVIEW

A MONTHLY RECORD OF SCIENTIFIC PROGRESS IN RADIOTELEGRAPHY AND TELEPHONY

VOL. 1 JUNE, 1920 NO. 9

Editor:

PROFESSOR G. W. O. HOWE, D.Sc., M.I.E.E.

Assistant Editor:

PHILIP R. COURSEY, B.Sc., A.M.I.E.E.

CONTENTS.

Two Shillings and Sixpence Net

THE
RADIO REVIEW

VOL. I JUNE, 1920 NO. 9

Refraction of Electric Waves.*

By T. L. ECKERSLEY, B.Sc.

It is well known to wireless engineers that it is more difficult to transmit wireless waves over land than over sea. Professor Zenneck and Professor Sommerfeld have explained fairly adequately how the absorption is produced and have shown theoretically how the conductivity and specific inductive capacity of the ground modify the values of the absorption coefficient. But it is not so generally known that the nature of the ground over which the waves travel determines the velocity of the waves.

The reduction in velocity is not a large quantity, but it is sufficient to have a marked influence in determining the direction of a ray which passes, for instance, over the boundary between sea and land.†

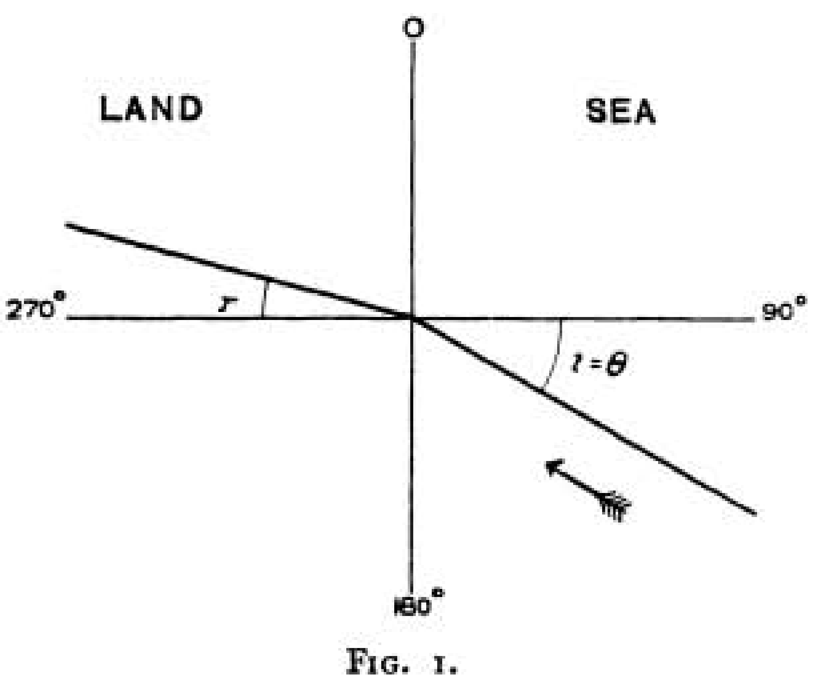


FIG. 1.

THEORY.

Suppose a wave travels from sea to shore in the direction of the arrow in Fig. 1, then at a few wavelengths inland, where the wave front has had time to settle down, the velocity of the waves will be the same in all directions (as the land is assumed to be more or less

---

* Paper received February 21st, 1920.

† [R. A. Fessenden, in describing in *The Electrician* of December 19th, 1919 (see RADIO REVIEW Abstract No. 431) the various causes of the discrepancies which were found in directional tests carried out in the United States during 1901—1906, says that "over water and parallel to a coast line, such as that between Cape Henry and Cape Hatteras, the error in direction was found to be due to the great difference between the resistance of the water and that of the sandy beach, causing the electromagnetic waves to bend in."—THE EDITOR, R.R.]

isotropic), and it is possible to apply Huygen's principle, and therefore to infer that if V_1 is the velocity of the wave over land and V_2 the velocity of the wave over sea—

$$\frac{\sin i}{\sin r} = \frac{V_1}{V_2} = \mu$$

where i is the angle of incidence, *i.e.*, the angle that the ray makes with the normal to the coast line, and r is the angle of refraction.

If the ratio V_1/V_2 is nearly unity, that is i is nearly equal to r then if $\delta\phi$ is the error in bearing and $\theta + 90°$ is the true bearing, it is easy to show that—

$$\delta\phi = \frac{\mu^2 - 1}{2\mu} \tan\theta$$

The curve (Fig. 2) shows diagrammatically some results obtained from a direction-finding station in Cyprus. The station was situated within a mile

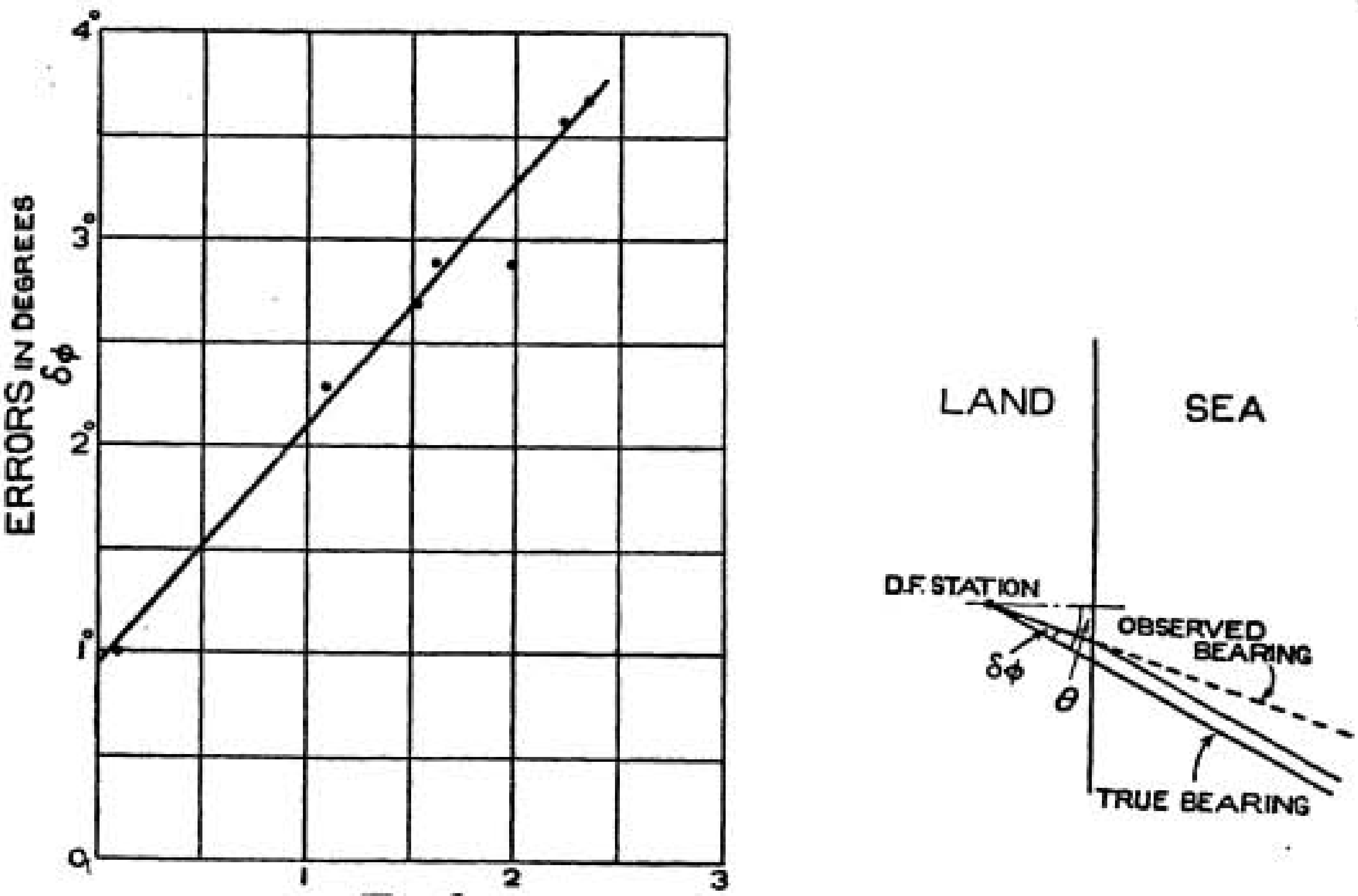


FIG. 2.

of the coast which ran nearly due north and south in the neighbourhood. The ordinates represent the errors in bearing of certain known stations plotted against the value of tan θ where θ is the true bearing — 90°.*

It will be seen that except for one observation the points lie very closely along a straight line. The error for $\theta = 0$, which is nearly 1°, agrees with the station error (determined fairly accurately with a theodolite).

* The bearings are reckoned in a clockwise direction from due north.

The observations, it will be seen, confirm in a remarkable manner the theory, the agreement in all cases except one being within one-tenth of a degree. The points actually plotted were obtained from the mean day bearings taken over a period of five months (March to July, 1918), the number of bearings per month being, on an average, about twenty to fifty.

The true bearings were calculated from the known latitudes and longitudes of the transmitting and receiving stations.

The wavelength of the stations varied between 800 and 1,100 metres, and strictly speaking the results should only be compared for the same wavelength, for it will be shown later that the amount of refraction varies with the wavelength being almost negligible with wavelengths over 2,000 metres.

The ratio of the velocity of the wave over sea to that over land calculated from the slope of the straight line just given is 1·020, thus the velocity over sea in this case is only 2 per cent. greater than the velocity over land.

We can get an expression for the ratio of these velocities in terms of the constants of the soil and sea water respectively from Zenneck's analysis of the transmission of waves over land.

The expression for the ratio of the velocities μ can be shown to be

$$\frac{1}{\mu} = \left\{\frac{\sqrt{\sigma_1^2 + p^2 k_1^2}}{\sqrt{\sigma_1^2 + p^2 (k + k_1)^2}}\right\}^{\frac{1}{2}} \cos\frac{(\phi_1 - \phi_2)}{2}$$

where $p = 2\pi \times$ frequency, $\tan\phi_1 = \frac{pk_1}{\sigma_1}$, $\tan\phi_2 = p\frac{k_1 + k}{\sigma_1}$

$4\pi k_1 =$ specific inductive capacity of ground.
$4\pi k =$ specific inductive capacity of air.
$\sigma_1 =$ conductivity of ground (electrostatic units).

If p is small enough, *i.e.*, if the wavelength is so long that $p^2(k + k_1)^2$ is small compared with σ, then

$$\frac{1}{\mu} = \left\{\frac{\sqrt{\sigma_1^2}}{\sqrt{\sigma_1^2}}\right\}^{\frac{1}{2}} \cos\left(\frac{\phi_1 - \phi_2}{2}\right) = \cos\left(\frac{\phi_1 - \phi_2}{2}\right)$$

but in this case ϕ_1 and ϕ_2 are both very small and hence $\frac{1}{\mu} = 1$ and there is no refraction.

As an illustration we may consider the following cases :—

(1) Take $\lambda = 3{,}000$, $4\pi k_1 = 1$, $4\pi k_2 = 2$
$\sigma_1 = 9 \times 10^5$ (a reasonable value for dry sand).

Then $\frac{pk_1}{\sigma_1} = 0{\cdot}11$, $\frac{p\,(k + k_1)}{\sigma_1} = 0{\cdot}165$.

$$\therefore \mu = 1{\cdot}004$$

and the bending will be practically negligible.

(2) Take $\lambda = 1{,}000$, the other constants remaining the same,

then $p = 2\pi \times 3 \times 10^5$, $\sigma_1 = 9 \times 10^5$, $\frac{pk_1}{\sigma_1} = 0{\cdot}333$, $\frac{p\,(k + k_1)}{\sigma_1} = 0{\cdot}50$.

$$\therefore \mu = 1{\cdot}067.$$

LL 2

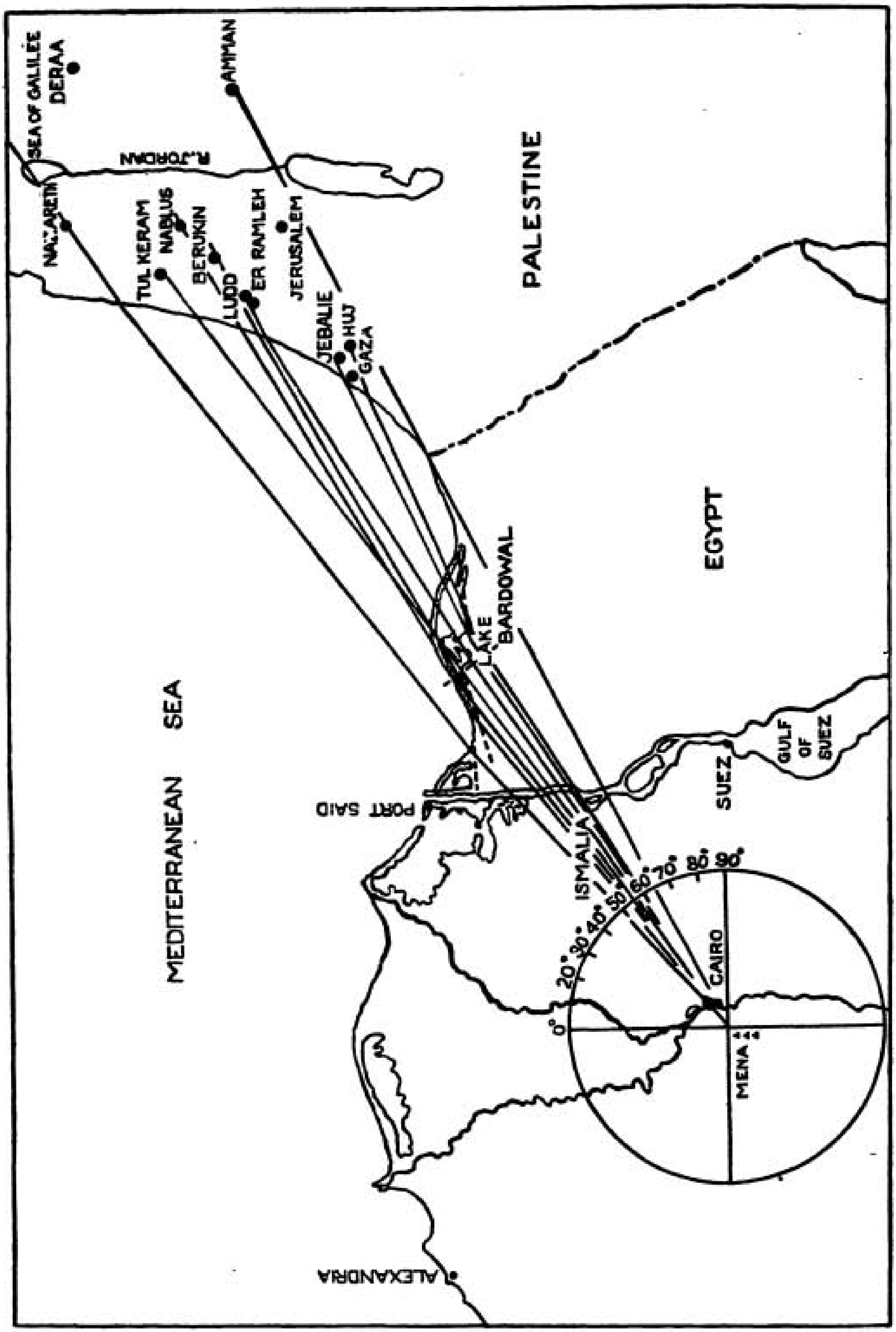


FIG. 3.—Chart showing paths of the waves.

This is a rather larger value than is actually found, *i.e.*, 1·02, but a larger value of σ is probable on the Cyprus coast than 9×10^5 which is a probable value for the more resistive dry sand of the Sinai Peninsula.

Another set of observations on this refraction is illustrated in Fig. 3, which is a map of the Egyptian and Palestine coast line.

The bent lines represent the probable directions of the rays of electromagnetic waves from the various known stations in the Palestine area, to the direction-finding receiving station near Cairo.

It will be seen that the observed bearing is in nearly every case too small by amounts which are nearly as much as 4° in some cases. These systematic errors in bearings were noticed some while before the explanation was arrived at, and there is therefore no hint of a forced agreement.

The observed bearings were in practically every case the mean of a very large number of observations extending over several months.

A graphical method of trial and error was employed in finding the path of the rays. A value for μ the ratio of the velocity over sea to the velocity over land was chosen, and then, starting from the known mean bearing of a given station, it was possible to map out the path of the ray. If the ray passed to one or other side of the place at which the station was known to be situated the value of μ was corrected to give a closer approximation.

In this manner a mean value of $\mu = 1{\cdot}05$ was determined.

This value is considerably greater than that determined from the Cyprus bearings, *i.e.*, 1·02, but this is a result to be expected as the desert sand of Egypt and Sinai has a much higher specific resistance than the soil of Cyprus.

The rays all pass very close to the known positions of the stations.

It must be remembered that the same value of μ is used for all the rays, and that this quantity has not been adjusted in each case to make the ray pass through the station. The results therefore indicate a fairly close agreement with theory.

Unfortunately practically all the rays cross the coast line of the Sinai Peninsula at Lake Bardowal; the coast line of this lake is so irregular, and so cut up with pools and swamps, that it is very difficult to determine the exact mean coast line where the ray crosses it. A fairly reliable estimate has been made with the help of 1/40,000 map of the district, but naturally it is difficult to avoid choosing the coast line so as to give good results.

The curve (Fig. 4) gives the errors at various stations, arranged in order of their bearings.

The most striking feature of this is that the mean error on the station at Tul Keram is zero, while the errors on the rest of the stations in this neighbourhood are about 4°.

This is not an accidental error or effect, for it is reproduced month after month, the probable error deduced from the discordances being less than ½°.

