THE
RADIO REVIEW

A MONTHLY RECORD OF SCIENTIFIC PROGRESS IN RADIOTELEGRAPHY AND TELEPHONY

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CONTENTS.

Two Shillings and Sixpence Net

The Calculation of Loads in Guy Ropes for Masts or Towers.*

By C. T. G-HOOPER, A.M.I.Mech.E.

IN selecting a suitable guy rope for staying any structure such as a tower or mast, experience is a very valuable guide ; but occasions may arise in which either conditions are so altered as to render past experience of doubtful value, or, the cost of the ropes being a considerable item, it may be desired to design them as economically as possible, that is, to supply ropes of no larger diameter than is consistent with the greatest loads they are likely to incur under working conditions.

For instance, the guy ropes staying the masts which support the aerial wire of a wireless telegraph station frequently have their continuity broken by means of insulators in order to lessen the risk of leakage to earth of the high-frequency current in the aerial. These insulators are necessarily of porcelain or other material of low tensile strength and consequently it is important that the load they will be called upon to bear should be known within fairly close limits.

The following are some simple rules, deduced from first principles, for ascertaining the tension likely to occur in any rope used for staying towers or masts. Six general cases have been taken, but the principles may be applied to almost any system of rope support.

The cases considered are :—

    1. Mast stayed by ropes attached to top.
    2. Mast stayed by ropes attached to intermediate point.
    3. Mast stayed at two points, one being the top.

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* Paper received June, 1919.

4. Mast stayed at two points, neither being at the top.
5. Mast stayed at more than two points.
6. When guy ropes are duplicated and form an angle with each other.

In the first five cases it has been assumed that the heaviest load is taken by a rope (or ropes in cases 3, 4 and 5) when its vertical plane is the plane of the wind pressure acting, and that no support is given by the other ropes, they being assumed to be redundant for the time being.

The general assumption has also been made that the lower end of the tower or mast is fixed or *encastré* and that deflection is completely restrained there. In dealing with masts this is a condition which holds in practice, and it is therefore considered that the above assumption is justified and that it will introduce no appreciable error into the calculations.

The nomenclature adopted is as follows :—

A = Length of rope in plan in feet.
C = Constant for wind pressure = p lbs. per sq. foot.
d = Mean outside diameter of mast in feet.
H = Height of mast in feet.
L = Length of rope.
θ = Angle between rope and vertical.
T = Tension in rope in lbs.
W = Total load on mast due to wind = CdH lbs.
ω = Load per foot run due to wind = Cd lbs.

Other symbols as given in the text.

The results arrived at will hold good only for structures of circular cross-section which present an unbroken surface to the wind. The tensions induced in the guy ropes of a lattice tower or mast cannot be calculated directly from the formulæ given, as the wind loads, theoretically at least, will be less than those imposed on a plated or solid structure of the same dimensions. It is, however, a simple matter to apply the same method of calculation to all similar erections of whatever cross-section provided that the terms W and d are correctly dealt with.

CASE I.—MAST STAYED BY ROPES ATTACHED TO TOP.

(Fig. 1.)

A mast is rarely guyed by means of ropes attached to its extreme end, but occasionally it has to be done in order that the

ropes may avoid obstructions such as buildings, etc., and as it presents the simplest case it will be considered first.
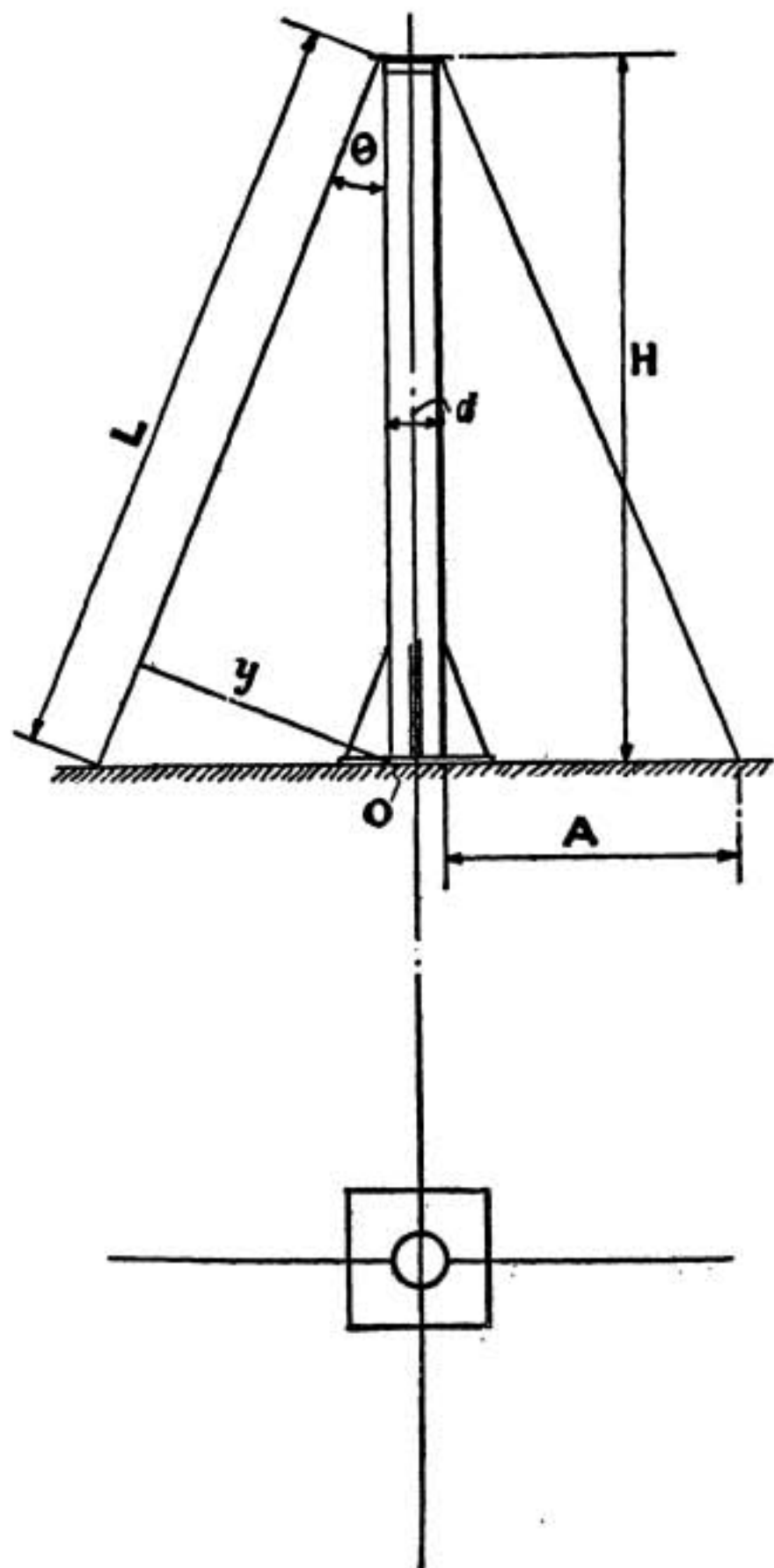
A mast supported as shown in Fig. 1 is under the same conditions as a cantilever with a uniformly distributed load and propped at its free end. It can be easily proved by equating the deflection at the end of a cantilever, due to a uniformly distributed load, to that due to a concentrated load at the same point, that the single force required to resist the deflection of the uniformly loaded cantilever is $\frac{3}{8}W$, where W is the total superimposed load. That is to say, the reaction at the propped end is $\frac{3W}{8}$ and consequently the reaction at the built-in end will be $\frac{5W}{8}$. In our case $W = CdH$, and at the built-in end there is also a fixing moment $= \frac{CdH^2}{8}$, and if we take moments about O, we get

FIG. 1.

$$T \cdot y = \frac{CdH^2}{2} - \frac{CdH^2}{8} = \frac{3CdH^2}{8}$$

o 2

$$\therefore T = \frac{3CdH^2}{8y} \quad \text{but } y = A\cos\theta = \frac{AH}{L}$$

$$\therefore T = \frac{3CdHL}{8A} \quad \text{and as } L = \sqrt{H^2 + A^2}$$

$$T = \frac{3CdH\sqrt{H^2 + A^2}}{8A} \qquad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad (1)$$

When T has been multiplied by a factor of safety a suitable rope can be selected.