This anomaly can be readily explained if we examine the coast line. At the point where the great circle joining Tul Keram and Cairo crosses the coast at Lake Bardowal the coast line curves round so that it is cut practically normally by this ray, and there is therefore no bending, and the ray pursues a straight path. The slightest change in the position of the transmitting

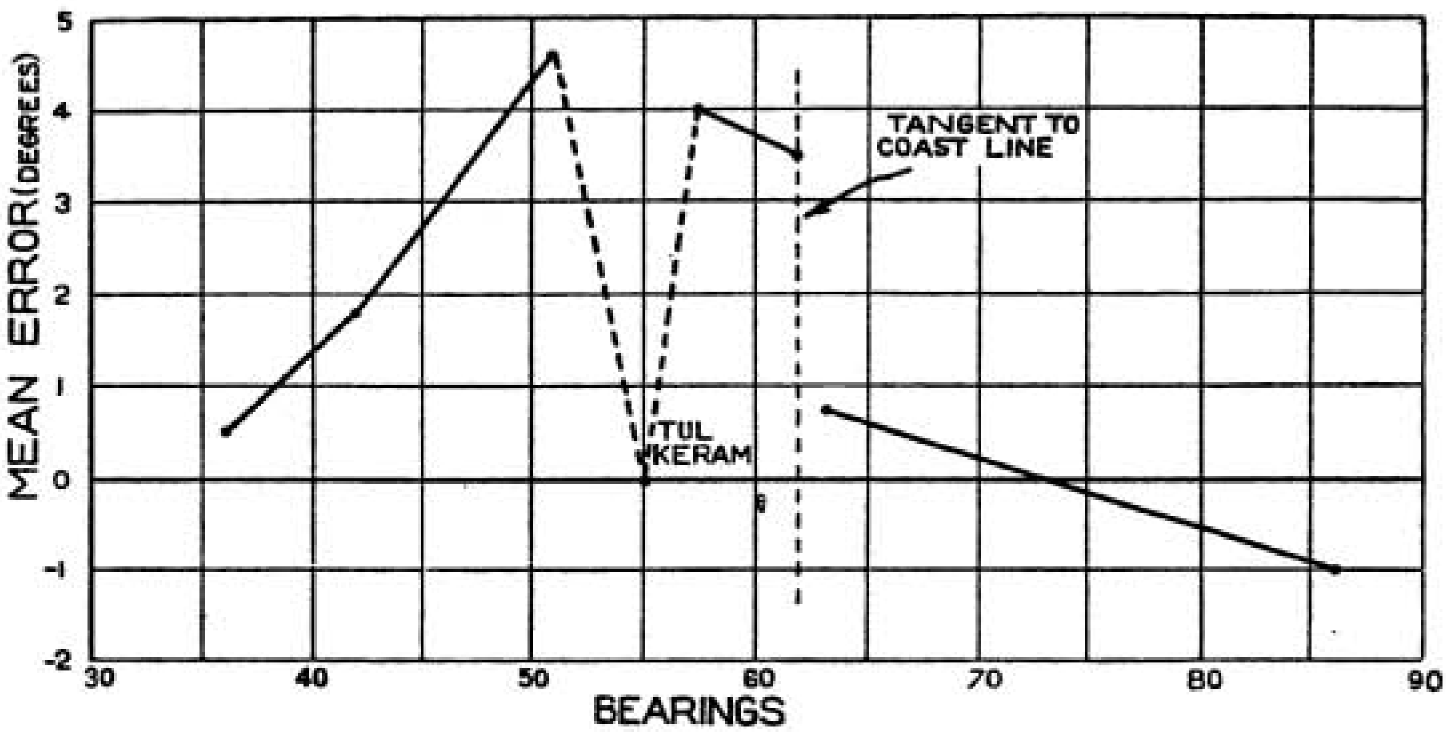


Fig. 4.

station shifts the direct ray to a point where it crosses the coast line at an acute angle, and distortion will again appear.

Perhaps it is not wise to press this explanation too far, but it is difficult to find any other adequate explanation of what is otherwise a very striking anomaly.

Another point of interest is in connection with the transmitting station at Amman. It will be noticed that the direct ray from Amman to Cairo (Figs. 3 and 5) is tangential to the coast line, and since there is no crossing of the coast line this will be a possible ray. At the same time another ray bent at the coast line at C and D (Fig. 5) is also possible. The waves arriving by the two paths AM and ACDM will be out of phase and travelling in different directions and will, in general, produce a rotating field, and a bad minimum on the direction finder will ensue. This result was quite marked at the receiving station at Cairo, and was one of the cases in which there was a really bad minimum in the daytime. This theory was further confirmed in a striking way as follows:—

Two stations were erected at Cairo, about 500 yards apart, and the mean bearings of Amman from these stations were 59° and 54·5° respectively (the difference 4·5° is well outside the limits of the probable errors); the true bearing is 63°. The difference is explained when we observe that the difference in optical length, *i.e.*, in phase of the two rays, is very different at the two stations (in spite of their nearness), resulting in a large difference in the mean direction of the resultants, *i.e.*, the bearings.

Wavelength.

It was shown on page 423 that on this theory the amount of refraction should depend very greatly on the wavelength of the transmitted wave. This result is again confirmed by observation. The bearings of the big power station at Damascus are of interest in this connection.

These are all very consistent on a 2,600 metre wavelength, and average 50·5°, which is the true bearing of the station, so that there is no error in spite of the fact that other stations, on the same mean bearings working on wavelengths of 600 to 1,000 metres, have errors of 3° or 4°. This effect cannot be ascribed to peculiarities of the coast line which is quite definite at the point where the ray crosses it.

The small station at Damascus working on $\lambda = 1{,}000$ gives a mean bearing of 46°, although at the greatest there cannot be more than 1° difference in the direction of the two stations.

These results show quite definitely that the long waves ($\lambda = 2{,}600$) sent out by the big station are not refracted, while the short waves ($\lambda = 1{,}000$) are bent at the coast; this is further confirmed by the fact that when the

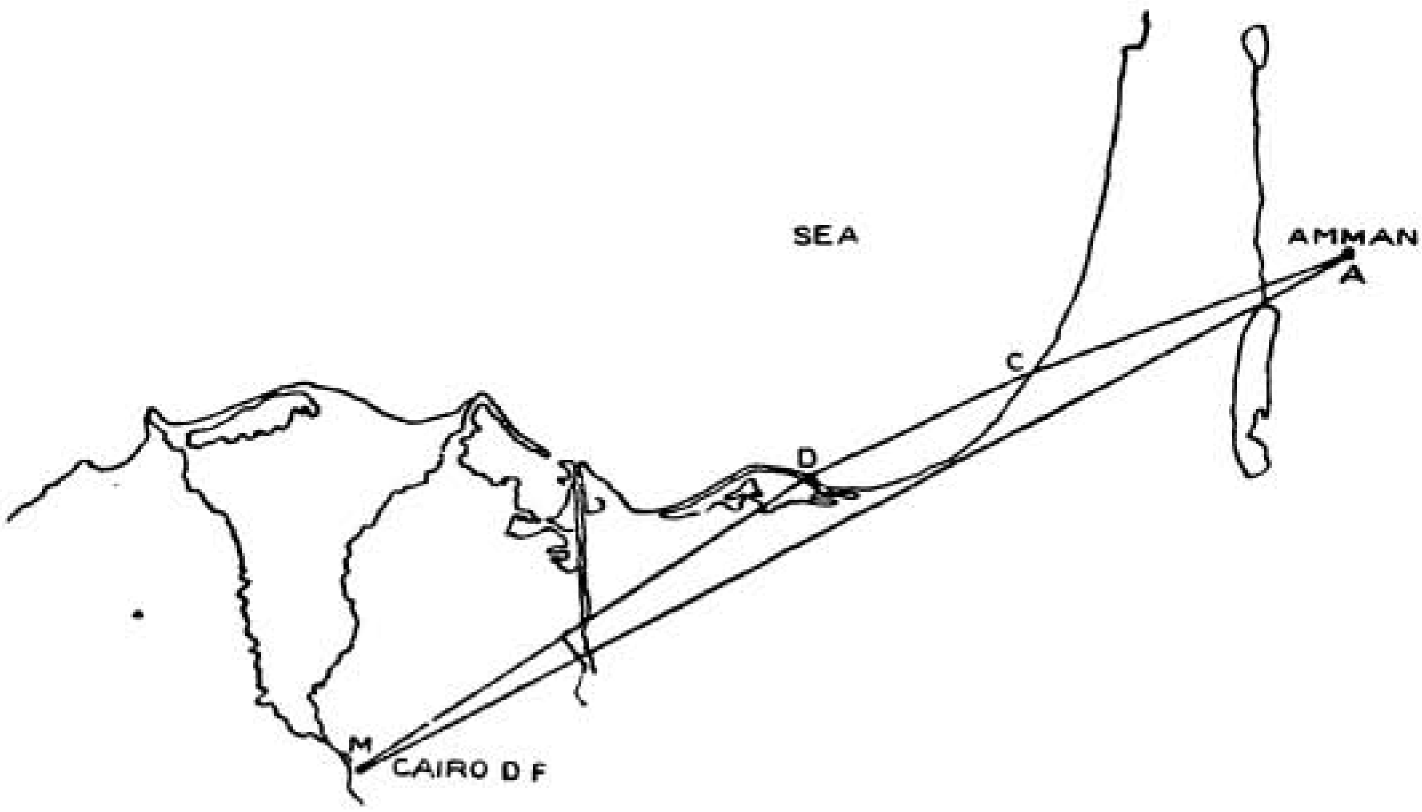


FIG. 5.

big station started working on a wavelength of 1,200 bearings as low as 47° (sharp minimum) were obtained.

This variation in the amount of distortion it will be remembered is in complete accord with the theory.

Perhaps the most interesting example is one which shows that the Germans were behind us in this respect and were still unaware of this refraction. In the final advance in Palestine some records of the German bearings from a direction-finding station at Tul Keram were captured. The mean bearings on some of our known stations were calculated, and are tabulated on page 428.

Bearings on Port Said and Alexandria are very nearly correct, it therefore appears probable that the D.F. station was set on these known stations, so that the error should be zero in these directions. The error on the other unknown stations was then − 6° or − 7°. If the station was set up in this

	SUB Port Said.	SUH Alexandria.	Ramleh.	Jerusalem.
Mean observed bearing .	246·75	257·5	197·8	155·5
Number of bearings . .	33	21	82	75
True bearing . . .	246·5	257·5	204·5	161·5
Error.	0·25	0	−6·7	−6·0

manner then the errors on the inland stations can be readily explained, Fig. 6. On account of the refraction, the apparent bearings of Port Said and Alexandria should have been 6° or 7° too great if the station had been oriented properly (due north and south) at the start. By setting on these known stations the Germans introduced an error in the station of — 6° or — 7°

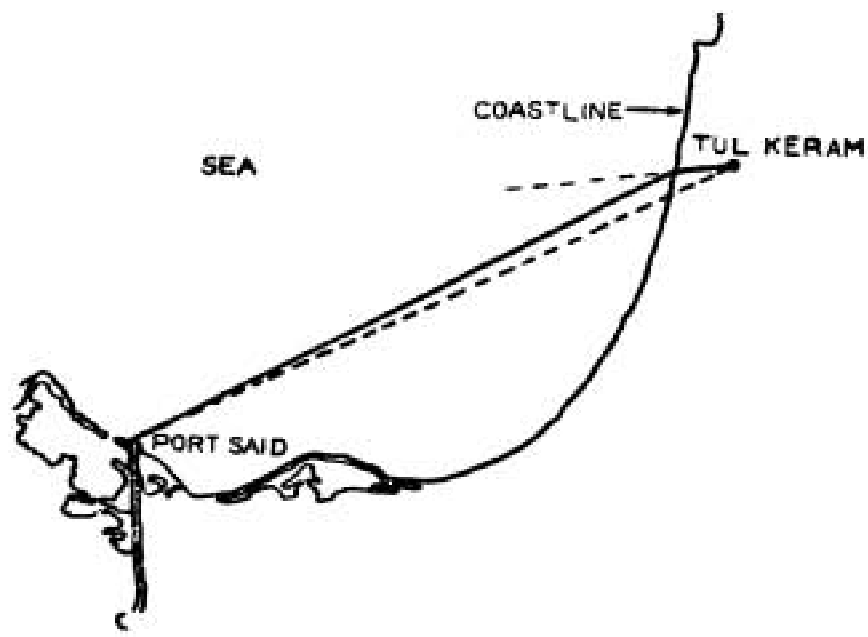


FIG. 6.

which showed up at once on inland stations for which the rays are all the way over land, as is the case with the two stations cited.

It therefore seems probable that there was very marked refraction at the coast line, and that the Germans were entirely unaware of it.

SUMMARY.

Direct observations are shown which go to prove that there is a systematic bending of rays which cross a coast line, and that this " bending " behaves as if it were due to a " Refraction " on account of the different wave velocities over sea and over land.

Further observations are cited confirming this point and agreeing in general with the theory of propagation of electric waves over land given by Zenneck, Hack, Sommerfeld and others.

A Form of Inductionless High Resistance.*

By N. W. McLACHLAN, D.Sc.(Eng.), M.I.E.E.

DESCRIPTION OF RESISTANCE.

A solution of cadmium iodide in amyl alcohol has been used at the National Physical Laboratory as a form of high resistance for many years.† As a general rule resistances of the order of 50 megohms or more have been utilised for direct current work. The specific resistance of the cadmium solution is so high that the inductive effect due to the geometrical configuration of the resistance is small enough to be neglected in resistances of the order of 0·1 to 0·3 megohm, these being the limits required in the tests for which the resistance was used. There might be an electrolytic variation with frequency, and experiments conducted to investigate this point are described below. The results of these experiments showed that the resistance was independent of the frequency up to 80,000 cycles per second, this being the highest frequency attained.

The form of resistance adopted is illustrated in Fig. 1. This design was chosen because of its compactness, but the tube can easily be modified and made straight if desired. This would, of course, be less inductive than the form shown. To avoid capacity effects, the cadmium electrodes should not be too near together. The specific resistance of the liquid varies with time, but the sample used in these tests had been in the laboratory for over ten years, and had probably attained a fairly constant value for any particular temperature. At 15° C. ρ was about $1{\cdot}4 \times 10^4$ ohms per cm. cube, but it depended on the strength of the solution.

The resistance shown in Fig. 1 is fixed in magnitude, but a variable resistance is merely a matter of design. One of the chief points is to prevent access of moisture, and evaporation of the liquid. A straight tube with a fixed electrode at the bottom and a movable one at the top could be adopted. The latter electrode would be adjusted by means of a glass tap with a groove, on which a thin cable suspending the electrode was wound. Or the electrode could be fixed and a glass rod lowered into the tube, thus varying the cross-sectional area of the liquid.‡ If there were no variation with time, the resistance could be read off by calibrating the tube, which could be immersed in a bath to preserve constant temperature.

METHOD OF MEASUREMENT.

The method of measuring the resistance using alternating currents is an adaptation of the Wien bridge suggested by Mr. D. W. Dye. The bridge accomplishes in one stage what the present substitution method does in two stages. The reason for not using the bridge is its limitation to acoustic frequencies, unless modifications are introduced with regard to the detector. The resistance under examination is used as a shunt to a condenser (see

* Paper received in final form February 13th, 1920.

† See N.P.L. Report for 1907. This particular solution was first used by Hittorf for high non-polarisable resistances.

‡ See F. W. Jordan, RADIO REVIEW 1, p. 173, January, 1920.

Fig. 2), the latter forming part of a resonance circuit. This circuit is loosely coupled to a valve generator circuit, the current and frequency in which are kept constant during any one set of tests. The condenser in the former circuit is adjusted till resonance is obtained and the reading of the thermo-ammeter A is a maximum. The shunt resistance is then removed and a

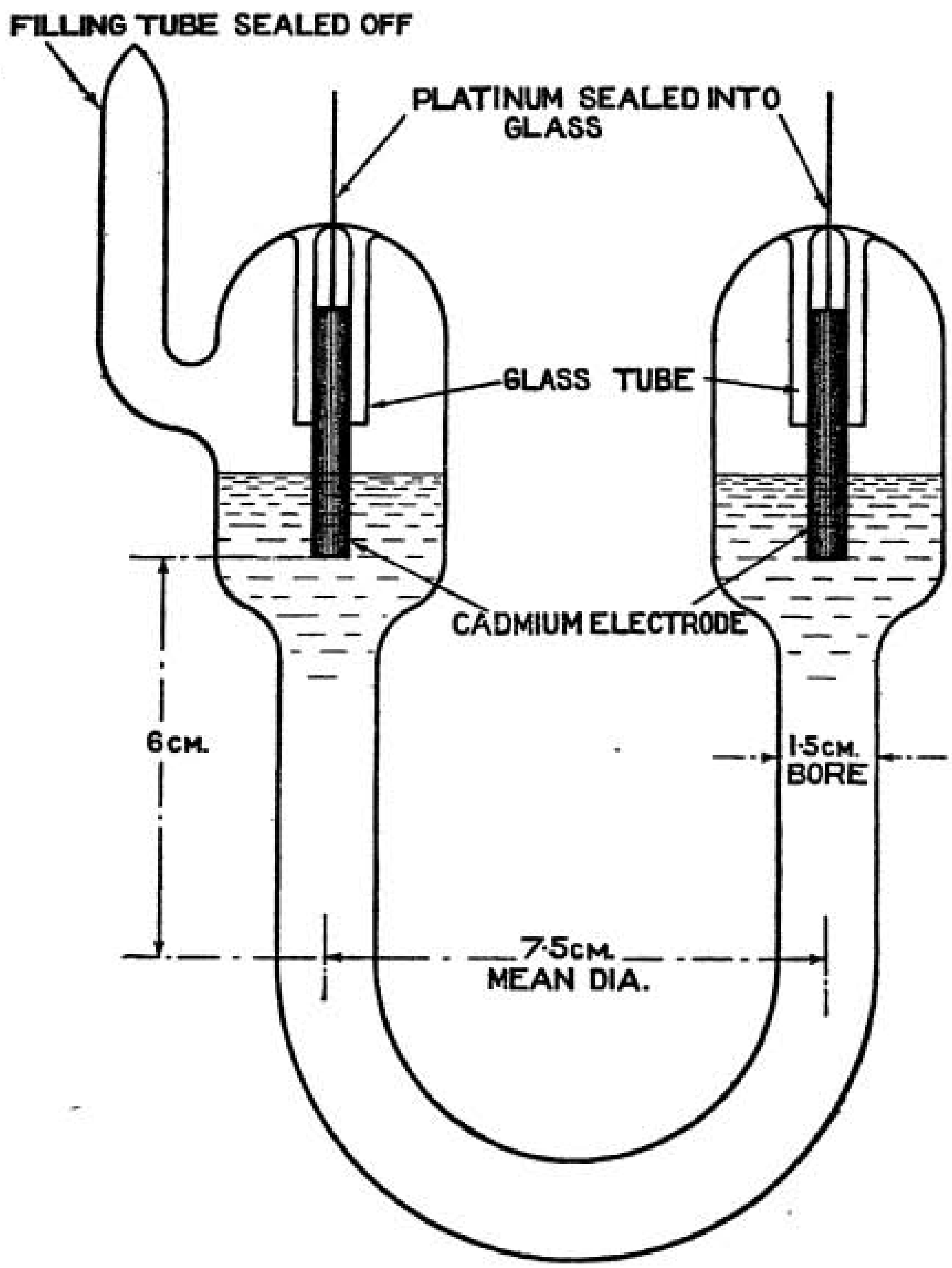


FIG. 1.

non-inductive resistance of small magnitude connected in series with the condenser (see Fig. 3), and adjusted until the reading of the thermo-ammeter at resonance is equal to that obtained in the previous experiment. If the high resistance has appreciable capacity, the condenser readings will be different in the two cases, the new value C being given by $C = C_1 + C_2$. In these experiments the capacity C_2 was negligible. Using the symbols of Figs. 2 and 3, it can be shown, by considering the impedance of the condenser and shunt resistance, that $R = \frac{1}{\omega^2 C^2 R_{eq}}$, provided $\frac{1}{\omega^2 C^2 R^2}$ is much greater than unity.