CASE 2.—MAST STAYED BY ROPES ATTACHED TO INTERMEDIATE POINT. (Fig. 2.)

Next considering a mast having a considerable portion of its length above the points to which the ropes are attached, such as
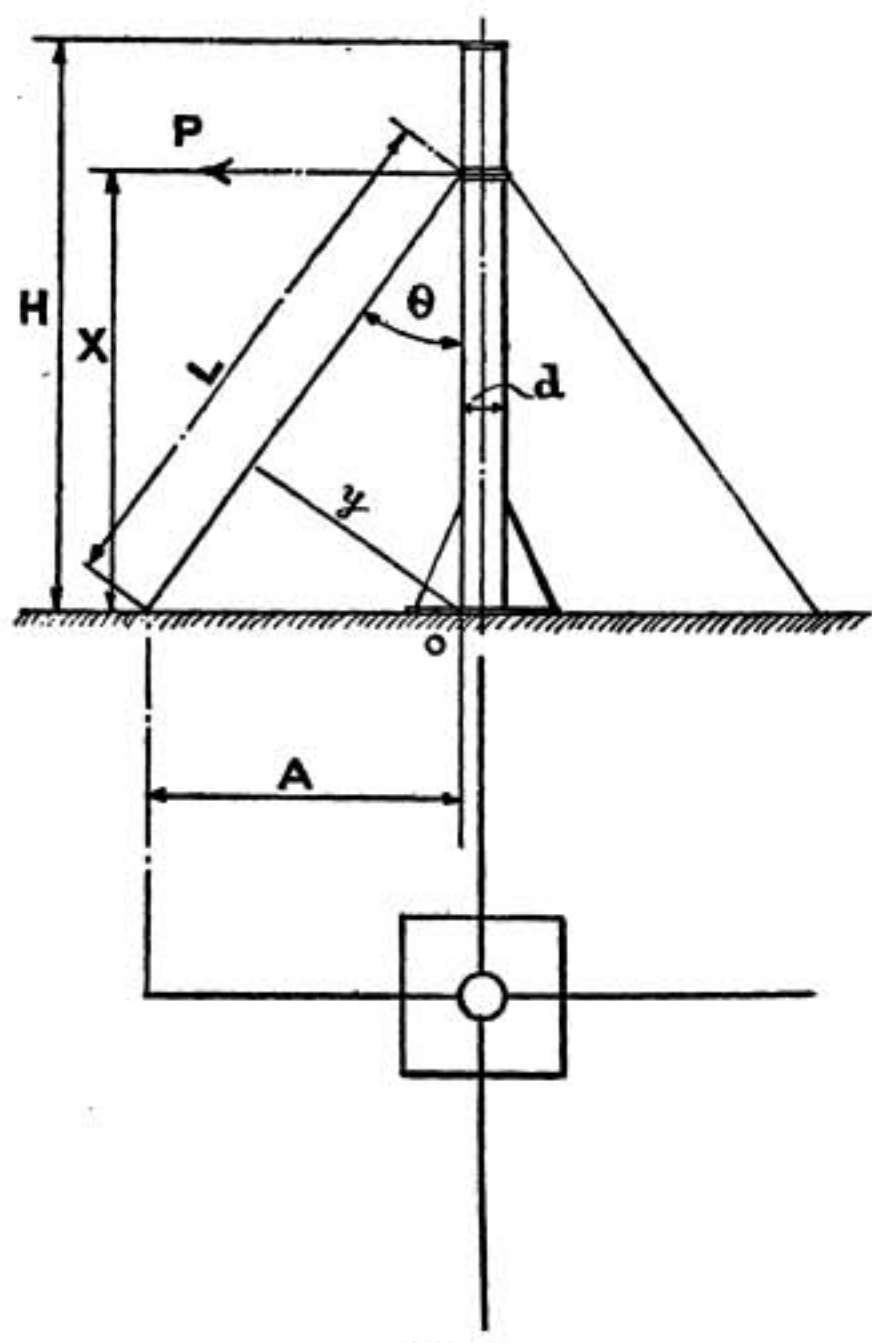

FIG. 2.

TABLE I.

k	K	$P = KW$	P by moments.
1·0	0·375	0·375 W	0·500 W
0·9	0·445	0·445 W	0·555 W
0·8	0·537	0·537 W	0·625 W
0·7	0·659	0·659 W	0·714 W
0·6	0·825	0·825 W	0·833 W
0·5	1·062	1·062 W	1·000 W

that shown in Fig. 2. It will be seen that this is an example of a uniformly loaded cantilever propped at some point other than its free end.

If X the height of the point of attachment be expressed as a function of H, the total height, say as kH, then the value of the horizontal reaction P (which is the horizontal component of the tension T in the rope) may be calculated from the equation

$$\frac{Pk^3H^3}{3EI} = \frac{WH^3k^2}{24EI}(6 - 4k + k^2)$$

(where E and I have their usual meaning in deflection formulæ), the left-hand side of the equation being the expression for the deflection of the mast at the point of attachment of the ropes under the concentrated load P, and the right-hand side representing the deflection at the same point due to the uniformly distributed load $\frac{W}{H}$ lbs. per foot run.

By cancelling we get

$$P = \frac{W}{8k}(6 - 4k + k^2) \text{ and making } \frac{6 - 4k + k^2}{8k} = K$$

$$P = WK = KCdH$$

In Table I., K has been calculated for all integer values of k between 0·5 and 1·0, and intermediate values may be estimated by taking the mean of the two nearest readings of k.

In order, therefore, to find the horizontal force P for any length of mast or tower stayed in the manner shown it is only necessary to obtain the ratio $k = \frac{X}{H}$ and against this ratio (expressed as a decimal) will be found the corresponding value of P in terms of W.

P must now be resolved in the direction of the rope, and from the triangle of forces,

$$T = \frac{P}{\sin\theta} = \frac{KW}{\sin\theta} = \frac{KCdH}{\sin\theta}$$

But $\sin\theta = \dfrac{A}{L}$

$$\therefore\ T = \frac{KC\partial HL}{A} = \frac{KC\partial H\sqrt{X^2 + A^2}}{A} \quad . \quad . \quad . \quad . \quad (2)$$

If the mast had been considered as a beam uniformly loaded and simply supported at its base and at the point of attachment of the ropes, and the force P calculated by taking moments, the results would have been as shown in the column marked "P by moments" in Table I. and it will be observed that as the ratio $\dfrac{X}{H}$ decreases the values obtained thus and those calculated by the deflection formula more nearly agree.

Therefore for values of k between, say, $0\cdot7$ and $0\cdot5$, P could be calculated quite accurately enough by ignoring the " built-in " effect at the mast base, and taking moments, thus :—

$$P = \frac{WH}{2X} = \frac{C\partial H^2}{2X}, \text{ and}$$

$$T = \frac{C\partial H^2}{2X\sin\theta} = \frac{C\partial H^2 L}{2AX} = \frac{C\partial H^2\sqrt{X^2 + A^2}}{2AX} \quad . \quad . \quad . \quad (2a)$$

The expression for the tension T given above in (2) could also have been arrived at by the method adopted in the previous case, by taking moments about the point O, thus if $T \cdot y$ is the moment of the tension about that point, and as the fixing moment at the

$$\text{base} = \frac{C\partial H^2}{2} - KC\partial H \cdot X = C\partial H\left(\frac{H}{2} - KX\right),$$

then $\quad T \cdot y = \dfrac{C\partial H^2}{2} - C\partial H\left(\dfrac{H}{2} - KX\right)$

$$= C\partial HKX \text{ and as } y = A\cos\theta = \frac{AX}{L}$$

$$T = \frac{KC\partial HL}{A} = \text{ the expression arrived at in (2).}$$

CASE 3.—MAST STAYED AT TWO POINTS, ONE BEING AT
THE TOP. (Fig. 3.)

If we next take the case of a mast stayed at two different points on its length as in Fig. 3, the method of treatment will depend on the relative positions in plan of ropes such as a and b.

For instance, if there be some angle between a and b as in Fig. 3 (ii.) it may be assumed that if the wind pressure acts in the plane of the rope a no assistance will be given by b and *vice versâ*. Therefore the loads in these ropes can be estimated by means of the two previous formulæ—viz. :—a by means of formula (1) and b by formula (2). This is, of course not strictly correct, but will give results on the safe side.
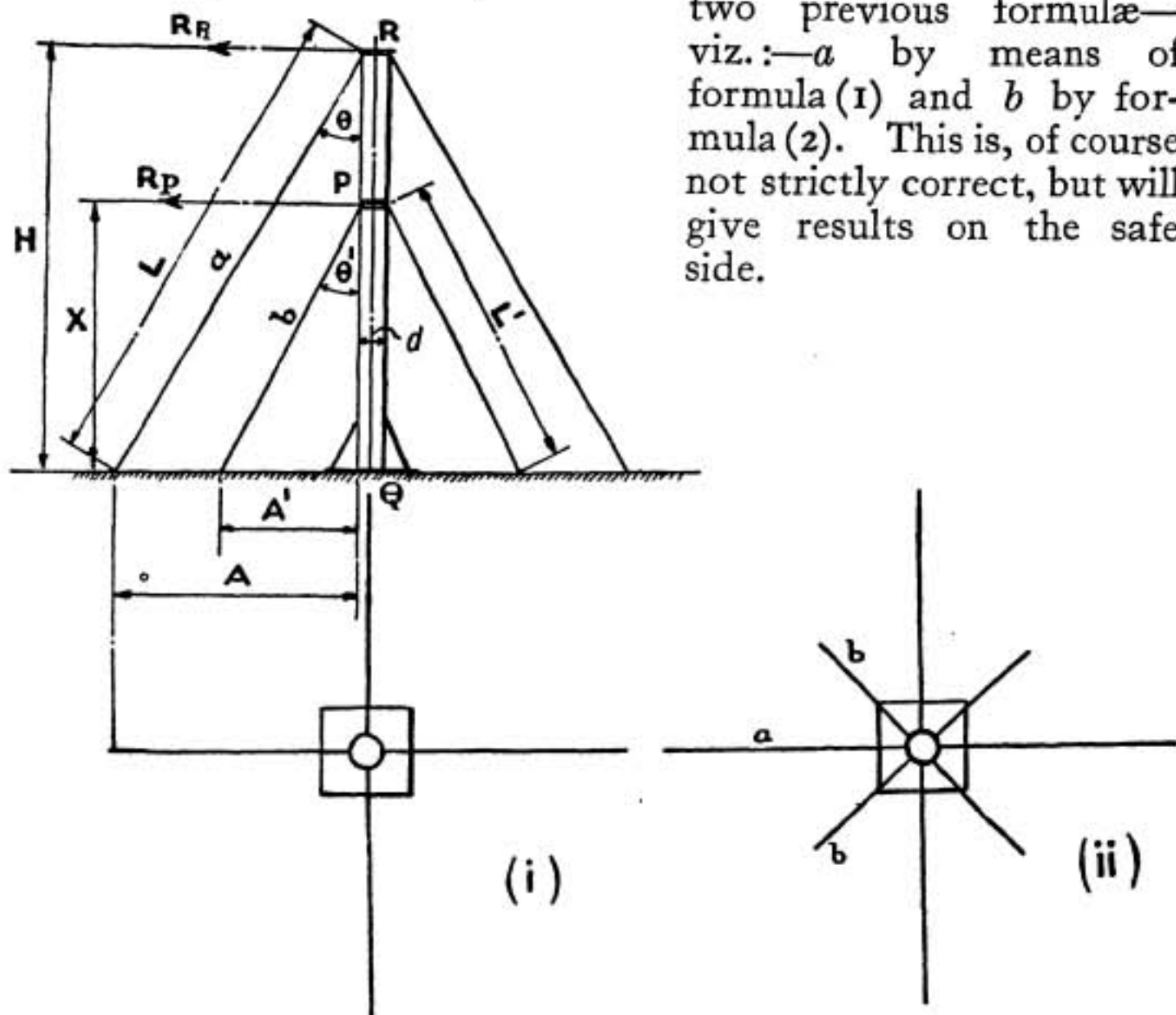

Fig. 3.

If, however, these two ropes are in the same vertical plane as in Fig. 3 (i.), it is obvious that deflection will be restrained at two points, by the tension T_A in the rope a of which R_R is the horizontal component, and the tension T_B in b of which R_P is the horizontal component. But it should be understood that unless the ropes a and b are both perfectly taut it will not be possible to estimate the reactions R_R and R_P accurately—so unless some means of tensioning these ropes be provided, such as rigging screws, it would be safer to design them with the two preceding formulæ (1) and (2), that is to say by ignoring the help given by a to b and *vice versâ*.

Assuming, however, that means are provided for giving some slight initial tension to the ropes, the mast would then be under the same conditions as a continuous beam carrying a uniformly distributed load, having one end built in and two further supports, one being at the free end. There are three reactions to be determined, R_Q, R_P, R_R, and if

TABLE II.

k	K	K'	$R_P = KW$	$R_R = K'W$
0·95	1·898	− 1·381	1·898 W	− 1·381 W
0·9	1·075	− 0·539	1·075 W	− 0·539 W
0·8	0·683	− 0·105	0·683 W	− 0·105 W
0·7	0·577	+ 0·05	0·577 W	+ 0·050 W
0·6	0·551	+ 0·137	0·551 W	+ 0·137 W
0·5	0·571	+ 0·196	0·571 W	+ 0·196 W

M_Q = the bending moment at Q

M_P = the bending moment at P

M_R = the bending moment at R = 0.