The resistance being independent of the frequency up to 80,000 cycles per second, as stated before, its value when used in conjunction with the

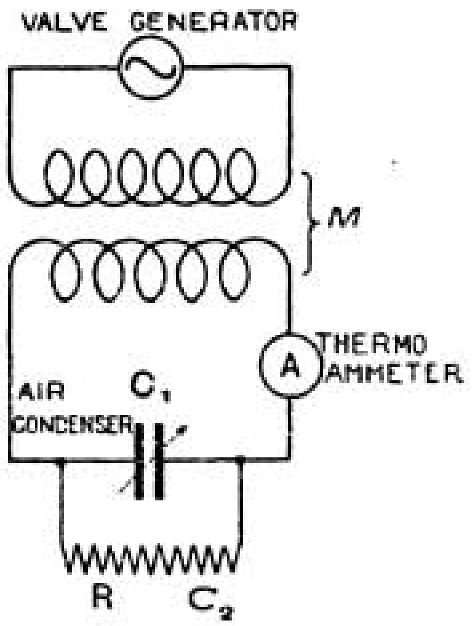


FIG. 2.

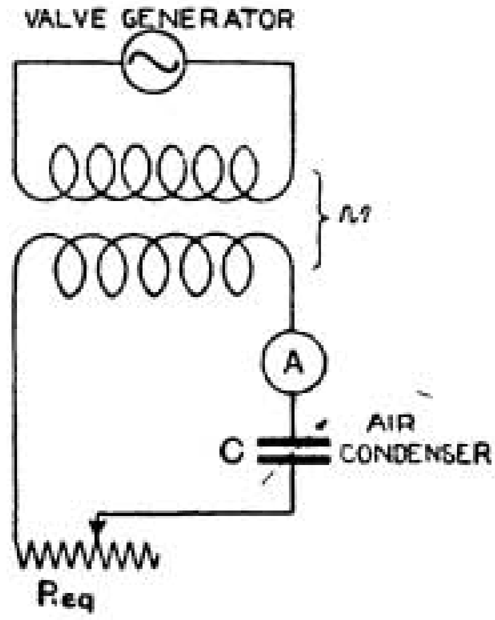


FIG. 3.

magneto (see below) was found by means of a megger. Since the solution is non-polarisable, a direct current generator can be used as a source of E.M.F. for the megger. Thus the actual value of the resistance can be found to within 1 or 2 per cent. immediately after it has been used. In this way allowance is made for any temperature rise which may occur.

USE OF RESISTANCE.

The necessity for an inductionless high resistance arose in carrying out research work on magnetos. The function of the resistance, when connected from the H.T. secondary lead to earth, in parallel with some form of spark gap, is to cause a leakage simulating that of a sparking plug when used in an engine. In this case the insulating properties of the plug are impaired by sooty deposits and temperature elevation. When testing a magneto, the gap is fixed and the resistance adjusted until regular sparking ceases. The value of the resistance to effect this is a measure of the capability of the magneto to withstand adverse plug conditions. This procedure is usually termed a "utility test."*

CONDITIONS TO BE FULFILLED.

A resistance for the above purpose must fulfil at least two conditions: (1) It must be inductionless up to frequencies of 20,000 cycles per second, because the magneto discharge is oscillatory; (2) It must have a large surface and volume to cope with the energy loss due to the passage of current from the magneto. This is important owing to the large temperature coefficient of the liquid. Although temperature variation can be dealt with as shown above, it is preferable to have as small a variation as possible.

* See A. P. Young and H. Warren, "The Process of Ignition." Paper before Inst. Automobile Engineers, February 4th, 1920.

Automatic Sending Device Installed in the Alipur Observatory, Calcutta,

For Sending the International Time Signals from the 30 K.W. Calcutta Radio Station.*

The instrument here described was designed and manufactured in the Indian Government Telegraph Workshops in Calcutta.

Essentially it consists of a wheel H, Fig. 2, 10 inches in diameter, rotated uniformly at a speed of 1 r.p.m. through worm gearing by a phonic motor driven by a vibrating reed, and carrying on its periphery brass contact strips let into ebonite.

The motor is in fact one used for the "Murray" drive as applied to the distributor of the Baudot printing telegraph system.

The arrangement of the brass contacts is shown in Fig. 1. Two brushes rest on the contacts. One, X, controls the sending key in the radio station and the second, Y, controls a pen on a chronograph and registers sixty beats to each revolution of the wheel.

A second pen on the same chronograph registers seconds beats from the observatory standard clock.

From this chronograph record, therefore, the observer can readily see whether the time sending apparatus is keeping correct and take steps if necessary to keep it so. Two adjustments are available for this latter purpose and will be described hereafter.

The first brush X is traversed across the periphery of the wheel so as to send the appropriate signals for each minute.

This brush is carried on a sliding sleeve B, Figs. 2 and 3. Connected to the sleeve is an arm D, which engages with the worm W by means of a pin. As soon as the brush X has finished the last signal the pin runs out into a shallow groove in the worm next the wheel D, and thereby raises X out of contact with the wheel.

The brush X can be set by means of a scale to make contact at any time from one second before to one second after brush Y.

The time wheel is started electrically by an impulse from the pendulum of the standard clock given at the second before three minutes to the correct time calculated after allowing for the lag in the land line and apparatus connecting the observatory to the wireless station.

This lag is of the order of two-tenths of a second.

The adjustment on brush X allows for any fraction of a second. For example, suppose the correct time to start the signal has been determined to be 7 hours 29 minutes, 36·4″, by the standard clock, the time wheel must start at 7 hours 29 minutes 36·2″, allowing 0·2″ for the lag. The clock will start the wheel at 7 hours 29 minutes 36″, and the brush X must be adjusted to make contact 0·2″ later than Y.

---

* Communicated by the Director-General of Posts and Telegraphs, India, January, 1920

Automatic Wireless Time Sender Installed in the Alipur Observatory, Calcutta.

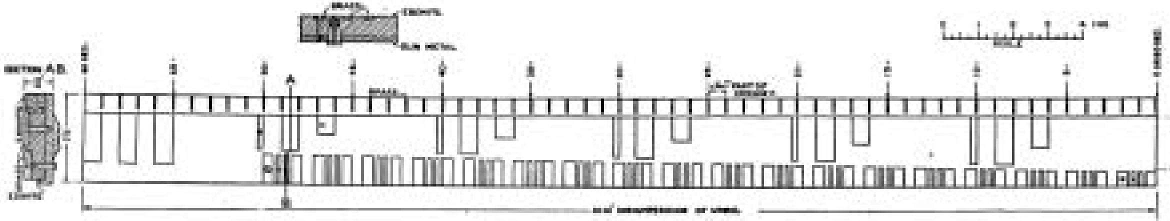


Fig. 1.

Fig. 1.—Arrangement of Contacts on Periphery of Wheel H.

Fig. 2.—Elevation and Section of Transmitting Wheel.

Fig. 3.—Plan of Apparatus and Diagram of Connections.

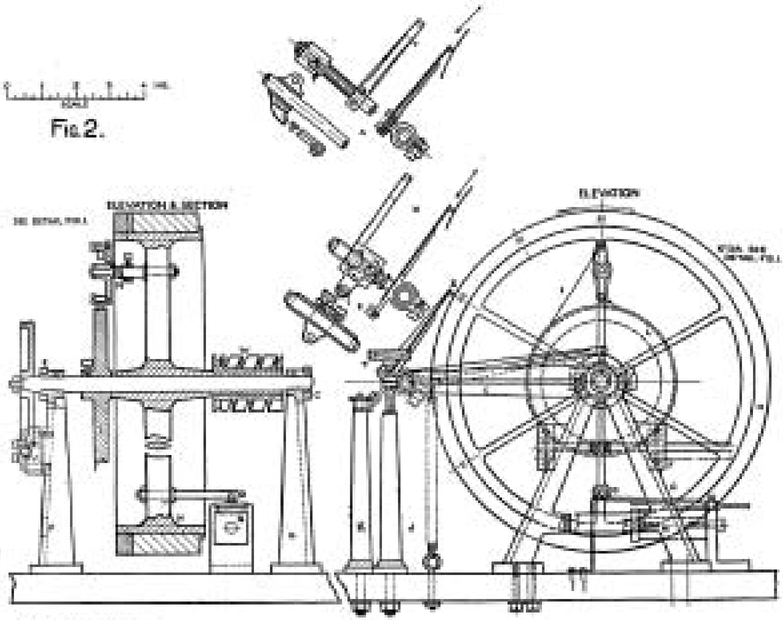


Fig. 2.

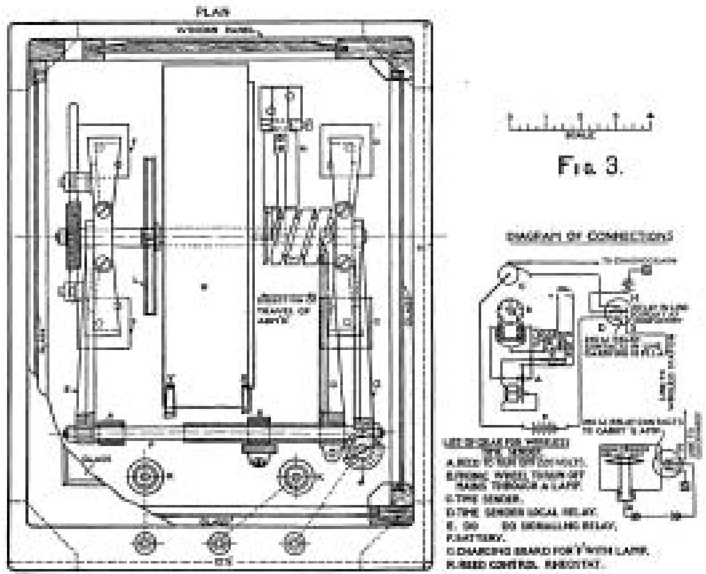


Fig. 3.

(To face p. 452.)

The time wheel H is loose on the spindle rotated by the phonic motor wheel and is connected to it by a friction clutch. The latter consists of a steel chain I, embracing the friction drum L, and held tight by a spring M, Fig. 2.

The time wheel is set ready for commencing the time signal by engaging the stop O with the armature of the electromagnet N.

When the phonic motor is started the clutch slips allowing the worm wheel and spindle to turn idly until the electromagnet N releases the time wheel and allows it also to rotate.

When the time wheel is in the starting position brush Y is set to make contact with the sixtieth second contact and brush X is set to make contact the appropriate fraction of a second before or after Y.

The brush carriers A and B are supported on a cross rod P, Fig. 3, clamped to the radial arms C and E, which swivel about the axle and supports of the time wheel. A milled screw T, resting on the pillar J, enables the whole brush gear to be moved simultaneously to advance or retard both brushes relatively to the time wheel.

When the time wheel is latched ready to start it is by means of T that brush Y is set to make contact with the sixtieth segment. From this position the screw T is long enough to permit of the brushes being advanced or retarded one second.

Since Y is making contact with a "second" segment when the impulse from the clock pendulum starts the time wheel, both records on the chronograph, one from the time wheel and one from the standard clock must coincide to begin with. If they commence to get out of step adjusting T will bring them back again provided the reed driving the phonic motor will keep time to within one second in three minutes. This presents no difficulty in practice. The screw T therefore is the first of the two adjustments referred to previously.

The second adjustment is provided in a rheostat inserted in series with the driving magnet of the reed.

The reed will run slightly faster with a small than with a large amplitude. The voltage on the mains may also vary.

The rheostat allows for both. The rheostat is set in mid-position and the reed is then weighted and the position of the weight carefully adjusted till the phonic motor runs at the correct speed. In practice this is done by watching the record of the time wheel on the chronograph. After this adjustment the position of the weight need not be touched, slight readjustments being made by means of the rheostat.

In adjusting the apparatus to send time the phonic wheel is set running fifteen minutes before time and the reed-rheostat altered till the two records on the chronograph coincide within one-tenth of a second or less in a minute. This usually needs little or no adjustment. After this has been verified and if necessary adjusted the apparatus can be set ready to start knowing that the adjusting screw T will provide sufficient margin to keep the two records in synchronism till the end of the three-minute signal.

Mention has been made previously of starting with brush X, making contact earlier than Y. This is done only when it is necessary to start at 60″ as the electrical impulse at the sixtieth second is missed by the clock for counting purposes. In this case although the true time to start might come between the sixtieth and first seconds it becomes necessary to start at 1″ and arrange for X to make contact early. For starting the apparatus the observer is provided with a key which in its rest position joins the clock pendulum circuit to the chronograph and when pressed joins it to the starting electromagnet. No great accuracy is required on the part of the observer as all that is necessary is to press the key any time after the second before time and wait till the pendulum on its next swing gives the impulse which starts the time sender. Then for three minutes the observer must watch the two records on the chronograph and if they commence to differ bring them into synchronism again.

In Fig. 3 is given a diagram of connections. The high-tension relay key is the sending key on the secondary side of the transformer in the wireless station.

Electronic and Ionic Oscillations in Thermionic Valves.

By THE EDITOR.

The use of the three-electrode thermionic valve as a generator of continuous oscillations has been known since 1913 and a great number of circuit arrangements have since been devised for the purpose. This application of the three-electrode valve has been one of the principal factors in the recent developments of radiotelegraphy and more especially of radiotelephony. At this moment, however, we wish to refer to some phenomena of a different type, of little practical importance it may be at the present moment, but of undoubted interest to all students of the thermionic valve. In the November issue of this Review (page 53) Professor Whiddington described a circuit arrangement, containing neither inductance nor capacity, which gave, however, a sustained oscillation of a definite frequency. The circuits were of the simplest character; a plate battery connected as usual between the filament and the plate, and a grid battery with potentiometer connected between the filament and the grid. The valve employed was soft and it was shown that the frequency obtained depended on the nature of the remanent gas, on the grid voltage and on the distance between the filament and the grid. Professor Whiddington explained the phenomenon by assuming that bursts of electrons occur from certain spots on the filament which have abnormally high emissivity and that these electrons travel to the grid in a certain definite time depending on the grid potential, the distance between the filament and the grid, and the ratio of the charge of the electron to its mass. After passing through the grid they are accelerated in the stronger field due to the plate voltage and soon reach such a velocity that they ionise the molecules with which they collide and thus produce positive ions which travel towards the filament with a velocity depending on the ratio of their charge to their mass. This ionic bombardment causes the filament to emit a fresh outburst of electrons and the cycle commences *de novo*. The period is the sum of the times taken by the outward excursion of the electron and the subsequent inward excursion of the ion, and these times, of which the latter is by far the greater, depend on the potential difference between the grid and the filament. Now with a four-volt filament and one volt on the grid this potential difference varies along the filament from + 1 to − 3 volts. The specially emissive spot on the filament is a very ingenious assumption to explain the definiteness of the frequency observed in spite of this range of the potential difference. Professor Whiddington's paper is of the nature of a preliminary announcement, but the agreement obtained between the observed frequencies and those calculated on the assumption that the ions concerned are those of mercury is very striking, and, as he says, the paper introduces a new and at first sight rather astonishing phenomenon.

In the *Physikalische Zeitschrift* for January 1st of this year a paper was published by Barkhausen and Kurz describing experiments of a somewhat similar character. They used hard valves and obtained oscillations due to the electrons alone. Professor Whiddington had calculated the wavelength for this case as 77 cm. for one volt on the grid of the valve employed by him, but had not apparently obtained such short waves experimentally. Contrary to the usual practice Barkhausen and Kurz applied a high positive potential to the grid and a smaller negative voltage to the plate. Under these conditions every electron emitted should pass to the grid and no current should flow in the plate circuit, unless some gas be present, which being ionised by the electrons would cause a flow of positive ions to the negative plate. In some experiments, however, it was found that this reverse current was not obtained, but that with − 100 volts on the plate the ammeter in the plate circuit indicated a current entering the valve at the plate and thus charging the plate battery. This was ultimately found to be due to internal oscillations of such a magnitude that electrons reached the plate in spite of its negative potential. After ordinary methods had failed to indicate any oscillations it was found by connecting parallel wires to the plate and grid, that stationary waves were maintained with a wavelength of about 1 metre and a frequency therefore of 300 million. Inductances and capacities outside the tube were found to have little effect, but the wavelength was reduced from 2·14 to 1·31 metres by increasing the filament heating current from 0·8 to 1·15 amperes and from 2·4 to 1·04 metres by changing the plate voltage from + 4 to − 300 volts. An increase of grid voltage also reduced the wavelength. The variations of wavelength are not uniform, however, but exhibit irregularities suggesting some resonance effect. A most important fact is that although these phenomena were obtained with three different valves with cylindrical anodes and axial filaments, no trace of such oscillations could be found in valves with parallel plane anodes. Even with cylindrical anodes, oscillations were only obtained in valves with closely-coiled fine grids. As Barkhausen and Kurz observe, these oscillations must be due to the electrons moving from the filament to the grid with a high velocity, passing through the grid, then brought to rest at a rate depending on the plate potential, then returning with increasing velocity, passing through the grid, being again brought to rest by the field between the grid and the filament, and so on. What the controlling mechanism may be, whereby the electrons are constrained to move to and fro in the same phase, the authors cannot explain. It may be that the bombardment of the filament by the returning electrons of an incipient oscillation causes an increased emission which tends to amplify the succeeding oscillation, although the space charge effect would tend to reduce the emission. The increase of frequency with increased filament current is presumably due to increased space charge which causes the returning electrons to slow up more rapidly as they approach the filament. It is possible that the phenomenon may involve in some way the emission of secondary electrons or δ rays as in the Dynatron. With 500 volts on the grid, the electrons striking it will certainly cause such an emission, but the emitted electrons will be unable to move far from the grid in such a powerful field. The shortest waves were obtained with a Schott-K valve with an anode of 2·1 cm. diameter with 500 volts on the grid and the highest possible filament current. The wavelength was 43 cm., but in the opinion of the authors a wavelength of 10 cm. or even less could be obtained by using suitable valves with very high grid voltages.

We have discussed these two papers at this length because they appear to call for further investigation. They certainly constitute an important addition to the already long list of contributions which the three-electrode valve has made to scientific progress.

An Automatic Call Device.*

By Major BASIL BINYON, B.A., O.B.E.

At the present time oral reception of wireless signals has come to be so generally applied that it is difficult to conceive of a mechanical machine capable of having the selectivity and sensitivity such as that possessed by the ear and the brain. The apparatus described is designed to operate with Morse signal calls of three or four letters, and does not require the use of any special code. The set comprises two units in addition to the ordinary wireless receiver, (1) a Turner valve relay,† and (2) the selector mechanism. The latter is the invention of Mr. Shepherd. The Turner relay responds to all signals of sufficient strength, and of the correct wavelength, and moves the selector mechanism one space for each such signal whether dot or dash. The selector comprises a number of contact springs arranged radially round the driving shaft which is controlled by the Turner relay. These springs are sorted out by a special mechanism so that they pass either above or below a fixed contact ring depending upon whether a dot or a dash is received. By connecting up the contacts on this ring in the appropriate manner, the alarm bell circuit will be completed when the proper arrangement of contact fingers is obtained by the signal that it is desired should operate the apparatus.

* Abstract of Paper read before the Wireless Society of London on April 30th, 1920.

† For description of this relay see *Journal of the Institution of Electrical Engineers*, 57, Supplement, pp. 50—65, April, 1920.

The apparatus is normally set to respond to "S.O.S." calls and calls for the receiving ship or station. The alarm bell is also rung should any one of the valves burn out. A drop indicator on the apparatus indicates whether the bell-ring is due to failure of a valve or whether it is a call for the ship, or a distress call.

A very successful demonstration was given of the apparatus working on a receiving aerial.

Thermionic Valve Nomenclature.