The values of the reactions can be calculated from the general equation of the Theorem of Three Moments, namely *

$$M_Q X + 2M_P H + M_R(H - X) = \frac{W}{4H}\left\{X^3 + (H - X)^3\right\}$$

and, as one end is built in, we have the additional equation

$$2M_Q = \frac{WX^2}{4H} - M_P$$

If, as in the last case, we express X as a function of H, say kH, by substituting this in the above equations we arrive at the following general expressions, for the bending moments and reactions at the points of support, viz. :—

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* This equation has been altered to suit the nomenclature used, and is more usually expressed as

$$M_A l_1 + 2M_B(l_1 + l_2) + M_C l_2 - \tfrac{1}{4}(\omega_1 l_1^3 + \omega_2 l_2^3) = 0, \text{ and in the above case :}$$

$$M_A = M_Q$$
$$M_B = M_P$$
$$M_C = M_R$$
$$l_1 = X$$
$$l_2 = H - X$$
$$\omega_1 \text{ and } \omega_2 = \omega = \frac{W}{H}$$

$$M_Q = \frac{WH}{4}\left(\frac{3k - k^2 - 1}{4 - k}\right)$$

$$M_P = \frac{WH}{4}\left(\frac{2 - 6k + 6k^2 - k^3}{4 - k}\right)$$

$$R_Q = \frac{W}{4}\left(\frac{k^2 - k^3 + 9k - 3}{4k - k^2}\right)$$

$$R_P = \frac{W}{4}\left(\frac{3 - 2k}{4k - 5k^2 + k^3}\right) = WK = CdHK \text{ where } K = \frac{3 - 2k}{16k - 20k^2 + 4k^3}$$

$$R_R = \frac{W}{4}\left(\frac{6 - 12k + 6k^2 - k^3}{4 - 5k + k^2}\right) = WK' = CdHK'$$

$$\text{where } K' = \frac{6 - 12k + 6k^2 - k^3}{16 - 20k + 4k^2}.$$

The two last reactions R_P and R_R are those with which we are chiefly concerned, and they have been calculated for values of k from 0·5 to 0·95 (see Table II.). It will be observed that between the points $k = 0·7$ and $k = 0·8$ the sign of the reaction R_R changes, that is to say, there is an intermediate point at which $R_R = 0$, and by equating the above expression for this reaction to zero this value of k will be found to be 0·74. Thus, when the value of $k\left(= \text{ratio } \frac{X}{H}\right)$ is between 0·5 and 0·74 the reactions at P and R will act in the same direction; but if k be greater than 0·74 these reactions will be in opposite directions.

If T_A and T_B are the tensions in ropes a and b respectively, then

$$T_A = \frac{R_R}{\sin \theta} = \frac{R_R L}{A} = \frac{K'CdHL}{A} = \frac{K'CdH\sqrt{H^2 + A^2}}{A} \quad . \quad . \quad (3)$$

$$T_B = \frac{R_P}{\sin \theta'} = \frac{R_P L'}{A'} = \frac{KCdH\sqrt{X^2 + A'^2}}{A'} \quad . \quad . \quad . \quad . \quad (3a)$$

Where θ', L', and A' have the meanings assigned in Fig. 3.

Case 4.—Mast stayed at two Points, neither being the Top. (Fig. 4.)

If, in the previous case, the rope a had been attached to a point some distance below the top of the mast, it would have presented a common example of the arrangement of guy ropes. As in the previous case, regarding the mast as a beam with one end built in and two further supports P and R, the reactions at these supports
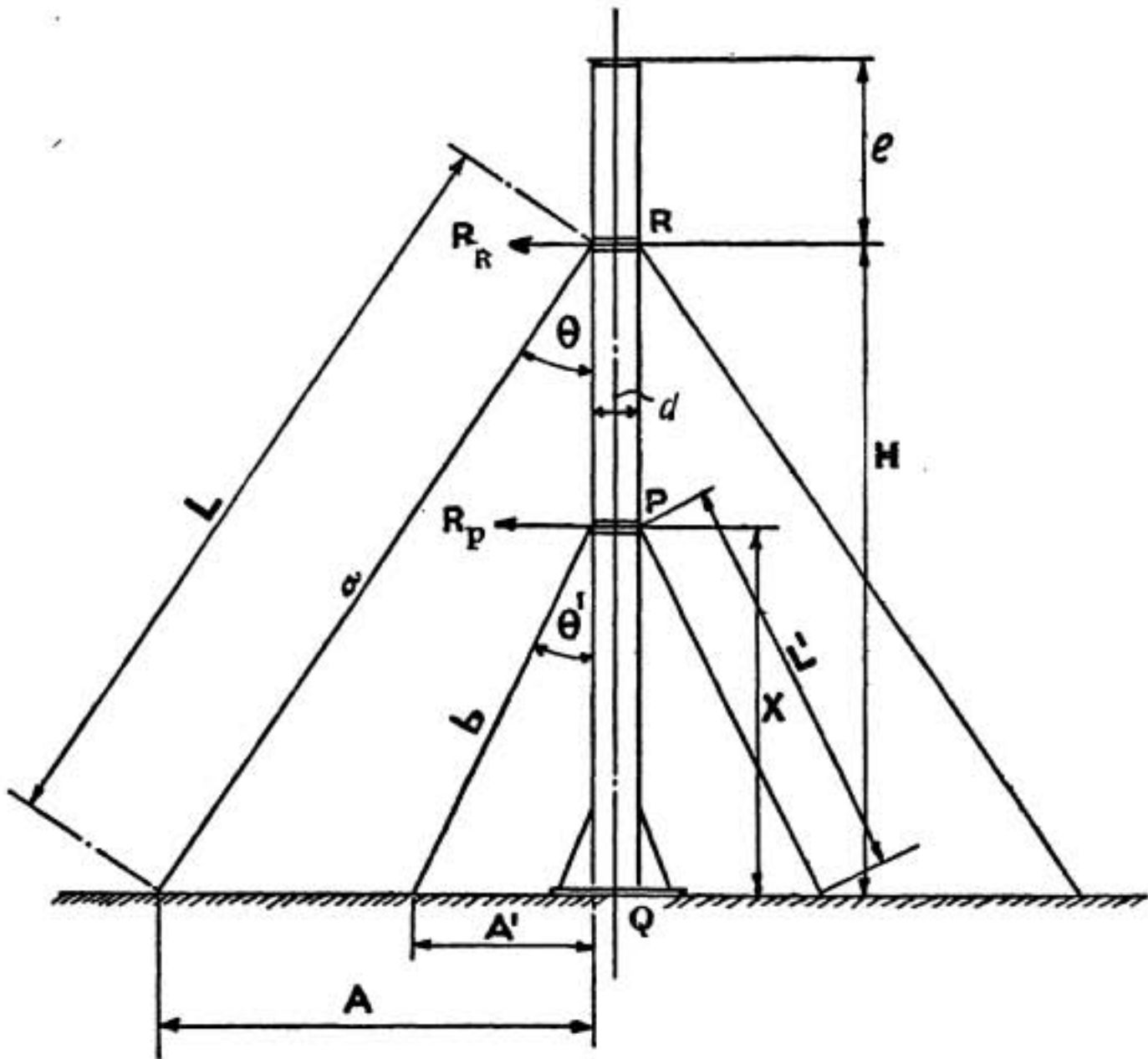
FIG. 4.

can be calculated as before from the equation of the Theorem of Three Moments :—

$$M_Q X + 2M_P H + M_R (H - X) = \frac{\omega}{4} \left\{ X^3 + (H - X)^3 \right\}$$ and the

equations due to the particular end conditions, viz. :—

$$2M_Q = \frac{\omega X^2}{4} - M_P \text{ for the end } encastré, \text{ and}$$

$$M_R = \frac{\omega e^2}{2} \text{ for the overhanging end.}$$

The prefix "M" denoting "bending moment at" and "R" denoting "reaction at" as before.

The bending moment M_P at the point P can be expressed generally :—

$$M_P = \frac{\omega}{16 - 4X}(2H^3 - 6H^2X - 6HX - X^3 - 4e^2H + 4e^2X)$$

and the remaining bending moments and reactions can be expressed in terms of M_P thus :—

$$M_Q = \frac{\omega X^2}{8} - \frac{M_P}{2}$$

$$R_Q = \frac{5\omega X}{8} - \frac{3M_P}{2}$$

$$R_P = \frac{\omega X(X^2 - 4e^2 - 5XH + 4H^2) - 4M_P(X - 3H)}{8X(H - X)}$$

$$R_R = \frac{\frac{\omega}{2}(H - X + e)^2 - M_P}{H - X} \text{ or } \omega(H + e) - R_Q - R_P.$$

These expressions for R_Q, R_P and R_R have been obtained by taking moments about the points P, R and the free end respectively, the corresponding equations being,

$$-R_QX + \frac{\omega X^2}{2} + M_Q = M_P$$

$$-R_P(H - X) - R_QH + \frac{\omega H^2}{2} + M_Q = M_R$$

$$-R_R \cdot e - R_P(H - X + e) - R_Q(H + e) + \frac{\omega(H + e)^2}{2} + M_Q = 0.$$

R_P and R_R are the reactions we require, and having obtained them the tensions in the ropes a and b will be given by

$$T_A = \frac{R_R}{\sin \theta} = \frac{R_RL}{A} = \frac{R_R\sqrt{H^2 + A^2}}{A} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

$$T_B = \frac{R_P}{\sin \theta'} = \frac{R_PL'}{A'} = \frac{R_P\sqrt{X^2 + A'^2}}{A'} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4a)$$

CASE 5.—MAST STAYED AT MORE THAN TWO POINTS.

A mast stayed at any number of places on its length can be dealt with by the method adopted in the last two cases, that is, by the Theorem of Three Moments. It is simply the case of finding the reactions at the points of attachment of the ropes. Having obtained these, they are then resolved in the direction of the rope, as in all the previous examples.

CASE 6.—WHEN GUY ROPES ARE DUPLICATED AND FORM AN ANGLE WITH EACH OTHER. (Fig. 5.)

All the previous cases considered have been those in which a single rope has been considered as supplying the reaction at the point of attachment to the mast.   In practice, however, two ropes are sometimes used, both being fixed to a common point on the mast, as shown in Fig. 5.

If at this point, R is the reaction as calculated by means of any of the formulæ given in the text for P, R_P, or R_R, the tension in each of the two ropes will be given by

$$T = \frac{R\sqrt{X^2 + A^2 + f^2}}{2A}$$

where f has the meaning given in Fig. 5.

This formula is obtained by resolving the reaction R in the two directions, and it may be noted that the factor $\sqrt{X^2 + A^2 + f^2}$ is the true length of the rope.
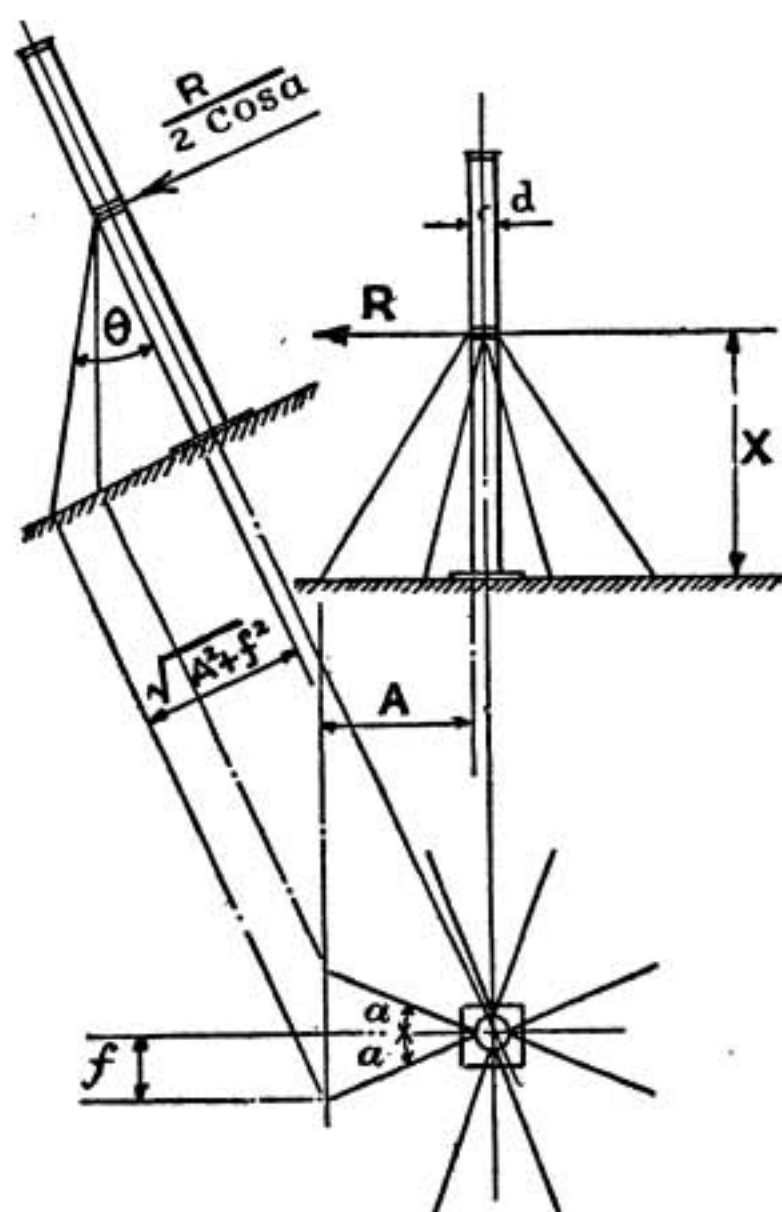
In calculating the tension by any of the preceding formulæ it should be remembered that the result will only be correct when the whole length of the mast is exposed to the wind, and when the point of attachment of the ropes to the ground is in the same horizontal plane as the base of the mast.

Should the latter be resting on a foundation Z feet high, above the horizontal level at which the guy ropes are anchored, as in Fig. 6a ; or if the point of anchorage be Z feet below the level of the mast base as in Fig. 6b, it will be necessary to substitute—

FIG. 5.

$$\frac{AH}{H+Z} \text{ for } A \text{ in the formulæ (1), (3) and (4).}$$

$$\frac{AX}{X+Z} \text{ for } A \text{ in the formulæ (2) and (2a), and}$$

$$\frac{A'X}{X+Z} \text{ for } A' \text{ in the formulæ (3a) and (4a).}$$
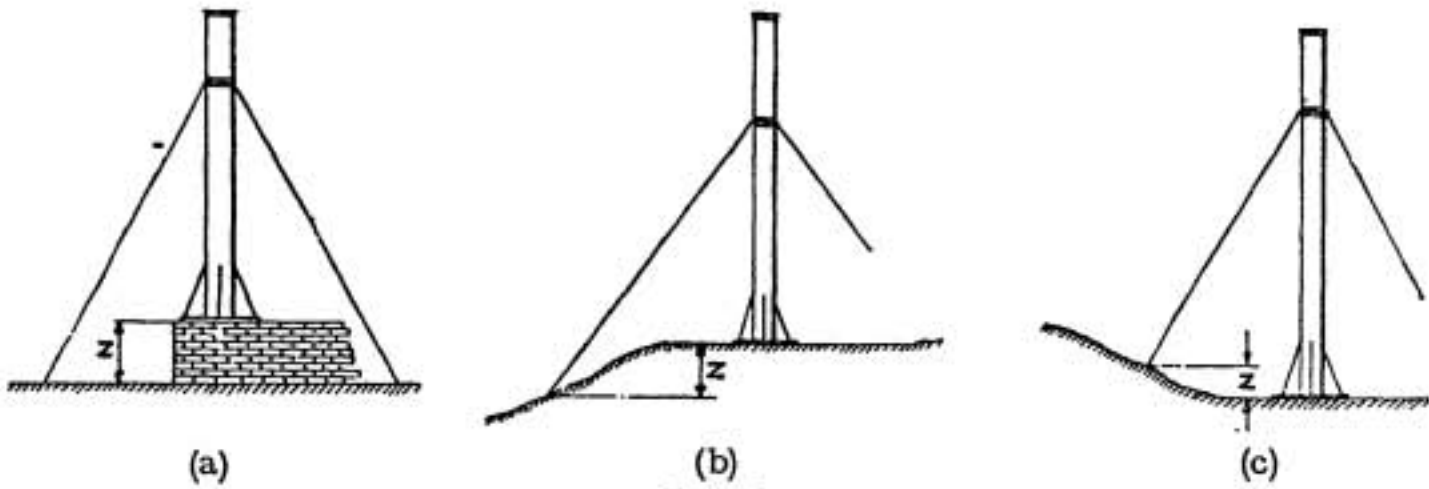