Barkhausen has suggested the following symbols for the various quantities arising in connection with three-electrode thermionic valves. These suggestions may prove of interest to English workers interested in the subject of valve nomenclature and symbols.*

Magnitudes in the anode circuit	Subscript	a
,, ,, grid circuit	,,	g
,, ,, heating circuit	,,	h
Power before amplification [unverstärkt]	,,	u
,, after amplification [verstärkt]	,,	v
Momentary value of total current	i	
,, ,, ,, voltage	e	
Mean value of current	I	
,, ,, voltage	E	
Momentary value of superposed alternating current .	$\mathfrak{i}$	
,, ,, ,, ,, voltage .	$\mathfrak{e}$	
Maximum value of superposed alternating current .	$\mathfrak{J}$	
,, ,, ,, ,, voltage .	$\mathfrak{E}$	

The characteristic: $I_a = f(E_g)$ with constant E_a
The grid-current characteristic: $I_g = f(E_g)$,, E_a
The anode-current characteristic: $I_a = f(E_a)$,, E_g

$$\left.\begin{aligned} &\text{Steepness [Steilheit]: } S = \left(\frac{\partial I_a}{\partial E_g}\right)_{E_a} \\ &\text{Voltage ratio [Durchgriff]: } D = -\left(\frac{\partial E_g}{\partial E_a}\right)_{I_a} \\ &\text{Internal resistance: } R_i = \left(\frac{\partial E_a}{\partial I_a}\right)_{E_g} \end{aligned}\right\} SR_iD = 1$$

Emission current: $i_e = i_g + i_a$; $(I_e = I_g + I_a)$.
Saturation current: $I_s =$ limiting value of I_e

Ratio of power amplification [Verstärkungsgrad]: $W = \sqrt{\dfrac{N_v}{N_u}}$

($N =$ Power).

* For further suggestions relative to Triode Nomenclature see correspondence on the following pages of the RADIO REVIEW: W. H. Eccles, p. 211 (January); L. B. Turner, p. 314, E. V. Appleton, p. 316 (March); E. V. Appleton, p. 368 (April); C. L. Fortescue, p. 417 (May); and A. Press, p. 472 (June).

M M

Review of Radio Literature.

1. Articles and Patents.

396. ON THE THEORY OF RADIOTELEGRAPHIC AND RADIOTELEPHONIC RECEIVER CIRCUITS. J. F. J. Bethenod. (*Proceedings of the Institute of Radio Engineers*, 7, pp. 517—525, October, 1919.)

A mathematical investigation of the values of the radio frequency and audio frequency currents obtained in a two-circuit inductively coupled receiver with the customary arrangement of a detector possessing a non-linear voltage-current characteristic.

397. DETERMINATION OF RATE OF DE-IONISATION OF ELECTRIC ARC VAPOUR. H. G. Cordes. (*Proceedings of the Institute of Radio Engineers*, 7, pp. 527—539, October, 1919.)

A theoretical discussion of an oscillatory circuit method of determining the rate of de-ionisation and the effect of this rate on the voltage required for a subsequent re-ignition.

398. THE DESIGN OF POULSEN ARC CONVERTERS FOR RADIO TELEGRAPHY. L. F. Fuller. (*Proceedings of the Institute of Radio Engineers*, 7, pp. 449—497, October, 1919.)

Deals exhaustively with the design of high power arc sets (100 kilowatt and over) from the engineering standpoint. A detailed summary of the radio cycle of operations based on the theories of Barkhausen and Pederson is first given from which it is possible to deduce certain relations which are in accordance with experiment. The effective value of the voltage across the arc which is useful in circulating the oscillatory current I_s is shown to be equal to the difference of the two effective values during the two halves of the I_s cycle. This quantity E_ϕ is equal to I_sR_s where R_s is the oscillatory circuit resistance. Experiment shows that when an arc is operating under good conditions its effective direct current resistance is equal to the resistance of the oscillatory circuit. From this it may be shown that the peak value of E_ϕ is equal to the direct voltage E_{da} maintained across the arc by the D.C. generator. It is also shown both analytically and experimentally that the voltage across the arc E_a is equal to $1{\cdot}4\ E_{da}$. These experiments were carried out at Palo Alto using a radio frequency voltmeter consisting of a hot wire milliammeter in series with a non-inductive resistance across the radio frequency terminals of the arc for the measurement of E_a, E_{da} being calculated from a knowledge of the electrical magnitudes of the direct current circuit.

The theory of the effects of the magnetic flux B_g upon extinction and ignition is worked out by considering the effect of B_g on I_s. It is found that there is an optimum value of B_g. For values less than this the gap ionisation is above normal and the effective value of E_a is decreased and thus I_s is decreased.

If B_g is above the optimum value β_g, although the extinction and ignition voltages are abnormally high the time of extinction is advanced and ignition is delayed. Such improper timing tends to produce harmonics.

The Poulsen cycle efficiency may be calculated from the following :

$$\text{Arc output} = R_s I_s^2 = \frac{E_{da} I_d}{\rho^2}$$

where $\rho = \dfrac{I_d}{I_s}$ and I_d is the direct current through the arc.

$$\text{Arc input} = E_{da} I_d.$$

$$\therefore \text{ Arc efficiency } \epsilon = \frac{1}{\rho^2}.$$

If $\rho = \sqrt{2}$ (as is shown to be the case in the preliminary discussion of the circuit theory) $\epsilon = 50\%$. This is the highest theoretical efficiency.

As a certain fraction of each radio frequency cycle is allowed for the extinction of the arc we may say that the length of the time required for this is inversely proportional to the frequency. Thus as the rate at which the ions are removed is dependent on the field strength we may write

$$\beta_g \propto \frac{1}{\lambda}.$$

The necessary field strength is also shown to be inversely proportional to the molecular velocity of the ions, and if it be assumed that the absolute temperature of the arc flame is proportional to the power input $E_{da} I_d$ we may write

$$\beta_g = \frac{K \sqrt{E_{da} I_d}}{\lambda}$$

where K is found to be 4·25 for kerosene and 8·50 for ethyl alcohol. Experimental data in support of this formula are given.

The use of high power converters necessitates the design of electromagnets up to a weight of 80 tons. In the search for a theoretical basis for design the work of Ewing and Weiss is considered but is not found suitable in this case where fields of 2 to 20 kilogauss are contemplated. Direct experiment seemed the only basis for design. It is shown from practical data that the best value for the tip-gap ratio (ratio of diameter of tip to thickness of gap) is $\sqrt{3}$ though small departures from this value do not seriously affect the flux density.

The best type of pole tip should start with an angle of 60° near the gap, changing to 55° part way down the cone and finally changing to 50° near the base of the cone (approximately one-third of the slant height for each angle).

The pole-gap ratio (ratio of pole diameter to thickness of gap) is important as being the main factor controlling the weight and cost of an arc converter. The magnetic circuit should be designed so that the knee of the saturation curve is reached at rated full load current. Experimental data show that the value of magnetic flux when the knee of the curve is reached does not increase much for values of the pole-gap ratio higher than 12. However, considerations of cost and weight make it advisable to run the ratio at values lower than this, *e.g.* 8. The magnetic air gaps now in use range from 1 to 7 inches.

All modern arcs are provided with an area of chamber cooling surface approximately proportional to the arc rating. Data for this relation are given.

The carbon electrode should not be operated above 200 D.C. amps. per square inch. Carbon or graphite may be substituted for the copper anode of a Poulsen set but these materials have never come into regular use because a water-cooled copper electrode is less troublesome.

399. PRINCIPLES OF RADIO TRANSMISSION AND RECEPTION WITH ANTENNÆ AND COIL AERIALS. J. H. Dellinger. (*Proceedings of the American Institute of Electrical Engineers*, 38, pp. 1095—1150, October, 1919. *Bulletin of the Bureau of Standards*, 15, pp. 435—495. *Scientific Paper of the Bureau of Standards*, No. 354, December 11th, 1919. *Revue Générale de l'Électricité*, 7, p. 118D, April 10th, 1920, Abstract.)

This paper which is largely mathematical compares coil aerials with ordinary antennæ as regards transmission and reception. The formulæ obtained may be used in designing an aerial for any particular set of conditions. The conclusions reached have been verified by experiments. The advantages of the coil aerial as regards direction finding, prevention of interference, reducing strays, and in submarine work make the development of this aerial particularly important. The principal formulæ given are evolved from fundamental electromagnetic theory, and some of the most important results are as follows :—

Radiated magnetic field intensity from an antenna or condenser aerial,

$$H = \frac{2\pi}{10} \cdot \frac{h_s I_s}{\lambda d}.$$

Radiated magnetic field intensity from a coil

$$H = \frac{4\pi^2}{10} \cdot \frac{h_s l_s N_s I_s}{\lambda^2 d}.$$

Received current in an antenna or condenser aerial

$$I_r = 300 \frac{h_r H}{R}.$$

Received current in a coil

$$I_r = 600\pi . \frac{h_r l_r N_r H}{R\lambda}.$$

Distance at which a given current is received in a coil, for a given transmitting current in an antenna,

$$d = \frac{1184\, h_s h_r l_r N_r I_s}{R\lambda^2 I_r}.$$

Relative effectiveness of coil and antenna, for the same height and wavelength

$$d_c/d_a = N \sqrt{2\ (1 - \cos 2\pi l/\lambda)}.$$

Relative effectiveness of coil and antenna, for the same height and wavelength, l small compared to λ,

$$d_c/d_a = 6{\cdot}28\,Nl/\lambda$$

Length of coil aerial equivalent to antenna of the same height

$$l = 0{\cdot}16\,\lambda/N.$$

Coil aerial reception factors.

$$\begin{aligned}\text{E.M.F. reception factor} &= a^2N/\lambda.\\ \text{Current reception factor} &= a^2N/(R\lambda).\\ \text{Voltage reception factor} &= a^2NL/(R\lambda^2).\end{aligned}$$

Radiation resistance.

$$R_a = (39{\cdot}7\,h/\lambda)^2 \qquad \text{(antenna)}$$

$$R_c = (13{\cdot}3\,a/\lambda)^4N^2 \qquad \text{(coil)}$$

Transmission formulæ were also given for antennæ and coils, identical with the ones previously published by the same author.*

The notation used in the above formulæ is as follows :—

Subscripts : s = sending ; r = receiving ; a = antenna ; c = coil.
I = effective value of current.
H = effective value of magnetic field intensity.
h = height of aerial.
d = distance along earth's surface from the sending aerial.
λ = wavelength.
l = horizontal length of coil aerial.
N = number of turns of wire on coil aerial.
a = length of side of square coil.
R = resistance of receiving aerial circuit.
L = inductance of receiving aerial circuit.

The results of the investigations show that the ratio of the ranges of communication with coil aerial and antenna is proportional to the number of turns, and horizontal length of the coil, and inversely proportional to the wavelength. The coil aerial is therefore particularly suitable for communication on short wavelengths. A coil aerial is quantitatively as powerful as an antenna only when its dimensions approach those of the antenna, but it is easier to make the resistance of a coil aerial small, thus making a small coil as effective as a large antenna. A small aerial as effective as the ordinary antenna may be secured without recourse to the closed coil principle, by using an aerial consisting of a condenser with two large parallel planes so arranged that the dielectric includes on ground.

400. ON THE SELF-INDUCTANCE OF SINGLE LAYER FLAT COILS. S. Butterworth. (*Proceedings of the Physical Society of London*, 32, pp. 31—37, December, 1919.)

Two formulæ are given in this paper for the computation of the self-inductance of single layer flat coils, one for the case when the inner and outer radii are not very different and the other for the case of small inner radius. The two formulæ are shown to be consistent and capable of including all possible cases. From them it is shown that the inductance of such flat coils can be expressed in the form $L = Qn^2r^3$ in which n is the number of turns

* See RADIO REVIEW Abstract No. 4.

per centimetre, r is the outer radius of the coil and Q a function of the ratio of the inner and outer radii. A table of this function follows :—

r_1/r_2		Q	r_1/r_2		Q	r_1/r_2		Q
0·00	..	6·970	0·35	..	5·996	0·70	..	2·528
0·05	..	6·964	0·40	..	5·632	0·75	..	1·946
0·10	..	6·930	0·45	..	5·213	0·80	..	1·397
0·15	..	6·845	0·50	..	4·743	0·85	..	0·8892
0·20	..	6·728	0·55	..	4·231	0·90	..	0·4574
0·25	..	6·544	0·60	..	3·682	0·95	..	0·1394
0·30	..	6·300	0·65	..	3·105	1·00	..	0·0000

A table is also given in the paper for calculating the mutual inductances between flat coils.

401. AN EXPERIMENT ON IMPULSE EXCITATION. J. H. Morecroft. (*Proceedings of the Institute of Radio Engineers*, 8, pp. 75—84, February, 1920.)

Oscillographic experiments on the effect of a unidirectional pulse on an oscillatory circuit are described. The oscillatory circuit of natural frequency 78·6 cycles per second was energised by direct current from a battery flowing through a portion of the circuit for a definite measurable time, the amplitudes and wave form of the exciting current and the current flowing in the oscillatory circuit being measured from simultaneous oscillograms. It is found that for the shortest time (0·002 second) of excitation used the amplitude of the first and second alternations of the oscillatory current are practically the same, and that the amplitude of the first alternation does not increase after the pulse has a length equal to one quarter of a cycle. As the pulse is lengthened the amplitude of the second alternation increases until the pulse length is half the natural period. For pulses lasting longer than one half period the amplitude of the second alternation decreases until it has that value which is fixed by the amplitude of the first and the decrement of the circuit. It is found that the greatest disturbance is produced in an oscillatory circuit by a rectangular pulse when this pulse has a duration equal to half the natural period of the circuit.

The effect of "infinite impedance" circuits when subjected to impulse excitation is studied and it is found that for pulses their filtering action is much less than for sustained waves of the same natural frequency as the "infinite impedance" circuit.

402. MEASUREMENT OF DIELECTRIC CONSTANT AT HIGH FREQUENCY BY THE WHEATSTONE BRIDGE. H. Joachim. (*Annalen der Physik*, 60, pp. 570—596, November 27th, 1919.)

A continuation of work published by Hertwig (*Annalen der Physik*, 42, p. 1099, 1913) but with various improvements which are fully described and discussed. The high frequency was obtained from a thermionic generator. The frequency employed in the tests was 10^6 ($\lambda = 300$ metres). Although heterodyne detection would have given greater sensitiveness, the author employed a rotary toothed ticker across the telephone receiver. Results are given for a number of inorganic salts and the variation of the constant with temperature is investigated and discussed theoretically. The variation of the constant with frequency is also discussed.

403. A METHOD FOR MEASURING VERY SMALL CAPACITIES AND INDUCTANCES. L. Pungs and G. Preuner. (*Physikalische Zeitschrift*, 20, pp. 543—545, December 1st, 1919.)

Heterodyne reception permits the detection of very small changes of frequency caused for example by the addition of small capacities or inductances. The use of the heterodyne principle for determining wavelength is stated to be due to Scheller. The authors propose the following method: two high-frequency circuits with thermionic generators ($f = 10^5$ to 10^6) produce beats (f about 1,000) which after rectification are superposed upon an alternating current of about the same frequency as the beats, produced by a third thermionic generator. This latter causes the beat tone to rise and fall in intensity, unless it has exactly the same frequency as the beat tone. The small capacity to be measured is connected in parallel with the condenser in the oscillatory anode circuit of one of the high frequency thermionic generators; it is then replaced by a known small capacity. If the latter is variable one can adjust until the tone is of constant intensity, if not one can calculate the capacity from the frequencies of the pulsating tone intensity. For further detail, the original paper should be consulted; the authors promise a further publication on the subject.

404. ELECTRIC ARC CHARACTERISTICS. E. Bräuer. (*Physikalische Zeitschrift*, 20, pp. 393—396, September, 1919. *Science Abstracts*, 22A, p. 567, Abstract No. 1538, December, 1919.)

The results of tests with various electrode materials for arcs are summarised in the form of a table giving the values for these various materials of the constants a and b in the equation of the characteristic; $ei = ai + b$, where e is the potential and i the current.

405. THE TELEPHONE RECEIVER: ITS MECHANICAL ACOUSTIC CHARACTERISTICS. W. Hahnemann and H. Hecht. (*Annalen der Physik*, 60, pp. 454—480, November 20th, 1919.)

A continuation of "Sound producers and receivers" (*Physikalische Zeitschrift*, 20, p. 104, 1919), and of "Sound fields and antennæ" (*idem*, 18, p. 261, 1917). From bridge measurements of the effective resistance and inductance of a receiver at various frequencies, curves are plotted of the power taken, both in a vacuum and in air with the earpiece at various distances from the diaphragm. The resonant frequency is changed by closing the sound opening and even by holding the receiver to the ear. The causes of the change of damping and of resonant frequency are discussed. From the resonance curves the damping is calculated in the usual way and from this the authors calculate the fraction of the power supplied which is converted into useful sound. For frequencies between 500 and 1,000 this is found to be from 0·1 to 1 per cent. The results are compared with those obtained by H. Abraham and M. Wien.

406. SPARK TRANSMITTERS. F. Lowenstein. (*French Patent* 497961, February 5th, 1919. Published December 23rd, 1919.)

The invention described in this specification consists in a multiple quenched spark gap apparatus for producing high frequency oscillations. The multiple gap is built up of a series of readily removable and replaceable units, each comprising one or more pairs of discs and electrodes with annular sparking surfaces of silver. The discs have cooling fins of sheet metal, preferably copper. The number of gaps in circuit may be varied by suitable switch apparatus.

For further particulars of the invention, see British Patent No. 122640.

407. ARC OSCILLATION GENERATORS. H. C. Rentschler. (*British Patent* 135185, November 10th, 1919, Convention date November 9th, 1918. Patent not yet accepted but open to inspection.)

The arrangement described is shown diagrammatically in Fig. 1. A containing vessel V which is mounted upon the pivoted arm A so that it can be swung into either a horizontal or a vertical position, encloses the two electrodes E_1 and E_2 and an additional mercury electrode M. To start the arc the switch S is placed in the upper contacts and the mercury splashed into contact with the electrode E_2 so that an arc is struck. On throwing over the switch to the lower contacts the arc strikes between E_1 and E_2 and sets up oscillations in the shunt circuit L C. The electrodes should be of a refractory metal such as tungsten, molybdenum, zirconium, or chromium and the anode E_1 should be larger than the cathode E_2. The vessel may be filled with hydrogen at a pressure of 40 cm. of mercury, or with helium. Oscillations of the first type are obtained so that the total current through the arc is not reversed during an oscillation.

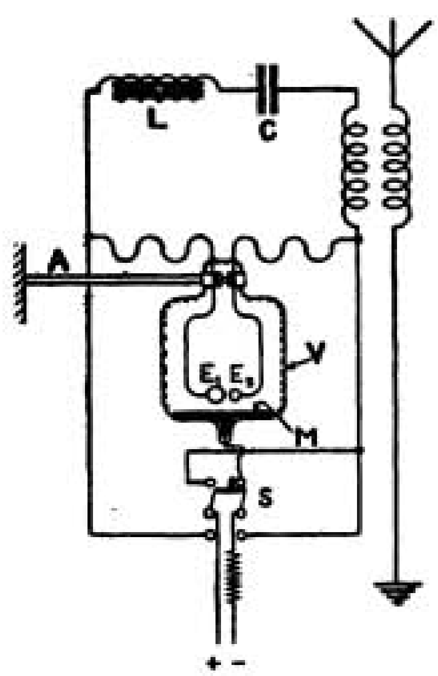


FIG. 1.