(a)   (b)   (c)

Fig. 6.

If, on the other hand, the point of anchorage is Z feet above the base of the mast, as in Fig. 6c, the expressions $\dfrac{AH}{H-Z}$, $\dfrac{AX}{X-Z}$ and $\dfrac{A'X}{X-Z}$ must be used in place of A and A' in the respective formulæ.
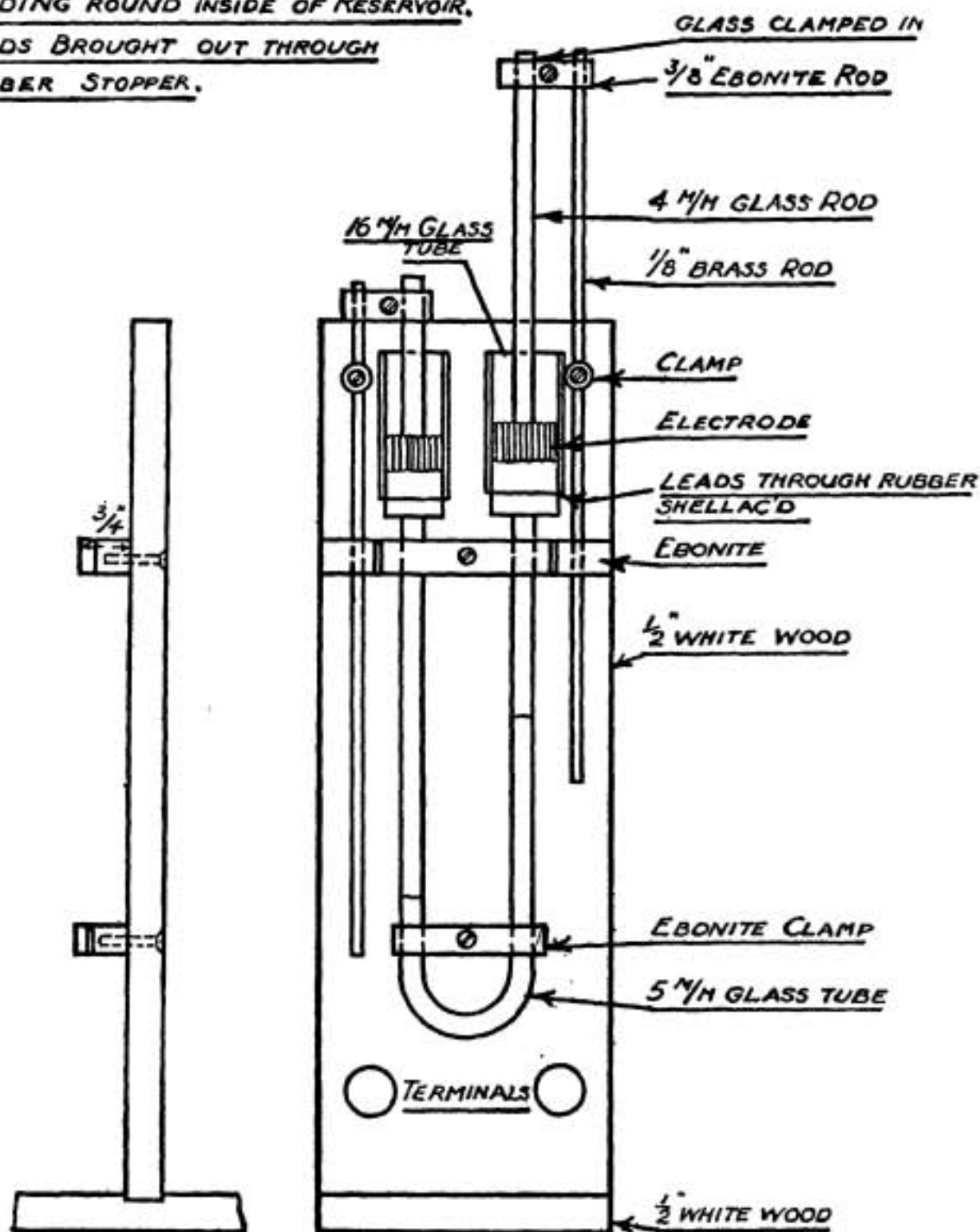
A Variable Liquid Resistance.
By F. W. JORDAN, B.Sc.

IN many experiments in electrical laboratories a smoothly variable resistance of fairly large value is frequently required. Such resistances are becoming very desirable in high-frequency work, especially in connection with cascade amplifiers.

The accompanying diagram describes very fully the construction of a variable resistance which has proved very useful in certain researches with triode valves. It consists of a glass U-tube with large open ends which act as reservoirs, solid glass rods sliding in the limbs of the U, and two electrodes. Each of the electrodes is formed by winding bare copper wire into an annulus which fits inside one of the large open ends of the U. The electrodes are fixed in position, and when in use the glass tube is filled with dilute copper sulphate solution.

The resistance between the electrodes is varied by sliding more or less of the vertical solid glass rods into the tube. The glass rods are held in position by clamping the brass rods which support them. This construction has the advantage of fixed electrodes, free from soldered joints.

ELECTRODE MADE BY WINDING COPPER WIRE OVER COPPER STRIP & BENDING ROUND INSIDE OF RESERVOIR. LEADS BROUGHT OUT THROUGH RUBBER STOPPER.

GLASS CLAMPED IN

3/8" EBONITE ROD

4 M/M GLASS ROD

1/8" BRASS ROD

16 M/M GLASS TUBE

CLAMP

ELECTRODE

LEADS THROUGH RUBBER SHELLAC'D

EBONITE

3/4"

1/2" WHITE WOOD

EBONITE CLAMP

5 M/M GLASS TUBE

TERMINALS

1/2" WHITE WOOD

0 1 2 3 4 5 6 7 8 9 10 11 12

INCHES

The Relative Advantages of Elevated Antennæ, Loop Aerials, and Underground Wires for the Reception of Radio-Signals.

By THE EDITOR.