408. A SMALL POULSEN GENERATOR FOR LABORATORY MEASUREMENTS. M. Giddemeister. (*Elektrotechnische Zeitschrift*, 40, pp. 616—617, November 27th, 1919.)

A very convenient and simple form requiring little attention burning vertically in a glass cylinder dipping into a vessel containing oil, up a tube in the centre of which passes the rod carrying the carbon electrode. The water-cooled copper electrode is carried from a metal plate which screws into a ring to which the glass cylinder is cemented. The current is 2 amperes at 220 to 250 volts. The only gas which has been found satisfactory is hydrogen.

409. HIGH FREQUENCY OSCILLATION GENERATORS. V. J. F. Bouchardon. (*British Patent* 135464, September 11th, 1919. Convention date November 21st, 1918. Not yet accepted but open to inspection.)

An arrangement of valve oscillation generators is described fed from a polyphase alternator as indicated in Fig. 2. The same alternator may be

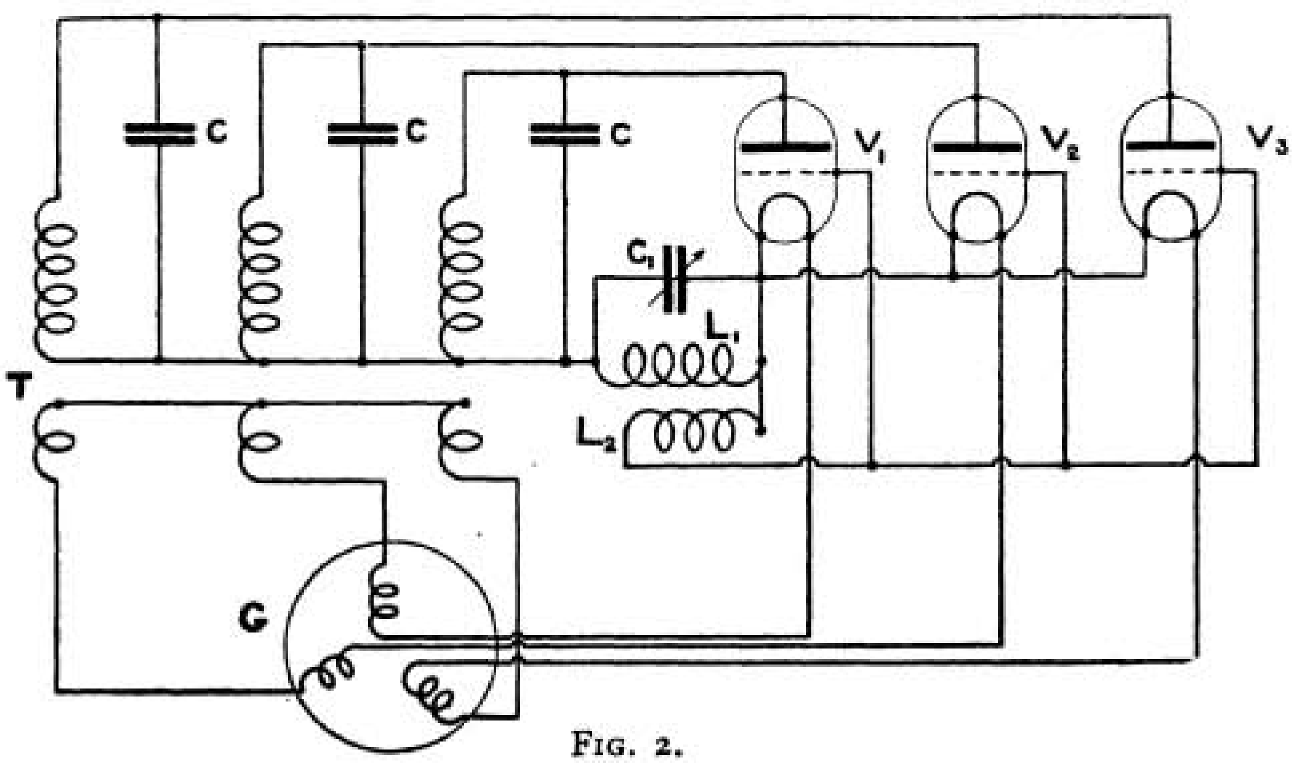


FIG. 2.

employed for feeding a polyphase spark transmitter. T is the three-phase step-up transformer, and L_1 L_2 the high frequency reaction coupling.*

410. HIGH FREQUENCY ALTERNATOR. O. Billieux. (*French Patent* 498164, November 22nd, 1917. Published December 31st, 1919.)

This specification describes a high frequency alternator in which the rotor consists of two discs, having teeth on their periphery and rotated in opposite directions. For this purpose they are each mounted on the end of a motor shaft. The stator consists of two armatures disposed perpendicularly to the moving discs and one on each side of the pair. A coil produces a magnetic field which traverses axially the two armatures, the two discs and the air gaps and the yoke. The discs have teeth of the same size but one has a greater number than the other.

* See also RADIO REVIEW Abstract No. 107.

411. Transmitting Systems. A. Taylor. (*French Patent* 498367, April 15th, 1919. Published January 9th, 1920.)

The specification describes improvements in radio-telegraphic transmission systems.

For further particulars, see British Patent 133901.*

412. Telephone Repeaters. B. Gherardi and F. B. Jewett. (*Proceedings American Institute of Electrical Engineers*, 38, pp. 1255—1313, November, 1919.)

A history of the development of telephone repeaters is given including descriptions of various methods of using three-electrode valves for this purpose.

413. Radiotelephony. E. B. Craft and E. H. Colpitts. (*L'Elettrotecnica*, 6, pp. 731—734, November, 1919, Abstract.)

The full paper is given in *Proceedings of the American Institute of Electrical Engineers*, 28, p. 337, March, 1919.

414. The Use of Wireless Telephony for Aiding the Operation of an Electric Power Distribution Company. (*Electrical Review, Chicago*, 75, p. 668, October 18th, 1919.)

Refers to the decision of the Georgia Railway and Power Company, to install wireless telephone apparatus at their central and sub-stations, and at various points along their high-tension lines.

415. Wireless Telephony. N. H. Slaughter. (*Journal of the Franklin Institute*, 189, pp. 1—24, January, 1920. *Telegraph and Telephone Age*, 37, p. 580, November, 1919, Abstract.)

The paper deals mainly with the development of wireless telephone sets for use in U.S. aircraft during the latter stages of the war. Prior to the beginning of the European War, wireless telephony had been used in military operations to a negligible extent, but almost immediately following the declaration of war by the United States orders were issued for the development of an aeroplane wireless telephone set. This development was undertaken by the Western Electric Company and the instruments described and illustrated in the paper are those manufactured by this company. The power plant comprises a wind driven generator yielding 25 and 275 volts for the filament and anode circuits respectively, and provided with a differential field winding connected in series with a two-electrode regulating tube so that a practically constant output voltage is obtained for all speeds between 4,000 and 12,000 r.p.m. A schematic diagram of the connections of the complete installation is given in Fig. 3, and shows both the transmitting and receiving circuits. The method of modulation used in the transmitter is the "constant-current" method. The choking coil L_0 maintains the

* Radio Review Abstract No. 218.

output current from the generator practically constant, so that when a varying current is drawn by the plate circuit of the modulator tube, under the influence of the transmitting microphone, this varying current is diverted from the anode circuit of the oscillating valve, thus controlling its output. A special sound insulating helmet was developed which almost completely excluded

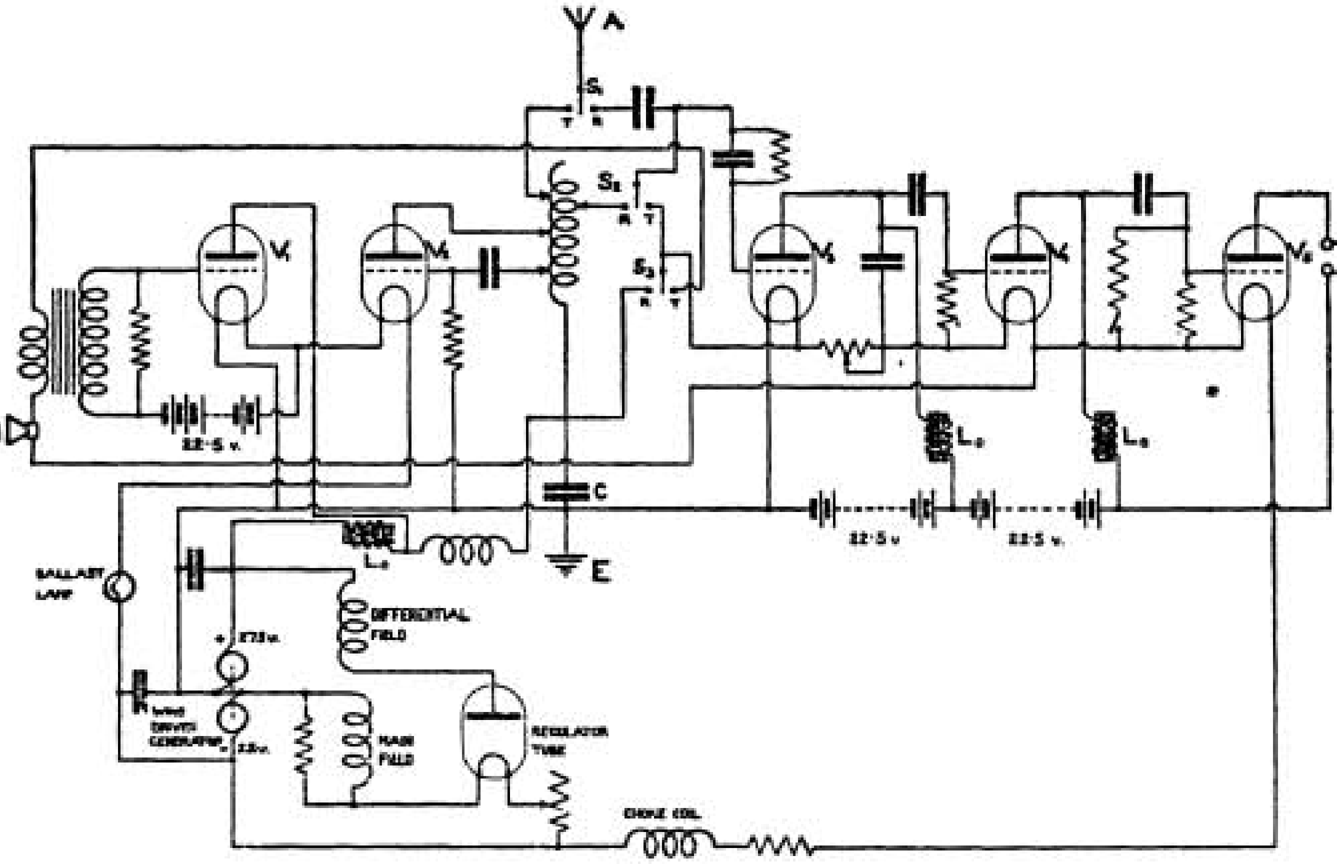


FIG. 3.

all sounds from the aviator's ears other than those received in the telephones. A single wire aerial was used of about 200 feet in length. A special form of reel for holding this wire was developed and was fitted with a centrifugal governor so as to limit the speed at which the wire is unreeled, thus preventing the breaking of the wire when the end is reached. A later type of apparatus is also illustrated in the paper but is not described in detail.

416. DEPENDENCE OF THE INPUT IMPEDANCE OF A THREE-ELECTRODE VACUUM TUBE UPON THE LOAD IN THE PLATE CIRCUIT. J. M. Miller. (*Bulletin of the Bureau of Standards*, 15, pp. 367—385. *Bureau of Standards Scientific Paper*, No. 351, November 21st, 1919.)

When used as an amplifier with the grid so negative that no electrons pass to it from the other electrodes, the input circuit is coupled with the output circuit through the internal capacities of the tube. The calculated formulæ based on these capacities are checked by actually measuring the various internal capacities of several tubes and then measuring the apparent resistance and capacity of the input circuit for various types of load in the anode circuit. Observed and calculated values are found to agree. With resistance or capacity loads the input circuit has always a positive resistance, but with inductive loads the input circuit may have a negative resistance, thus leading to increased amplification and sustained oscillations. Detailed calculations are given in the paper.

417. THE VACUUM-TUBE AS A GENERATOR OF ALTERNATING-CURRENT POWER. J. H. Morecroft and H. T. Friis. (*Proceedings American Institute of Electrical Engineers*, 38, pp. 1193—1221, October, 1919.)

A " P—10 " type " pliotron " tube was used for these tests. Rated anode voltage = 1,000—2,000 volts, filament current 3·65 amps., and safe loss on plate 250 watts. The first part of the paper deals with the operation of the tube when separately excited with an alternating p.d. superimposed upon the steady voltage in the grid circuit, and gives an account of an oscillographic study of the waveforms and phase relations of the grid and anode voltages and anode current. A load circuit consisting of a resistance (variable) in series with a condenser was joined across the tube to absorb the A.C. power output. It was found that the output reached a maximum for some particular value of the load resistance, and increased with the square of the exciting A.C. voltage in the grid circuit up to a certain value of that voltage, and afterwards more slowly.

With a properly evacuated tube the amount of power that can be expended on the plate is sufficient to bring it to a dull red heat. If the values of the applied voltages are properly adjusted, the power output in the load circuit may be greater than that used on the plate, and the safe value of the D.C. anode circuit input may be as much as three times the safe plate rating. The usual working efficiency of the tubes is about 30 per cent., but it has been found possible to obtain over 70 per cent. efficiency by proper adjustments,* although on the assumption of sinusoidal currents the output cannot be greater than half the input.

Tests indicated that a direct current ammeter used to measure the filament current does not indicate that current correctly when the tube is oscillating, and that the filament temperature is much hotter when oscillating than when not oscillating. The ordinary static characteristics do not give a true criterion as to the operation of the tube when oscillating as the grid and plate get hotter when taking the static curves than they do in normal operation under the same conditions.

Calculations indicated that both the losses and output of the tube are greatest for a sinusoidal plate current, but that the efficiency is then low. As the plate current is made to approach the form of a short pulse the efficiency rises, and for such a short pulse with a rectangular waveform the efficiency may reach 82 per cent. To obtain high efficiency the conditions should be so adjusted that during this short pulse, which occurs when the plate voltage is a minimum, the saturation current should flow.

A few tests were also made with the tube self excited, but difficulties were experienced in obtaining the high efficiencies owing to the alternating com-

* Neglecting the filament power input.

ponents of the plate and grid voltages not being exactly 180° out of phase, and a special means of adjusting this phase is suggested. Some experiments were also made with high-frequency self-excited oscillations, and these substantially confirmed the low-frequency tests.

418. THE AMPLITUDE OF THE OSCILLATING CURRENT SET UP BY AUDION GENERATORS. A. Blondel. (*Comptes Rendus*, 169, pp. 943—948, November 24th, 1919.)

This paper continues the treatment given in an earlier communication * dealing with the derivation of the oscillation characteristics of triode valves by a graphical construction from a family of static curves. It deals particularly with the first case there considered, viz., the use of an inductive reaction coupling between the anode and grid circuits of the valve, and an example is given of the derived characteristics, showing the method of construction, for one such case. The bulk of the article is devoted to a mathematical treatment prepared to show that the amplitude of the oscillations is zero when the conditions of priming are strictly realised (decrement reduced to zero by retroaction), and how the amplitude of the oscillations is limited by the curvature of the static characteristic starting with the simple fundamental equations of the anode circuit (consisting of inductance and capacity branches in parallel) equations are deduced for ω ($= 2\pi \times$ frequency), and for the amplitude of the fundamental of the current. These equations involve the constants of the circuit and the slopes of the oscillation characteristics.

419. CONTRIBUTION TO THE THEORY OF AUDION GENERATORS: THE CONDITION FOR EXCITATION AND THE DEGREE OF DAMPING OF FEEBLE OSCILLATIONS OBTAINED FROM THIS APPARATUS. A. Blondel and C. Lavonchy. (*Revue Générale de l'Électricité*, 6, pp. 875—893, 923—930, December 20th and 27th, 1919.)

This article is based upon a previous publication by A. Blondel † dealing with the conditions for the excitation of oscillations in triodes.

The present article is almost entirely mathematical, and deals first with the theory of sustained oscillations making use especially of a general mathematical theorem due to Hurwitz. In particular the treatment centres round the condition at the limit of self-excitation, *i.e.*, round the point at which the damping has been reduced to zero (by the retroactive coupling), and the transition period has been reached between stability and the instability when sustained oscillations are set up. Three oscillatory states are defined—below, at, and above this transition point—and a series of equations is evolved relating to these states.

The second section of the paper gives the application of the theory to a study of the sustained oscillations set up by a triode. The cases considered

* RADIO REVIEW Abstract No. 352.
† *Journal de Physique*, July, 1919.

include a " flywheel " coupling between the anode and grid circuits ; a tuned anode coupled to an untuned grid circuit ; an aperiodic state obtained with the grid and anode circuits inductively coupled but with neither circuit oscillatory ; and a general case with tuned anode circuit coupled inductively to the grid, and with an additional capacity coupling between the anode and grid of the valve.

The third section of the paper deals with the stability of the amplitude of the sustained oscillations. The treatment is based upon the special plate-current—plate-voltage characteristics previously described by A. Blondel,* and the influence of the curvature of the characteristics upon the stability is shown. The dynamic characteristic of the lamp, whether a straight line or an ellipse, ends in the regions of the derived characteristics where the effective resistance (slope of the characteristic) is sufficient to limit any further increase of amplitude by reason of the damping to which it gives rise. The mathematical treatment should be referred to in the original.

420. DETERMINATION OF THE OUTPUT CHARACTERISTICS OF ELECTRON TUBE GENERATORS. L. M. Hull. (*Bulletin of Bureau of Standards*, 15, pp. 497—517. *Scientific Papers of the Bureau of Standards*, No. 355, December, 1919.)

The direct coupled circuit is taken in this paper as typical of the circuits which may be used with triode valves for the purpose of generating oscillations. In this circuit the anode is joined to the grid through an inductance across which is shunted the condenser, the filament being joined to a tapping on the inductance. A portion of the inductance is thus included in the anode circuit and a portion in the grid circuit. The capacity (in series with a resistance) shunted across the whole inductance represents the antenna. The paper is divided into five sections, namely, introduction, oscillating tube, derived characteristic, power output, current output. The fundamental component of the electron current which will be supplied by a given tube, under the action of sinusoidal plate and grid voltages can be computed as functions of these voltages from a family of " static characteristics " of the tube. Curves showing the plate and grid currents as explicit functions of the grid voltage, taking account of the simultaneous changes in plate voltage which would occur if these currents supplied an output circuit having a given ratio of coupling reactance, are called the derived characteristics of the tube. The effective power output of the tube is:

$$P_0 = \frac{nE_g}{2}\left(I_p - \frac{1}{n}I_g\right)$$

where E_g is the amplitude of the grid voltage, I_p and I_g are the amplitudes of the fundamentals of the plate and grid currents respectively, and n is the ratio of the plate and grid coupling reactances. Hence the efficiency of the tube for any inductively coupled output circuit is:

$$\eta = 0{\cdot}5\,\frac{E_g}{E_0}\left(\frac{nI_p - I_g}{{}_0I_p}\right)$$

* RADIO REVIEW Abstract No. 352.