ONE of the results of the development of the thermionic amplifier has been the greatly increased employment of relatively small loops as receiving aerials. This is a return to the earliest method on record for detecting electromagnetic waves, since Hertz used a loop receiving aerial in his classic experiments. The detectors now in use, however, are of a sensitiveness undreamt of even ten years ago. There are at the present time three types of aerials in use, viz., the elevated antenna, the closed loop, and the horizontal underground wire, and a number of papers have been published during the last few months dealing with various aspects of the relative advantages of these various methods of detecting radio-signals. Apart from mechanical, financial, or military considerations the discussion must centre round two points, firstly, their sensitiveness and secondly their freedom from atmospheric disturbance. To any one acquainted with the delay and inconvenience caused at present in long distance transmission by " atmospherics " it will not be surprising if more stress is laid on the latter consideration. If an aerial can be employed of a type which discriminates to an increased degree between the desired signal and the atmospheric disturbance, one is prepared to sacrifice much in sensitiveness, since, if necessary, the signal can be amplified up to the requisite strength. In many cases the signal is quite audible but unreadable because of " atmospherics." Both underground wires and loops appear to be superior to the elevated antenna in this discriminating property. This is due to a large extent to the directiveness of the former, since they do not pick up atmospherics at their full intensity unless these come in the same direction as the signal. There seems to be no doubt, however, that the discrimination goes further than this and that both the loop and the underground wire

give a larger ratio of signal to static—to use the American phrase
—than does the elevated antenna, even when the signal and static
come from the same point of the compass.

The electromagnetic waves emanating from a transmitting
station and travelling over the earth's surface are associated with
radial alternating currents in the upper layers of the earth's crust,
which are poor conductors especially the surface layer. If a long
copper cable be buried in a direction radial to the transmitting
station, this alternating current will flow through it in preference
to the surrounding soil, especially if several cables are arranged
T-shape or fan-shape, coming together at the receiving station
and then spreading out again. In this way the current which
would otherwise flow over a considerable area is concentrated on
the receiver. The cables should preferably be buried below the
very dry upper layer, the better to collect the current. If well
insulated cables are used, the system can be sharply tuned ; there
is then no conducting connection between the copper core and the
earth, but the insulation of the cable acts as the dielectric of a
condenser. The velocity of an electromagnetic wave along such a
cable is less than the velocity through space in the ratio of the square
root of the specific inductive capacity of the dielectric. Its wave-
length for a given frequency will be correspondingly reduced. If
the total length of the cable is a half the wavelength or one and a
half wavelengths, it will be in resonance to the received wave with
a current maximum at the centre. Many interesting experiments
with buried insulated wires are described by A. H. Taylor in
the August number of the *Proceedings of the Institute of
Radio Engineers*,* and striking examples given of the reception of
distant stations when " atmospherics " made this impossible on
ordinary antennæ. There is, however, room for much further
research along the lines indicated above.

If it be granted that atmospheric disturbances are propagated
by electromagnetic waves of the same general character as the
signal waves, they also will be associated with earth currents and
if the direction of propagation is the same, any discrimination on
the part of the underground receiving system must be due to the
different characteristics of the two waves as regards frequency and
decrement. Any difference between the underground wires and
an antenna in their discriminating power must be due, however,

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* RADIO REVIEW, Abstract No. 149.

to their different characteristics when regarded as oscillatory circuits.   The same is true with respect to coil or loop aerials.

Two papers of interest have recently been published dealing with the loop aerial, one by Max Abraham of the Telefunken Company (until recently Professor at Strassburg) treating the problem from a purely academic point of view, and the other by Captain Blatterman of the U.S. Signal Corps of a more practical nature.   It was known that the maximum amount of energy that a given type of antenna can abstract from an electromagnetic wave and deliver to the detector is theoretically independent of its height and is dependent only on the amplitude of the wave and on the wavelength. The condition to be fulfilled to obtain this maximum is that, of the three resistances—viz. (1) the radiation resistance, (2) the loss resistance due to wires, earth, imperfect dielectrics, etc., and (3) the useful resistance that is, the detector resistance reduced to its equivalent value in the aerial—the second should be negligible and the third should be equal to the first.   The radiation resistance of an antenna being proportional to the square of the height, it follows that if the detector resistance in a 10-foot antenna is reduced to a hundredth part of that in a 100-foot antenna, and if moreover the loss resistance is reduced in the same proportion, both of these aerials will, if tuned to the same electromagnetic wave, collect from the ether and deliver to the detector the same amount of energy.   Now Abraham shows that a loop is able to supply exactly the same amount of energy to its detector under the same conditions, but that on account of its small radiation resistance, the conditions are practically impossible to attain since it is impossible to reduce the loss resistance in the necessary proportion.   It is useful, however, to bear this fact in mind when designing loops and their detecting arrangements.

To make a circuit respond readily to impulses to which it is tuned, and but slightly to aperiodic or low-frequency impulses it is necessary to reduce the damping of the circuit as much as possible.   Abraham comes to the conclusion that the superiority of the loop is largely due to the fact that its damping ratio $R/2L$ is usually smaller than in an elevated antenna.   A further reason is to be found, however, in the fact that to waves of a greater length than those of the signals or to aperiodic disturbances of small decrement, the phase angle represented by the distance between the two vertical sides of the loop is relatively less and that therefore for a given electromotive force induced in each side, the resultant

electromotive force in the whole coil is smaller. Since atmospheric disturbances always appear to have much longer wavelengths than those employed in telegraphy this may be an important factor in reducing their effect on a loop. The paper by Captain Blatterman records and analyses a great amount of valuable experimental work in comparing the results obtained with loops of various sizes and numbers of turns. Since all loops are equally effective if their resistances are suitably reduced and their detectors properly adjusted, it follows that the choice of a proper design is largely a question of the ratio of the three resistances enumerated above. Blatterman gives much valuable data with respect to the resistances actually found in loops of various designs at different frequencies.

The Design of Multiple-Stage Amplifiers Using Three Electrode Thermionic Valves.

By PROFESSOR C. L. FORTESCUE.

(Abstract of paper read before the Wireless Section of the Institution of Electrical Engineers on Wednesday, November 19th, 1919.)

THE methods given in this paper were developed in the course of working out the design of valve amplifiers for use for naval wireless telegraphy purposes, and permission to publish this paper has been specially given by the Admiralty. The author is indebted to various co-workers for numerous suggestions which led, finally, to the form given. A vast amount of experimental work on the subject was carried out at H.M. Signal School, Portsmouth, by Lieutenant J. K. Catterson-Smith, R.N.V.R., and Lieutenant W. A. Appleton, R.N.V.R. Many suggestions were made at different times by Mr. H. A. Madge and Mr. Gossling of the Signal School, Portsmouth, and by Captain H. J. Round of the Marconi Company.

The paper is divided into four main sections :—

(A) Description.
(B) Reaction Effects and the Tendency for Alternating Currents to be Maintained in the Circuits connected to the Tubes.
(C) Other Limitations to the Effective Amplification.
(D) Theoretical Treatment.

In the first section general descriptions are given of four main arrangements :—

(1) The simple case of a single valve used as a resistance amplifier ;
(2) The use of tuned circuits instead of resistances ;
(3) Selective and non-selective amplifying ; and
(4) Cascade amplifying.

The action of an amplifying system, electrical, mechanical, and otherwise is strongly affected by any transfer of energy back from the output end of the system to the input end, by any form of return coupling.   If this coupling is such that the changes at the input end are accentuated it follows that changes of a given amplitude can be maintained by a smaller power supply. In the extreme case the coupling may be strong enough to do more than maintain the changes at the input end.   The system is then unstable and oscillations are generally set up and maintained.   If the coupling between the ends of the system tends to oppose the changes at the input end the effective amplification is reduced.   The return coupling may be a capacity coupling, a mutual inductance, or a combination of the two or resistance coupling may also be employed in conjunction with either capacity or inductive coupling.   Capacity coupling is always present to some extent. In practice it is desirable to reduce this unavoidable coupling as much as possible.

The tendency towards the generation of oscillations may in practice be controlled by varying the grid voltage of the valves.   By making the grid more positive, the grid damping is increased and the valve becomes more stable.