Where E_0 is the steady supply voltage and ${}_0I_p$ is the reading of the direct current ammeter in the other circuit. It is possible to get 50 per cent. efficiency from a tube if n is chosen so that

$$(I_p - I_g/n) = {}_0I_p \text{ when } E_g = E_0/n.$$

Physically this implies that the fundamental constituent of the plate current must be greater than the direct current constituent by the amount I_g/n, that is the plate current wave must be flattened at both extremes of the alternation. It is a familiar experimental fact that a highly distorted or flattened wave of the plate current leads to high efficiency, though not necessarily to high output.

From the current characteristics of the tube the power output can be obtained graphically as a function of the grid voltage : $P_0 = f\,(E_g)$.

Moreover $$E_g = L_g\sqrt{\frac{P_0}{RCL}}$$

where L_g is the grid inductance and R, C, and L, are the total resistance, capacity and inductance respectively of the antenna circuit. A simultaneous graphical solution of these two equations gives the power output from the tube as a function of any of the three electrical constants of the output circuit. Such solutions can be obtained graphically for any type of tube whose static characteristics are known. A number of curves are given in the paper illustrating these graphical solutions and the various output currents and harmonic constituents of the output currents obtainable from various tubes.

421. THE ALGEBRA OF IONIC VALVES. W. H. Eccles. (*Electrician*, 84, pp. 162—163, February 13th, 1920.)

This paper is written as an introduction to the theory of ionic tubes, and deals first with diodes, and then with triodes.

Considering only the straight part of the characteristic curve, its equation may be written

$$i_a = h_a\,(e_a - e_s),$$

where i_a is the anode current, e_a the anode voltage, h_a the slope of the characteristic line, and e_s the intercept on the e_a axis when the straight part of the characteristic is produced. This quantity e_s may be regarded as a back E.M.F. in the tube. Under these conditions the tube may be said to obey Ohm's law. If h_a and e_s are given their appropriate values corresponding to the point considered, the same equation may be used to represent the conditions at that point.

In the case of triodes, using the same reasoning, the above equation becomes :

$$i_a = h_a\,(e_a + ge_g - e_s),$$

where g is the voltage factor, and e_g is the grid voltage. Writing this equation as

$$i_a = h_a\,e_a + h_g\,e_g + h_o$$

the first equation suggested by Latour is obtained.* The symbol e_l may be used for $e_a + ge_g$ and is called the lumped voltage. Applying the above to the case of a triode amplifier, with a resistance R in the anode circuit, and writing r_a for $1/h_a$, the internal resistance of the tube, the expression for the voltage amplification becomes $\dfrac{Rh_g}{1 + Rh_a}$ or $\dfrac{gR}{R + r_a}$. This result is correct for both the curved and straight parts of the characteristic.

422. A GRAPHICAL STUDY OF THE OPERATION OF AUDIONS AS SENSITIVE RECEIVERS OR AS DECREMENT REDUCERS ("*desamortisseurs*") IN A RESONANT CIRCUIT. A. Blondel. (*Comptes Rendus*, 169, pp. 1377—1382, December 29th, 1919.)

The continuation of a previous paper † dealing with the derived characteristics of triode valves. When these characteristics are plotted in terms of i (the variable part of the plate current) instead of e (the variable part of the plate voltage) they enable the amplifying properties of these valves to be studied when the coupling is adjusted below the value necessary to sustain oscillations, and when a forced oscillation of the resonant frequency is applied to the apparatus. Two cases are considered, (1) when the alternating E.M.F. is applied to the plate circuit, and (2) when it is applied to the grid, and it is shown how, by means of the curves given, the amplitude of the resultant oscillatory current in the plate circuit may be obtained graphically in each case.

423. THE CALCULATION OF AUDION CONSTANTS. R. W. King. (*Physical Review*, 14, pp. 532—533, December, 1919. Abstract of Paper read before the American Physical Society.)

Given the characteristic equation of a triode as $I_p = \kappa \left(\dfrac{E_p}{\mu} + E_c\right)^{\eta}$ it has been found possible to deduce expressions for μ and κ from theoretical considerations.

Let α = distance from plate to grid (flat plate).
β = " " grid to filament (flat plate).
n = number of grid wires per unit length.
r = radius of the grid wires.
A = total plate area.
R_p = radius of cylindrical plate.
R_g = " " grid.
R_f = " " filament.
l = length of the complete cylindrical structure.

The following results were obtained, assuming $\eta = \frac{3}{2}$:—

* M. Latour, *Electrician*, 78, pp. 280—282, December 1st, 1916.
† RADIO REVIEW Abstract No. 418.

(1) Flat plate type with the filament symmetrically placed between grids and plates :

$$\mu = \frac{2\pi r n}{\log_\epsilon (1/2\pi \alpha n)}.$$

$$\kappa = 2{\cdot}33 \times 10^{-6} \frac{A}{\sqrt{\alpha + \beta}} \left(\frac{\mu}{\alpha + (\mu - 1)} \right)^{\frac{3}{2}}$$

(2) Cylindrical type with coaxial single strand filament :

$$\mu = \frac{\left(2\pi R_g{}^2 \frac{1}{R_g} - \frac{1}{R_f} \right) n}{\log_\epsilon \frac{1}{2\pi r n}}$$

$$\kappa = 14{\cdot}65 \times 10^{-6} \frac{l R_p{}^{\frac{1}{2}} \mu}{[(R_p - R_g) + R_g (\mu + 1)]^{\frac{3}{2}}}$$

(3) Cylindrical type with several parallel strands of filament arranged on an internal or external coaxial cylinder :

The expression for μ is the same as in case (2),

$$\kappa = 14{\cdot}65 \times 10^{-6} \frac{R_p l \mu^{\frac{3}{2}}}{\sqrt{\pm (R_p - R_f) \pm (R_p - R_g) \pm (R_g - R_f)}\,(\mu + 1)^{\frac{3}{2}}}$$

(the signs should be chosen to make all terms positive). Some examples of measurements on type (1) valves are given in the paper, and show good agreements between the calculated and observed values.

424. THE USE OF AUDIONS OR THREE-ELECTRODE LAMPS DURING THE WAR. G. Ferrié. (*Revue Générale de l'Électricité*, 6, pp. 933—935, December 27th, 1919.)

The author refers to an article by L. Kühn published in September, 1919,* in which reference was made to the lack of development of valve apparatus in Germany. It is stated that at the time of the armistice the Germans had no valve transmitters in use. A tribute is paid to the development work carried out in America and England, and the remainder of the article is devoted to a brief summary of the various development works carried out by the French Radiotélégraphie militaire. The following are dealt with in turn : Three-electrode valves, amplifiers, valve transmitters, aircraft receivers, single-frame radiogoniometers, earth telegraphy, measuring apparatus (wavemeter standardisation), and high power stations. Dates are given indicating the historical development of these various branches.

425. AN INVESTIGATION OF THE INTERNAL ACTION OF A TRIODE VALVE. W. H. Eccles. (*Radio Review*, 1, pp. 11—20; 67—77; 127—134, 1919.)

* *Jahrbuch der Drahtlosen Telegraphie*, 14, pp. 395—495, September, 1919. RADIO REVIEW Abstract No. 295.

N N

426. THE DEPENDENCE OF THE AMPLIFICATION CONSTANT AND INTERNAL PLATE CIRCUIT RESISTANCE OF A THREE-ELECTRODE VACUUM TUBE UPON THE STRUCTURAL DIMENSIONS. J. M. Miller. (*Proceedings of the Institute of Radio Engineers*, 8, pp. 64—73, February, 1920.)

The formulæ for the relations between the anode current per unit area of filament i_a, anode voltage v_a and grid voltage v_g of a triode can be deduced theoretically from the results of Maxwell's investigation of the screening effect of a grating of equally spaced parallel wires between two infinite conducting planes. A simple application of Maxwell's formula gives the following expressions for the anode current and the internal anode circuit resistance R for a tube with plane electrodes.

$$i_a = \frac{2{\cdot}33 \times 10^{-6}}{x^{\frac{1}{2}}\left(x + \frac{b_1 b_2}{\alpha}\right)^{\frac{3}{2}}}\left(v_a + \frac{b_2}{\alpha} v_g\right)^{\frac{3}{2}} \text{amperes.}$$

$$R = \frac{x^{\frac{1}{2}}\left(x + \frac{b_1 b_2}{\alpha}\right)^{\frac{3}{2}}}{1{\cdot}8\, L} \frac{10^6}{\left(v_a + \frac{b_2}{\alpha} v_g\right)^{\frac{1}{2}}} \text{ ohms.}$$

where b_1 = distance filament to grid.
b_2 = distance grid to plate.
$x = b_1 + b_2$.
$\alpha = -\frac{a}{2\pi}\log_{\epsilon}\left(2 \sin \frac{\pi c}{a}\right)$
c = radius of grid wire.
a = distance between grid wires.
and L = length of filament.

Using these formulæ satisfactory agreement is found between measured and computed values in the case of tubes having plane grids and anodes, but not for tubes of cylindrical design. Curves are given for the rapid pre-determination of amplification constants from structural dimensions.

427. IONIC OSCILLATIONS IN THREE-ELECTRODE THERMIONIC VALVES. R. Whiddington. (*Radio Review*, 1, pp. 53—58, November, 1919.)

428. PRODUCTION OF VACUUM TUBES FOR MILITARY PURPOSES. N. H. Slaughter. (*Physical Review*, 14, pp. 453—456, November, 1919.)

The specification, production, testing and performance of the vacuum tubes manufactured for use by the U.S. Signal Corps during the war are dealt with in this paper.

429. RECEIVING APPARATUS. E. Bellini. (*French Patent* 497848, April 5th, 1919. Published December 18th, 1919.)

The invention consists in a receiving arrangement for directive wireless telegraphy and telephony, and it has for its object to render very distinct the direction of the maximum intensity of reception. The invention is characterised by the employment of an auxiliary circuit which may be oscillating or not, coupled to two aerials or two radiogoniometer secondary circuits, which are untuned. The aerials or the said circuits when not directed towards the transmitting station will produce an electromotive force and a current in the auxiliary circuit, and by adjusting the radiogoniometer coils until no current is produced in the auxiliary circuit the direction of the received signals is ascertained. Various arrangements of auxiliary circuits are illustrated.

430. VARIATION IN DIRECTION OF PROPAGATION OF LONG ELECTROMAGNETIC WAVES. A. H. Taylor. (*Bulletin of Bureau of Standards*, 15, pp. 419—433. *Bureau of Standards Scientific Paper*, No. 353, November 29th, 1919.)

Describes a method of getting absolute zero with a direction finder by compensating the antenna effect by means of mutual inductance from a coil supplied from another frame aerial at right angles to the main coil. The two-coil (Robinson) method is compared with the single-coil minimum method and found to give equally good results, although it is stated that the former requires more experience. The apparent bearings of Annapolis 35 miles and New Brunswick 175 miles away have been studied and tables and curves are given showing the variation. In one case at sunset, New Brunswick appeared to shift 68° in sixteen minutes. Tests on 4,000 metre waves show smaller variation than the long waves. Tests on still shorter waves are in progress. Spark signals appear to show smaller variations than continuous wave signals. The reasons are briefly discussed, and it is suggested as probably being due to less well defined interference effects, between waves travelling between the stations by different paths, with damped wave trains than with continuous waves. Hence the former would show smaller apparent variations.

431. THE FESSENDEN PELORUS (WIRELESS COMPASS): A CAUTION AS TO ITS USE. R. A. Fessenden. (*Electrician*, 83, pp. 719—721, December 19th, 1919. *Revue Générale de l'Électricité* 7, p. 85D, March 13th, 1920, Abstract. *L'Électricité* 2, p. 16, March 15th, 1920, Abstract. *L'Elettrotecnica*, 7, p. 103, February 25th, 1920.)

A brief description is given of the various types of the Fessenden "Pelorus," including many references to the original descriptions and patent specifications. Errors in the readings may be due to: opaque regions due to varying local conductivity of the ground; varying local and temporal absorption due to vegetation; the difference between the resistance of water and of a sandy beach. The last causes the waves to bend in towards the land. In the latest type of "Pelorus" readings are taken on two or more wavelengths, as it has been found that the amount of directional error is a function of the wavelength. Hence when a difference is noted between the apparent directions measured on different wavelengths, it indicates that some error is present, and by observations of the differences between the different wavelength readings, it has been found possible to estimate the magnitude of the error and allow for it. The paper includes a curve taken by the U.S. Navy Department showing the variations in apparent direction through a week. The errors were greatest during the night and generally towards the shore side, but occasionally errors in the other direction were noted due apparently to clouds of ionised air.

432. DIRECTIONAL SYSTEMS OF WIRELESS TELEGRAPHY. (*Génie Civil*, 75, p. 671, December 27th, 1919.)

Abstract of lecture by H. R. Sankey—see RADIO REVIEW Abstract No. 147 for the original.

433. PROPAGATION OF ELECTROMAGNETIC WAVES OVER A PLANE CONDUCTING SURFACE. H. Weyl. (*Annalen der Physik*, 60, pp. 481—500, November 20th, 1919.)

A mathematical paper, the physical results of which are not clearly stated. The author criticises adversely the method adopted by Sommerfeld but also obtains a result which may be regarded as a superposition of a space wave and a surface wave.

434. A SYSTEM FOR THE RECEPTION OF CONTINUOUS WAVES. J. Scott-Taggart. (*Wireless World*, 7, pp. 593—601, January, 1920. *Electrical Review*, 85, pp. 808—809, December, 1919, Abstract.)

Paper read before the Wireless Society of London. For abstract see RADIO REVIEW, 1, pp. 181—183, January, 1920.

435. WHY TICKLER COILS ARE INEFFICIENT FOR LONG UNDAMPED WAVES. (*Everyday Engineering Magazine*, 8, p. 104, November, 1919.)

Resonance curves are given showing the loss of energy at the receiver brought about by the detuning necessary to obtain an audible heterodyne note at long wavelengths. The use of a separate heterodyne is advocated for long wavelengths in order to reduce this loss.

436. RECORDER. L. Williams. (*French Patent* 497912, April 7th, 1919. Published December 20th, 1919.)

The invention consists of an electrically operated recording or reproducing instrument which may be employed for producing a record of the number and character of electric waves produced in wireless telegraphy. The marking fluid is contained in a well having a fine outlet into which an electrode dips, and the arrangement is such that when current flows between the electrode and the well, the fluid is expelled and thus indicates the passage of the current by the mark on a recording strip.

For further particulars of this invention, see British Patent No. 123220.

437. THE PHOTOGRAPHIC RECORDING OF WIRELESS MESSAGES. (*Génie Civil*, 75, p. 387, October, 1919.)

Describes apparatus developed by the General Electric Company (U.S.A.).

438. THE USE OF THE THREE-ELECTRODE VALVE AS A RELAY. W. H. Eccles and F. W. Jordan. (*Revue Générale de l'Électricité*, 6, p. 812, December, 1919. *L'Elettrotecnica*, 7, p. 82, February 15th, 1920. *Radio Amateur News*, 1, p. 349, January, 1920, Abstract.)

Abstract of paper read before the British Association (see RADIO REVIEW, 1, pp. 143—146, December, 1919).

439. RECORDING OSCILLOGRAPHS AND AMPLIFIERS OF EXTREMELY LOW FREQUENCY; THEIR APPLICATION TO THE RECORDING OF RADIOTELEGRAPHIC SIGNALS. H. Abraham and E. Bloch. (*Revue Générale de l'Électricité*, 7, pp. 211—222; pp. 255—272, February 14th and 21st, 1920.)

Reviews critically all the methods previously used for the automatic registration of wireless signals and describes successful experiments made in 1916–18 for the French Army with valve amplifiers and Morse and other recording apparatus. The latter require working currents of the order of one milliampere and to reach this value the valve amplification must be pushed to a maximum. This has been done by a combination of H.F. and L.F. amplifiers, the resultant Morse signals being amplified by special instruments designed for extremely low frequencies so that the rhythm of the signals can be followed.

For reception a coil was used in place of an ordinary antenna because it was found possible to eliminate the effects of strays more completely by taking advantage of the radiogoniometric properties of the former. Most of the work was done with a circular coil 1·2 metres in diameter, and having 40 turns 14 mm. apart.

The two French military amplifiers types R_1 and R_6 are described. The type R_1 is a nine valve arrangement, resistance coupled, and can be used as an autodyne receiver. The type R_6 is an eight valve amplifier of superior design with both resistance and capacity coupling. Its special features are (*a*) the arrangement of connecting leads inside the amplifier case, and (*b*) the high resistance pancake coils which are included in the anode circuits and prevent instability. This instrument is designed to give maximum amplification on wavelength between 3,000 and 6,000 metres. A separate heterodyne must be used with it.

Two other novel types of amplifiers have been devised—one for extremely low frequencies and one for continuous currents. In the first type the connections between successive valves are made by means of condensers of 0·1 or 0·2 mfd. capacity. Each condenser is thus included in a high resistance circuit of several megohms and thus possesses a time constant which may be as large as several seconds. Hence, oscillations, the period of which is less than this amount will be efficiently amplified by this arrangement. In all cases the linking condensers are made as small as the rhythm of the signal currents will allow. For example, for the reception of signals sent by hand 0·5 mfd. is used; in the case of automatically sent signals of 40 or 50 words a minute 0·1 mfd. is sufficient. Experience shows that it is a good plan to shunt the anode circuit resistance (60,000 ohms) with capacities of the order of 0·25 mfd. in order to prevent reaction between this amplifier and the ordinary audio-frequency amplifier which precedes it in the stages of amplification.

The second type—the continuous current amplifier—will function at all frequencies. It is of the resistance coupled type but a battery is included in the wire connecting the high resistance in the anode circuit of one valve to the grid of the next so that the grid potential may be maintained at its most favourable value.

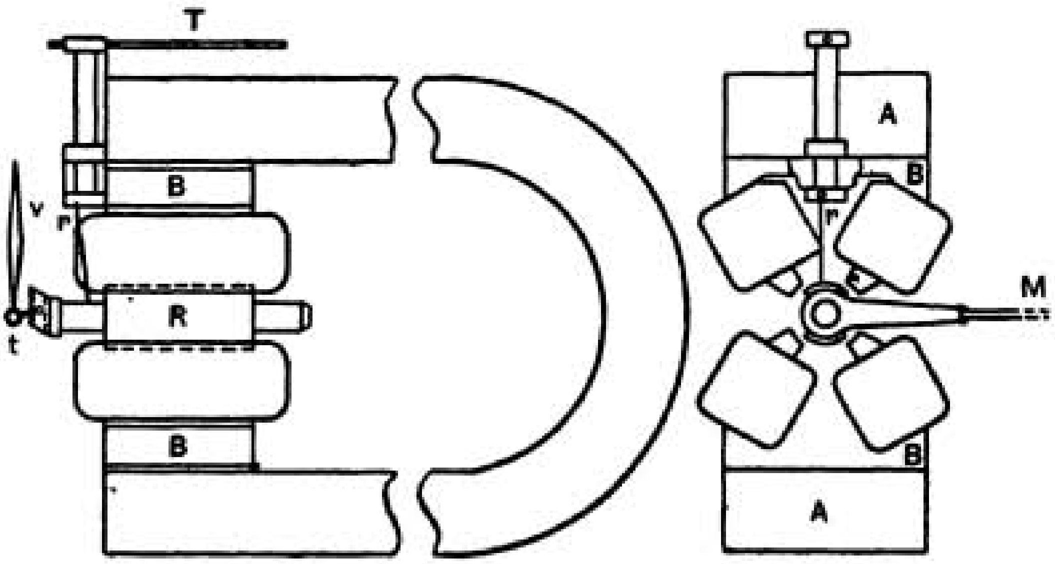


FIG. 4.

The recording apparatus used was specially designed for the work, and was of the moving iron type as it was not possible to get a moving coil instrument of sufficiently short period to respond with a milliwatt. The principle on which the recorder works is similar to that of a quadrant electrometer except that its action is magnetic instead of electric. A diagram of the essential parts is shown in Fig. 4, where **A** is a permanent magnet which has for its pole pieces the cores of two electromagnets BB, each with two coils arranged so that the magnetic force is radial. A rotor **R** of iron is placed along the axis. Its form is such that it is nearly in indifferent equilibrium between the poles. A spring of variable tension gives it a position of stable equilibrium. The connections between the four coils are made in such a way that the passage of the current which augments the field due to one pole diminishes that due to the two adjacent poles and augments the one opposite. The rotor thus tends to turn in the direction of the stronger field. The moving iron cannot carry the pen (which produces a trace on smoked paper) directly, but causes the trace with the aid of an intermediary lever.

Most of the large European stations have been recorded using the amplifying assembly and this recorder (examples of Morse and oscillograph types are given), no trouble with atmospherics being experienced. For the American stations regenerative circuits and very sharp tuning are necessary. The amplification is made so enormous that the anode current of the last valve reaches saturation value during a signal. This current is not altered by any strays however strong the latter might be. During the intervals between the signals the grid of the last valve becomes strongly negative and a stray of moderate intensity has not sufficient effect to cause this potential to mount to zero. Moreover, in the case of two sets of signals simultaneously heard on a telephone set, but sufficiently unequal in intensity, the record of the stronger signals only is obtained on the oscillograph.

440. "RECEPTION THROUGH STATIC AND INTERFERENCE," BY R. A. WEAGANT. L. de Forest. (*Proceedings of the Institute of Radio Engineers*, 7, pp. 543—553, October, 1919.)

A critical discussion (mainly adverse) by Lee de Forest of the above paper.* Weagant's reply is included.

441. MY INVENTIONS (VI.). N. Tesla. (*Electrical Experimenter*, 7, p. 506, October, 1919.)

This instalment contains a criticism of Weagant's claims in respect to his X-stopper.* Tesla states that artificial and natural ætheric disturbances are propagated in exactly the same way, both setting up electromotive forces in a horizontal as well as in a vertical sense.

442. THE UNI-CONTROL RECEIVER. R. E. Thompson. (*Proceedings of the Institute of Radio Engineers*, 7, pp. 499—516, October, 1919.)

Proposes a design for a receiver which will provide a gradual and continuous sweep from the shortest to the longest wavelengths within the range of the instrument. A set of capacity and inductance switches are geared together and controlled by a single handle to provide continuous variation of circuit frequency. The use of a motor for turning this handle is proposed. To prevent the continual jamming produced by ship-to-shore and ship-to-ship communication on one wavelength, it is proposed that ships should use different wavelengths and be fitted with a uni-control receiver.

443. STANDARDISATION OF RECEIVER WAVELENGTH RANGES. (*Everyday Engineering Magazine*, 8, p. 116, November, 1919.)

A plea for the more accurate definition of the wavelength ranges of receiving apparatus. Five classes of receivers are suggested for wavelength ranges between 60 and 20,000 metres.

444. THE HOROPHONE. (*Electrical Review*, 85, p. 767, December, 1919.)

A description is given of a compact receiving set specially designed for receiving time signals sent from the Eiffel Tower radio station.

* See RADIO REVIEW Abstract No. 18.

445. THE UNITED STATES NAVAL COMMUNICATION SERVICE. S. W. Bryant. (*Journal of the Franklin Institute*, 188, pp. 751—770, December, 1919. *Technical Review*, 6, p. 226, March 2nd, 1920.)

The U.S. Naval Radio Service was established in 1912. Its name was subsequently altered to the "Naval Communication Service" while at the same time the scope of its activities was extended to cover both wire and cable communications as well as wireless.

This article summarises the work of this department, and deals particularly with its activities during the war, especially in connection with U.S. communications to and from Europe and in the establishment of radio-compass stations and also centralised control stations for regulating the working of groups of radio stations in congested areas.*

446. THE PROGRESS OF WIRELESS TELEGRAPHY DURING THE WAR. J. Bion. (*Technique Moderne*, 11, pp. 417—423, October, 1919.)

The rapid development of continuous wave radio work during the war seems to indicate that soon only C.W. will be employed in practical working.

The improvements made in the three-electrode valve have enabled it to be used as an ultra-sensitive detector and amplifier, and have also enabled great strides to be made in low power radiotelephonic work. Wireless direction finding has also been developed and considerable accuracy is now obtainable.

447. THE WIRELESS TELEGRAPH APPARATUS OF THE GERMAN ARMY. A. Salomon. (*Revue Générale de l'Électricité*, 6, pp. 833—843, December, 1919. *Electrical World*, 75, p. 909, April 17th, 1920.)

The following apparatus is described and illustrated :—

Telefunken Dynamo-Alternator, giving D.C. and 540 ~ A.C.
Telefunken and Bosch Alternators for Aircraft, etc.
Pedal and Handcrank Driving Apparatus for Generators.
Deutsche Telephonwerke combined Transmitting and Receiving Set.
Telefunken Receiving Apparatus.
Deutsche Telephonwerke Complete Receiving Set.
Two-stage and Four-stage Valve Amplifiers.
Earth Telegraphy Apparatus.

448. A NEW TRANSFORMER AND OIL CONDENSER. (*Everyday Engineering Magazine*, 8, p. 107, November, 1919.)

449. STANDARDISED AUDION CONTROL PANELS. M. B. Sleeper (*Everyday Engineering Magazine*, 8, pp. 102—103, November 1919.)

Constructional details and illustrations of panels for mounting audions o experimental purposes.

---

* See also RADIO REVIEW Abstract No. 360.

450. WIRELESS IN WARTIME GERMANY. (*Scientific American*, 121, p. 575, December, 1919.)

A short note summarising some of the wartime developments in Germany. It is mentioned that the capacity of the Goldschmidt machine at Eilvese was increased to 800 kw. towards the end of the war. Methods of double sending with two transmitters acting on one antenna were also developed.

451. LONG DISTANCE RADIO COMMUNICATION IN CHILE. E. W. Fielding. (*Proceedings of the Institute of Radio Engineers*, 8, pp. 59—63, February, 1920.)

A detailed description of the construction and working of the Chilean radio stations at Llanquihue and Punta Arenas.

452. THE SUBMARINE'S UNDER-WATER RADIO. (*Electrical Experimenter*, 7, p. 539, October, 1919.)

An account of experiments and developments due to the Bureau of Standards, leading to a system of wireless transmission and reception during submergence.*

453. A LOOP OF WIRE. W. J. Henry. (*Scientific American*, 120, p. 368, October, 1919.)

A popular account of the use of loop aerials in trench wireless sets.

454. HOT-WIRE TELEPHONES. A. Williams and L. D. Williams. (*British Patent* 131258, May, 1919. Patent accepted, August 21st, 1919.)

Describes various arrangements of metal-foil heaters for thermal telephones.

455. IMPROVEMENTS IN INDUCTANCE COILS. H. A. Ewen. (*British Patent* 133513, November, 1918. Patent accepted, October 16th, 1919.)

The special feature claimed in this patent is the use of a metal strip of U-shape section which is wound up to form the inductance. The edges of the strip may be embedded wholly or partly in an insulated material to provide mechanical support, and connection is made to any point of the strip by means of a plug fitting between the adjacent sides of the U.

456. "THE ELECTRICAL OPERATION AND MECHANICAL DESIGN OF AN IMPULSE EXCITATION MULTI-SPARK GROUP RADIO TRANSMITTER," BY B. WASHINGTON. E. W. Stone. (*Proceedings of the Institute of Radio Engineers*, 7, pp. 541—542, October, 1919.)

A further discussion of the paper with the above title.†

---

* See also RADIO REVIEW Abstract No. 85.
† See also RADIO REVIEW Abstract No. 8.

457. ELECTRIC CONDENSERS. W. H. Edridge and E. E. G. Boite. (*British Patent* 130667, March 8th, 1918. Patent accepted, August 14th, 1919.)

The arrangement described provides for fine adjustment of the capacity of variable condensers of the vane type by means of a worm wheel mounted upon the spindle of the condenser. An auxiliary handle serves to turn the worm through a friction drive. Means is provided for disengaging the worm and wheel when desired.

458. CONDENSERS. W. H. Edridge and E. E. G. Boite. (*French Patent* 497970, March 8th, 1919. Published December 23rd, 1919.)

This specification describes variable condensers for wireless telegraphy and telephony.

For further particulars, see British Patent No. 130667.*

459. TELEMECHANICAL COMMUTATOR. R. Martin. (*French Patent* 693368, April 20th, 1916. Published August 7th, 1919. *Revue Générale de l'Électricité*, 7, p. 118D, April 10th, 1920, Abstract.)

Arrangements are described for the control of any form of distant apparatus by wireless. A special form of relay is employed.

460. ELECTRIC RESISTANCES, SENSITIVE TO LIGHT. T. W. Case. (*British Patents* 133403 and 133404, September, 1918. Patents accepted, October 10th, 1919.)

A compound comprising thallium and sulphur, preferably thallium-oxy-sulphide, is described for use in a photophone receiver. The second patent deals with constructional details and with the mounting of the sensitive material.

461. NAVAL AIRCRAFT RADIO. T. Johnson, Jr. (*Proceedings of the Institute of Radio Engineers*, 8, pp. 3—58, February, 1920.)

Experiments on the use of wireless by naval aircraft have been carried out by the United States Navy Department from 1912 onwards. The results of early work are summarised and the modern standard transmitting telegraph and telephone sets described. Of the spark transmitters now in use two are of the same design—synchronous rotary spark. These sets are mounted in a stream line case on the wing of the flying boat, the generator and spark gap being driven by a small propeller. Wavelengths from 200 to 500 metres are available in one set and from 335 to 425 metres in the other. Another standard transmitter is of the impact excitation type (two tungsten gaps in series) designed for work on 375 metres only.

In the description of the standard service transmitting valves the question of Wehnelt coated filaments *versus* tungsten filaments is discussed, the

* RADIO REVIEW Abstract No. 457.

evidence being in favour of the former for very low power transmitters and the latter for high power work.

For use on telephone sets a microphonic transmitter has been specially designed which is so mounted that it is exposed on both sides to extraneous noise vibrations and only affected by the directional impulses of the voice from one side. In order to prevent the carbon granule from falling away from the front electrode when the transmitter is held in a horizontal position the button is mounted at an angle of 30 degrees with the diaphragm.

To enable transmission to be carried on from the craft while resting on the

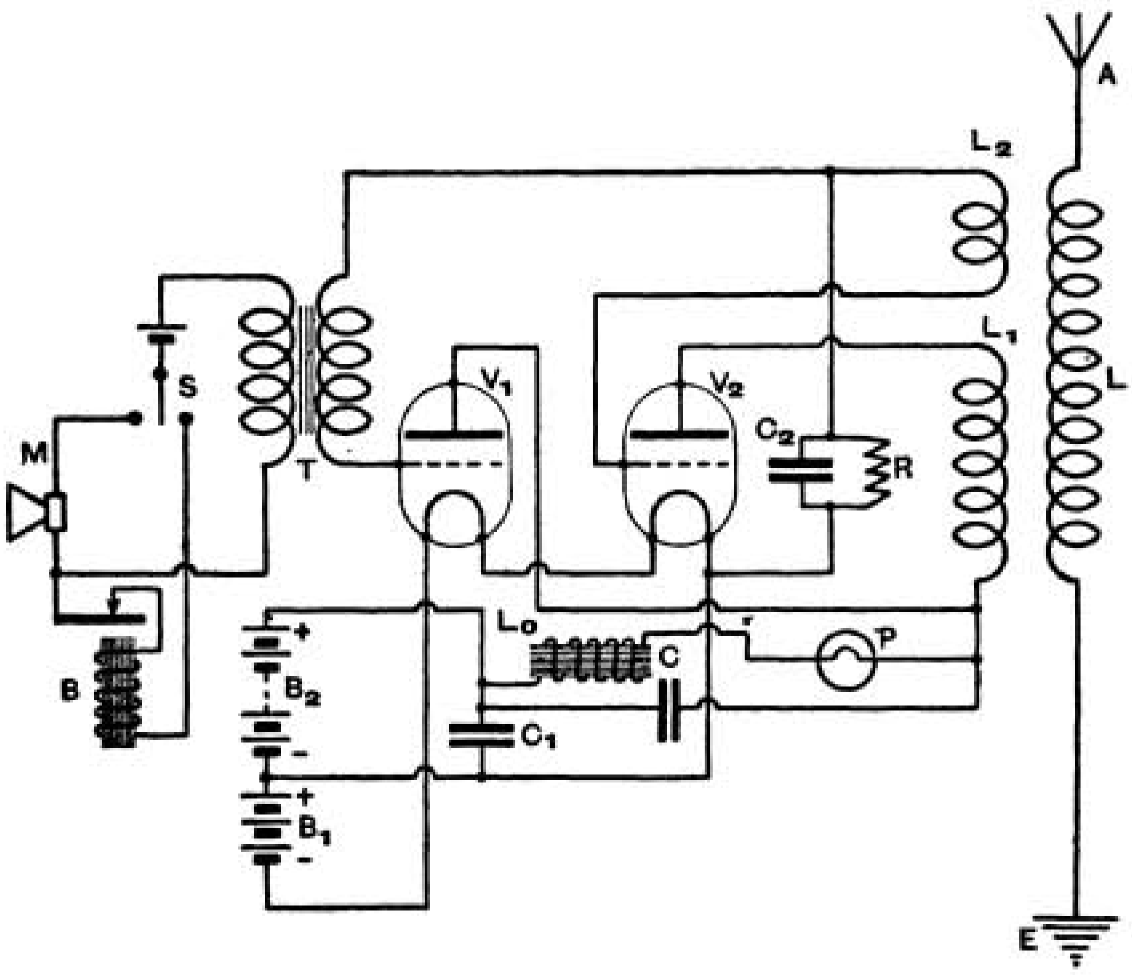


FIG. 5.

water a storage battery is used which is charged by means of a generator which is driven whenever the engine is running. The same fundamental circuit (see Fig. 5) is used for all craft and provides communication by either continuous wave telegraphy, buzzer-modulated telegraphy or telephony.

For continuous wave telegraphy the tube V_2 is used as "oscillator," the telegraph key being inserted in the grid leak R. The tube V_1 is used as a "modulator." The buzzer B and the microphone M are interchangeable by means of a switch, S. The output of the microphone transformer T is impressed on the grid of the modulator and the output of the modulator is introduced in the anode circuit of the oscillating tube through the incandescent lamp P, and the iron cored inductance L_0. The flickering of the incandescent lamp indicates the correct functioning of the modulator tube.

The method of determining airplane antenna constants, using a calibrated valve oscillator is described.

2. Books.

TELEPHONIC TRANSMISSION, Theoretical and Applied. By J. G. Hill, Assistant Staff Engineer, General Post Office, London. (London: *Longmans, Green & Co.*, 1920. Pp. xvi. + 393. Price 21*s*. net.)

Mr. Hill's book is almost entirely concerned with the one feature of wire telephony which is absent in radio transmission. It is an exposition of the theoretical development and practical application of the laws governing the transmission of currents from sending to receiving station along the wires connecting them. Yet it should have much interest for the radio engineer from both the theoretical and the practical points of view. On the theoretical side, the problems of wire telephony involve the general case of current propagation. Resistance, leakance, inductance, capacitance, must all be taken into account. The wave forms with which the telephone engineer must deal are probably the most complex types known in alternating current engineering. The frequencies and electrical constants of the circuits lie in that medium range in which the energy stored in the magnetic and electric fields, and that dissipated in the conductor and the dielectric are of equal importance in determining the performance of the circuit.

In the commercial application of the laws of transmission, the divergencies between the techniques of the "wired" and the "wireless" branches are more marked. Yet the methods by which the results of scientific study are reduced to practical rules for ensuring, at minimum cost, proper standards of speech transmission and absence of interference in the older branch are of considerable interest to any radio engineers who are willing to let their imagination speculate upon the probable development of their own branch of the art and to consider what form the standardisation which must accompany development is likely to take. This is an interesting theme, but a review is not the place for following it up.

Previous books on Transmission have been text-books dealing chiefly with the application of mathematics to elucidate the theory of transmission in the abstract. Breisig, Kenelly, Fleming have all viewed the subject from this standpoint. Mr. Hill's book deals with the application of the theory of transmission to commercial telephone practice in the concrete. It is a manual containing all that a transmission expert has found useful or necessary in the course of a long experience, revised and condensed into just such a book as every specialist feels he would like to compile, or at least to possess, on his own subject.

The arrangement of the theoretical chapters is somewhat novel. The key to the treatment adopted is to be found principally in Appendix II., which contains an elementary mathematical derivation of the equations representing the relations between voltage and current in the steady state in an infinite uniform line. These are derived without use of differential equations, and the proofs will be appreciated by many to whom the solution of a differential equation is the product of a magician's wand, only to be accepted as solid fact after the unsatisfactory test of re-differentiation. The more orthodox methods are given in Appendix I. The results of Appendices I. and II. are applied in Chapter II. to the simple case of an infinite line under direct current. The rules for forming equivalent circuits are established in Appendix III., and applied to the direct current case of lines of any length with and without terminal apparatus in Chapter III. The sequence would be easier to grasp if the whole of this matter were included in the text instead of being split between text and appendix. Loaded lines and the design of artificial cables are dealt with in Chapter IV., still on a direct current basis. Chapter V. deals with the nature of alternating speech currents, leading up to the application of the previous work to the case of alternating currents in Chapter VI. Chapter VII. treats of the difficult subject of reflection and transmission losses and gains at points of change and impedance. Chapter VIII. commences the application of the theory to practical cases and deals with the constants of different telephone lines. A long chapter on British Post Office practice in loading follows. Methods of measurements on telephone lines, with many details of tests and apparatus are described in Chapter X., including a particularly interesting reed governor for controlling the speed of high frequency alternators. This and the two following chapters on the standard cable and its uses and on cost problems in telephonic transmission, are unique in the literature of telephone engineering. They show how, by reduction of complex formulæ to expressions seemingly empirical, yet well grounded, by admissible approximation, by experimental checks, by standardisation of methods and apparatus, and by the use of curves and graphical methods, the transmission expert has adapted the work of the mathematician content with the derivation of an algebraic expression for the use of the practical engineer demanding maximum efficiency at minimum cost.

The last chapter treats of the application of the thermionic amplifier to telephone circuits; as one reads it one feels that the changes in practice which must follow on the introduction of this long-sought-for speech relay, together with the use of ultra-sound frequencies referred to on p. 357, will soon call for a second edition of even so complete a book as that under review. Let us hope that by the time this happens telephone engineers will have adopted a standard nomenclature for this new branch of their art. "Lamp," "valve," "relay," "relay lamp" and "three electrode thermionic valve" are all used where "triode" would be applicable and precise. Mr. A. N. Whitehead has said (*Introduction to Mathematics*, p. 88), "The essential principle involved was quite clearly enunciated in Wonderland to Alice by Humpty Dumpty when he told her, *à propos* of his use of words, 'I pay them extra and make them mean what I like.'" But it is wasteful and confusing to "pay" several words "extra" to make them all mean the same thing. If that thing is new, it is far better to employ a new word than to make an old one work overtime.

Mr. Hill and the publishers are to be congratulated upon the care used in the preparation of the text and diagrams and on the get-up of the book. Misprints are very few and unimportant, and matter, formulæ and diagrams are clearly presented. The close spacing between lines of type is a little irritating, but if the object has been to reduce the size and cost of the volume, this can easily be forgiven.

The work is the first of a series of Manuals of Telegraph and Telephone Engineering prepared mainly by Post Office specialists under the editorship of Sir William Slingo. Mr. Hill has set a high standard for his colleagues: if they equal or surpass it, this series will form the most comprehensive and authoritative source of information available on Telegraph and Telephone practice.

W. H. GRINSTED.

COURS ÉLÉMENTAIRE DE TÉLÉGRAPHIE SANS FIL. By Georges Viard. (Paris: *Librairie de l'Enseignement Technique*. 1918. Pp. 303. Price 12 fr.)

This book is based upon a course of lectures given at the École Supérieure des Postes et Télégraphes. It is a simple non-mathematical account of the development and of the present state of the subject. It presupposes very little mathematical or scientific knowledge on the part of the reader. After a historical introduction, the first chapter is devoted to definitions and examples of force, work, power, conservation of energy, electric and magnetic fields, alternating currents, damped oscillations, harmonic analysis, etc. Chapters follow on the production and use of damped oscillations, coupling, quenched sparks, various charging circuits with D.C. and A.C. supply, the production of undamped waves, the nature of electromagnetic waves, radiating and absorbing circuits, detectors, the reception of continuous waves, radiotelegraphic measurements, constructional details of stations, and radiotelephony.

The book is lucidly written and well illustrated, and can be recommended to French readers requiring a comprehensive but non-mathematical description of the subject.

G. W. O. H.

Books Received.

WIRELESS TELEGRAPHY AND TELEPHONY—First Principles, Present Practice and Testing. By H. M. Dowsett, M.I.E.E. (London: *The Wireless Press, Ltd.* 1920. Pp. xxxi. 331. Price 9*s*. net.)

Correspondence.

SKIN EFFECT IN SQUARE WIRES.

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—On page 227 of the issue of February, 1920, you refer to some mathematical work by Mr. H. W. Edwards on the skin effect of square conductors. In so far as Mr. Edwards' work has already been treated of by the writer in a paper on "Resistance and Reactance of Massed Rectangular Conductors" (see *Physical Review* for October, 1916) I am at a loss to understand the reliance placed upon the former's work.

The chief difficulty appears to have been that Mr. Edwards assumed a form of general solution for his partial differential equation which was entirely unwarranted. The physical work on the other hand I have every reason to believe was quite admirably done.

A. PRESS.

East Pittsburg, Pa., U.S.A.,
March 30th, 1920.

[We were acquainted with the paper referred to by Mr. Press, but have taken the opportunity of looking through it again to confirm our impression that it was not quite satisfactory. On page 417 the author says that the only assumption made is that the field in the skin of the conductor has a rectangular path conforming to the contour of the conductor. On the following page, however, he seems to give up this assumption in favour of another, viz. that the current density is the same at all points of the skin. However this may be, he concludes with an example of a square conductor 5 mm. on the side, $S = 0{\cdot}25$ and a frequency of 2,000 ; he then states that $S\sqrt{f} = 3{\cdot}54$ which is an obvious error unless the frequency was 200 and not 2,000 as stated. His calculated value of R_f/R_0 is 1·8. Now for a round wire of equal cross-section R_f/R_0 is little greater than 1 for $f = 200$, and is only 1·23 for $f = 2{,}000$. His calculated value for the square wire is therefore so high compared with that for the round as to cast considerable doubt on the accuracy of the method. For these reasons we felt justified in omitting any reference to the paper.—EDITOR.]

EARLY DEVELOPMENTS OF THE THREE-ELECTRODE TUBE.

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—In the February issue of the RADIO REVIEW, p. 259, M. Marius Latour refers to his publication in 1916 of a theory of the three-electrode tube, and states that this " theory is now classical and has been reproduced and possibly developed, by different authors (Hazeltine, van der Bijl, Carson, Ballantine, etc.)."

I am not disposed to be drawn into polemical discussions on questions of priority, for obvious reasons. It will naturally not be easy to give proper credit as far as priority of developments in Europe is concerned, because there the three-electrode thermionic tube was developed by the stimulus of war exigencies, and the publication of the results was naturally withheld for military reasons. Now that the war is over we find that the British, French, Germans, and others have made valuable contributions to this art during the period of the war. As regards the elementary theory of operations of the three-electrode tube, there can be no question of priority. M. Latour's paper appeared several years after the fundamental problems connected with the operation of this type of device had all been solved in the United States, where the investigations were stimulated, not by the war, but prior to the war, by the requirements of satisfactory telephone service over extensive regions.

M. Latour does not seem to be cognisant of the fact that high-vacuum three-electrode or audion tubes have been in *commercial service* since the summer of 1914 as telephone repeaters on the long-distance lines of the Bell Telephone System. It stands to reason that the use of such a device in such an intricate system of telephone communication, which involves lines stretching over several thousand miles, thus necessitating the use of several repeaters in series, must be preceded by a solution of the theory of operation of the device, the problem of its design, and the design of transformers and circuits with which the tube is to operate. The successful transmission of speech by radio telephone from Arlington, U.S., to Paris and Honolulu, in 1915, with a system which involved the use of high-power, high-vacuum, three-electrode tubes was the culmination of an extended series of investigations carried on by the engineers of the American Telephone and Telegraph Company and the Western Electric Company. The success of these experiments was the direct result of a thorough understanding on the part of these engineers of the theory of operation of the three-electrode tube as amplifier, detector, modulator, and oscillation generator.

The theory of the tube which I published was worked out by me in the winter of 1913 to 1914, and has been used ever since by the Western Electric Company in the design of tubes and their attending circuits. This work was based on careful investigations carried out by H. D. Arnold, during the years 1912 and 1913 on the characteristics of three-electrode tubes. (Langmuir and other engineers of the General Electric Company had also about that time studied the characteristics of three-electrode tubes, but this work was not known to me at the time I derived the amplification equations of the tube.) Furthermore, as early as 1914 I had established equations giving the relations between the electrical constants of the tube and its structural parameters. These equations have been used in the design of Western Electric tubes since then, and, as a matter of fact, the type of tube of which thousands are used to-day on the telephone lines of the Bell System has exactly the same electrical constants as the first tubes that were used commercially in 1914. In spite of this early work, I would, in justice to M. Latour, certainly have mentioned his 1916 paper in some of my publications, if I had known of it.

As regards the type of tube having a cylindrical structure placed horizontally above the press, and which M. Latour insists on calling a "French valve," I may say that this type of tube has exactly the same structure and arrangement as one of the very first types designed by me. My purpose in placing the structure horizontally above the press was merely to facilitate the manufacture. I have found, however, that it is not as good a structure as other Western Electric types by which it has been replaced some six years ago.

The tubes developed and manufactured by the Western Electric Company are not and have never been "tubes without high vacuum" or so-called "soft valves" as M. Latour states in a paper in the Société Française des Électriciens, 1919. These tubes are and have been from the beginning evacuated to such an extent that gas plays no part in the operation of the tube. The necessity for this condition was recognised by H. D. Arnold in 1912.

H. J. VAN DER BIJL.

New York, N.Y.,
March 16th, 1920.

The above letter has been submitted to M. Latour, who has replied as follows:—

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—I beg to call the attention of Mr. H. J. van der Bijl to the fact that any public claim of priority must be based on *published* documents such as papers or patent specifications.

Although I feel perfectly sure of the high personal ability of Mr. H. J. van der Bijl I cannot consider the fact that American engineers had built valve amplifiers for commercial use in 1914 as sufficient to prove beyond doubt that they had developed at that time the theory of the three-electrode valve now under discussion. I should say that any one working with valve amplifiers would be led after long tests to an amplification of telephonic currents. The intricacy of the system of telephone communication referred to by Mr. H. J. van der Bijl may introduce difficulties inherent to the use of repeaters on telephone lines but these difficulties are irrelevant to the theory under discussion.

As a matter of fact the operation of the three-electrode valve as an amplifier has been known since the issue of the American Patent No. 841387 of Lee de Forest in 1907, and the issue of the European Patents of von Lieben and Reisz. It was possible therefore for American engineers to disclose from 1907 to 1916 the *general* theory of the three-electrode valve expounded in my paper of 1916. As the American technical Press has been silent on this rather mathematical subject up to 1918 I consider my priority now recognised in American publications as being completely established.

MARIUS LATOUR.

Paris,
April 12th, 1920.

THE KALLIROTRON, AN APERIODIC NEGATIVE RESISTANCE TRIODE COMBINATION.

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—In Captain L. B. Turner's paper on the Kallirotron in your April issue an approximation is made which simplifies equation (16) into equation (17) on page 326 but which is not legitimate for the numerical values given on page 327 inasmuch as equation (16) makes $m = \infty$, while equation (17) gives $m = -8$.

The author's point can, however, be proved in the following manner. If equation (16) is inverted, numerator and denominator multiplied by $a_1 a_2$, a_1 replaced by $\alpha_1(1 + e)$ and a_2 by $\alpha_2 (1 - e)$ as described on p. 327, and finally g/a replaced by ν, as suggested by Captain Turner in his letter in the March issue, we find

$$\frac{1}{m} = \frac{1 + r_1\alpha_1 + r_2\alpha_2 - (\nu_1\nu_2 - 1)\, r_1r_2\alpha_1\alpha_2 + (r_1\alpha_1 - r_2\alpha_2)\, e + (\nu_1\nu_2 - 1)\, r_1r_2\alpha_1\alpha_2 e^2}{\nu_1r_1\alpha_1 + (\nu_2 + 1)\, \nu_1r_1r_2\alpha_1\alpha_2 + \nu_1r_1\alpha_1 e - (\nu_2 + 1)\, \nu_1r_1r_2\alpha_1\alpha_2 e^2}$$

If the algebraical division is performed, we obtain

$$\frac{1}{m} = \frac{1}{\mu} + \frac{\left(r_1\alpha_1 - r_2\alpha_2 - \dfrac{\nu_1r_1\alpha_1}{\mu}\right) e + \left(\nu_1\nu_2 - 1 + \dfrac{(\nu_2 + 1)\, \nu_1}{\mu}\right) r_1r_2\alpha_1\alpha_2 e^2}{\nu_1r_1\alpha_1 + (\nu_2 + 1)\, \nu_1r_1r_2\alpha_1\alpha_2 + \nu_1r_1\alpha_1 e - (\nu_2 + 1)\, \nu_1r_1r_2\alpha_1\alpha_2 e^2}$$

where $\dfrac{1}{\mu} = \dfrac{1 + r_1\alpha_1 + r_2\alpha_2 - (\nu_1\nu_2 - 1)\, r_1r_2\alpha_1\alpha_2}{\nu_1r_1\alpha_1 + (\nu_2 + 1)\, \nu_1r_1r_2\alpha_1\alpha_2}$

μ has exactly the same meaning as in the paper, namely the amplification for infinitely weak signals.

As the two resistances r_1 and r_2 are independent, they may be adjusted so as to satisfy two conditions. Let one be to make μ as large as possible without endangering stability and the other to make $r_1\alpha_1 - r_2\alpha_2 - \dfrac{\nu_1r_1\alpha_1}{\mu} = 0$ If we assume that e is so small that powers higher than the square may be neglected (e is of course not a voltage, but a ratio of voltages, and thus dimensionless), we finally get

$$\frac{1}{m} = \frac{1}{\mu} + \frac{\left(\nu_1\nu_2 - 1 + \dfrac{(\nu_2 + 1)\, \nu_1}{\mu}\right) r_1r_2\alpha_1\alpha_2}{\nu_1r_1\alpha_1 + (\nu_2 + 1)\, \nu_1r_1r_2\alpha_1\alpha_2}\, e^2$$

Under practical working conditions the coefficient of e^2 is positive, so that whatever the sign of e may be, $\dfrac{1}{m} > \dfrac{1}{\mu}$, or $m < \mu$.

G. BRAMWELL EHRENBORG.

Croydon,
April 9th, 1920.

The above letter has been submitted to Capt. L. B. Turner, who has replied as follows:—

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—Mr. Ehrenborg's criticism in his letter of the 9th inst. is justified. I regret I did not notice that, as he points out, the rough approximation by which expression (16) is simplified into expression (17) may lead to inconsistent results.

But it is not necessary to use expression (17) in order to arrive at a numerical demonstration of the limiter-amplifier property of the Kallirotron in the symmetrical case ($r_1 = r_2 = r$) investigated in my paper. We can calculate almost as simply from the accurate expression (16) directly. This is of the form

$$m = \frac{A+B}{C-B}$$

where A and C vary with the signal strength e, and when $e=0$ are each very nearly equal to B, which does not vary with e. The exact values of A and B therefore do not matter, and we have only to examine the values assumed by m as C slightly changes under the action of the signal.

Retaining the approximation that $1/(1-e^2) = (1+e^2)$, and taking the numerical values of page 327 which make $B = \frac{64 \times 10^{10}}{49}$, expression (16) becomes

$$m = \frac{2B}{\frac{2B}{\mu} + e^2\left(\frac{1}{\alpha^2}+\frac{2r}{\alpha}\right)} = \frac{\mu}{1+0{\cdot}49\,\mu e^2}$$

where as before μ is the magnification with indefinitely weak signals. Therefore

$$me = \frac{\mu e}{1+0{\cdot}49\,\mu e^2}.$$

The formula reached at the top of page 328, from which Table 3 was calculated, is

$$me = \frac{\mu e}{1+0{\cdot}42\,\mu e^2}.$$

Hence Table 3 stands almost unchanged, the slight error there is being in the direction to disfavour the limiting effect.

Mr. Ehrenborg's analysis leads him to an unsymmetrical arrangement in which $r_1 \neq r_2$. Whether this is a useful arrangement can only be seen by carrying the calculation a little further than he has gone. He shows that in his arrangement $m < \mu$ whatever the sign of e (as is the case, of course, in my symmetrical arrangement); but for the limiter effect the more stringent condition must be satisfied that me reaches a maximum as e increases.

L. B. TURNER.

King's College, Cambridge,
April 23rd, 1920.

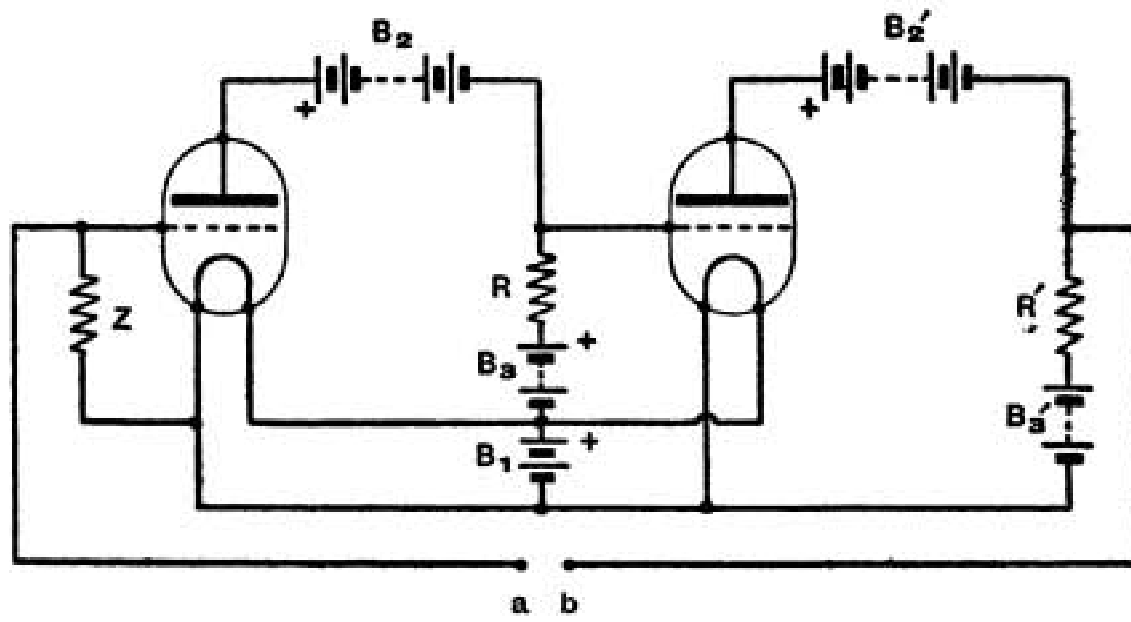
TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—Referring to the last paper of Mr. L. B. Turner in your issue of April, 1920, I beg to call the attention of your readers to my French patents No. 491186 (1915), and No. 501472 (1918).

In the last patent I describe an aperiodic resistance amplifier built with an even number of valves (two) and acting as a negative resistance, or more generally as a negative impedance of any desired nature, according to the accompanying diagram.

The plate batteries may be divided into two parts, one of which B_3 or B_3'

counterbalances the ohmic drop of the mean plate current in resistance R or R′. The nature and the value of the auxiliary impedance Z determine



the nature and the value of the negative impedance appearing between terminals a b.

I have been the first to introduce the idea of negative resistance in the conception of certain amplifier connections,—see also my earlier patents with Weintraub (1907).

MARIUS LATOUR.

Paris,
April 19th, 1920.

TRIODE NOMENCLATURE AND SYMBOLS.

TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—With reference to the letter of Captain Turner in the March issue of the RADIO REVIEW relative to Triode Nomenclature and Symbols, may I suggest that the letter g be associated preferably with the conception of electrical conductance where the voltage and current refer to the same circuit? From this standpoint I am fully in accord with the suggestion of Captain Turner relative to his symbols g_g and g_a.

The notable suggestion of Mr. Appleton, relative to the function $\partial i_a/\partial v_g$ being called mutual conductance, is, I feel, a very beneficial one, but I would suggest similarly that the function $\partial i_g/\partial v_a$ be likewise distinguished as the *conjugate mutual conductance*. Such designation was employed in my paper on Triode Constants in the *Electrician* of January 9th, 1920. It would be in keeping with the above if such mutual conductances were distinguished by the character m rather than the character a as referred to by Captain Turner. Thus, I would write the mutual conductance of Mr. Appleton as m_a and the conjugate mutual conductance $\partial i_g/\partial v_a$ as m_g. The time has come when some more or less common system of nomenclature is essential to the art.

A. PRESS.

East Pittsburg, Pa.,
April 12th, 1920.