There are several limitations to the effective amplification of the set. Amongst these may be mentioned :—

(1) External interference of the same nature as the P.D. variation to be amplified.

(2) Minute irregularities in the behaviour of the valves themselves.

(3) Constancy of the batteries used ; bad contacts, etc.

The theoretical treatment of the problem is based on the slopes of the straight parts of the four characteristic curves of the valve, viz :—

$$k_1 = \frac{di}{dv'}; \quad k_2 = \frac{di}{dv}; \quad k_3 = \frac{di'}{dv'}; \quad k_4 = \frac{di'}{dv}.$$
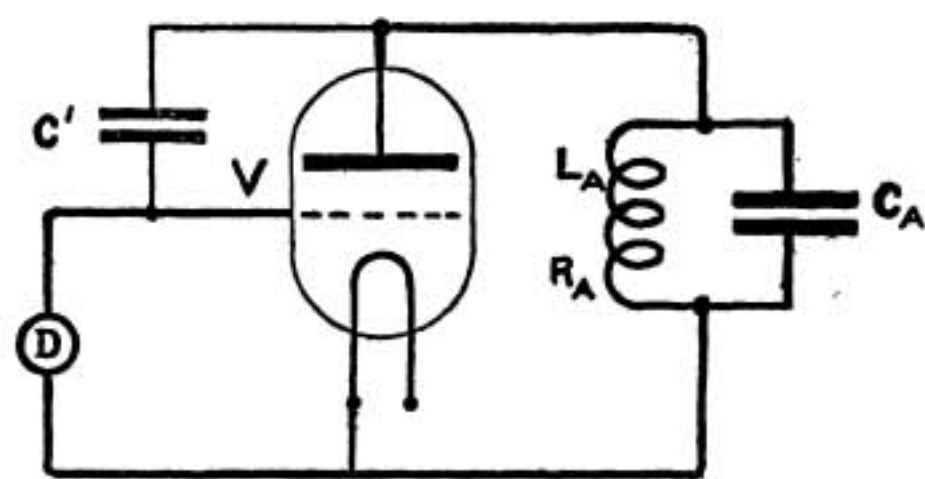

FIG. 1.

where v = anode voltage; v' = grid voltage; i = anode current, and i' = grid current; and the assumption is made that the static characteristic of the valve is followed at high frequencies.

For the complete case for a single valve (see Fig. 1) it is shown that the amplification

$$\frac{\delta v}{\delta v'} = \phi = - \frac{k_1 - j\omega C'}{j\omega(C_A + C') + k_2 + 1/(R_A + j\omega L_A)}$$

where C', C_A, L_A, and R_A have the meanings shown in the Fig.   From

P 2

this equation it is evident that the internal capacity of the valve (indicated by C') affects both the resonant frequency and the sharpness of the resonance. The sharpness of resonance depends also in the relative values of the terms $1/(\omega L_A)$ and $\omega(C_A + C')$ as compared with k_2. If they are small then resonance is not marked. This is the prevailing condition when C_A is the self-capacity only of the winding L_A.

The exact conditions for resonance are given by

$$(C_A + C') = L_A/(R_A{}^2 + \omega^2 L_A{}^2)$$

and under these conditions the maximum voltage step-up is

$$\frac{k_1 - j\omega C'}{k_2 + R_A/(R_A{}^2 + \omega^2 L_A{}^2)}.$$

The effect of the valve capacity is to throw an extra load upon the input circuit—represented by the alternator D in Fig. 1. This leads to additional damping of that circuit, and shows that there will be no tendency to generate oscillations *at the resonant frequency*. At other frequencies this will not necessarily be the case.

When dealing with more than one valve, it is assumed that the valve characteristics are identical and that the circuits are identical, and equations are developed similar to the above for the amplification and for the power taken, drawn from that circuit, for the cases of two and three valves while general equations are also indicated for any number of valves.

Professor G. W. O. HowE opened the discussion, and suggested that the difference between the static and dynamic characteristics mentioned in the paper, might arise through changes in the temperature of the filament brought about by changes in the anode current. When taking the static curve the filament temperature would be able to follow changes in the anode current, but with the valve oscillating it would not be able to do so.

Mr. L. B. TURNER described an arrangement of two valves with resistance coupling only, making use of the retroactive coupling to secure amplification. This arrangement he termed a " Kallirotron." He claimed to have maintained a voltage amplification of 2,000 using only two valves.

Mr. CATTERSON-SMITH described the difference between the amplification obtainable with resistance-coupled amplifiers and that with transformer-coupled ones. With the former the amplification increased steadily with the wavelength, whereas with the latter there was usually a sharp maximum of amplification at some particular wavelength. Transformer coupling was therefore best for short wavelengths. He also described colloidal platinum and carbonised cellulose resistances for use with multi-vale amplifiers.

Captain H. J. ROUND spoke about " valve-noises," and pointed out that they were least troublesome with short wavelengths. He had obtained a voltage magnification of 0.5×10^6 using twenty-two valves in cascade on short wavelengths without trouble from valve noises.

Major ERSKINE MURRAY referred to the difference between the static and dynamic characteristics obtained with power valves as used in the R.A.F.; and Captain SLEE dealt with the noises in amplifiers arising

through bad contacts and irregularities in the H.T. batteries, while Mr. Scott-Taggart and Dr. W. H. Eccles also contributed a few remarks.

Mr. B. S. Gossling quoted some calculations he had made relative to valve noises being due to the deposition of positive ions from the residual gas upon the valve filaments and showed that to coat the filament with a single layer only of ions would require about 100 seconds. This therefore could not be the cause of the noises, although this time agreed closely with the rate of slow variation of anode current noticed when a valve was first switched on to circuit.

Professor Fortescue reserved the bulk of his reply to the discussion for communication to the Institution Journal.

A System for the Reception of Continuous Waves.

By J. SCOTT-TAGGART.

THE arrangement described is of interest largely because it solves in one way the problem of producing a continuous-wave wireless receiving circuit capable of "standby" and "tuned" adjustment combining ease of manipulation and high selectivity. In addition the circuits may be adjusted so as to reduce radiation to a negligible value. The complete arrangement was designed by the author, and used for certain special artillery communications during 1917 and 1918. As evidenced by reports it proved of exceptional value in battle and overcame the difficulty, previously experienced, of interference by neighbouring "spark" stations.

The arrangement may be divided into three essential circuits: (A), (B), and (C). (Fig. 1.) The circuit (B) is of the usual type. An aperiodic retroactor coil L_2 is variably coupled to a variable inductance L_1, for the purpose of causing the circuit (B) to generate oscillations if required. The frequency of these oscillations is determined chiefly by the value of the condenser C_1. The filament of the vacuum tube V_1 is heated by a 6-volt accumulator B_1 through a rheostat R_2 of about 5 ohms resistance. The plate battery B_2' of about 60 volts and the primary T_1 of a step-up transformer $T_1 T_2$ are connected as shown, a fixed condenser C_3 of about 0·0003 mfd. being connected across B_2' and T_1 to by-pass the high-frequency component of the plate current of V_1.

The circuit (A) is exactly the same as (B) except that no aerial or earth connection is made, and the filament of V_2 is heated from the common battery B_1. A double-throw change-over switch S enables the receiver (C) to be connected to either T_4 or T_2. This circuit (C) comprises a "note-magnifier" $V_3 V_4$ and the receiving telephones T.

The circuit (A) is placed near to the circuit (B) and their distance apart should preferably be variable. For eliminating interference (A) may be placed as much as six feet away from (B) although one to two feet is more
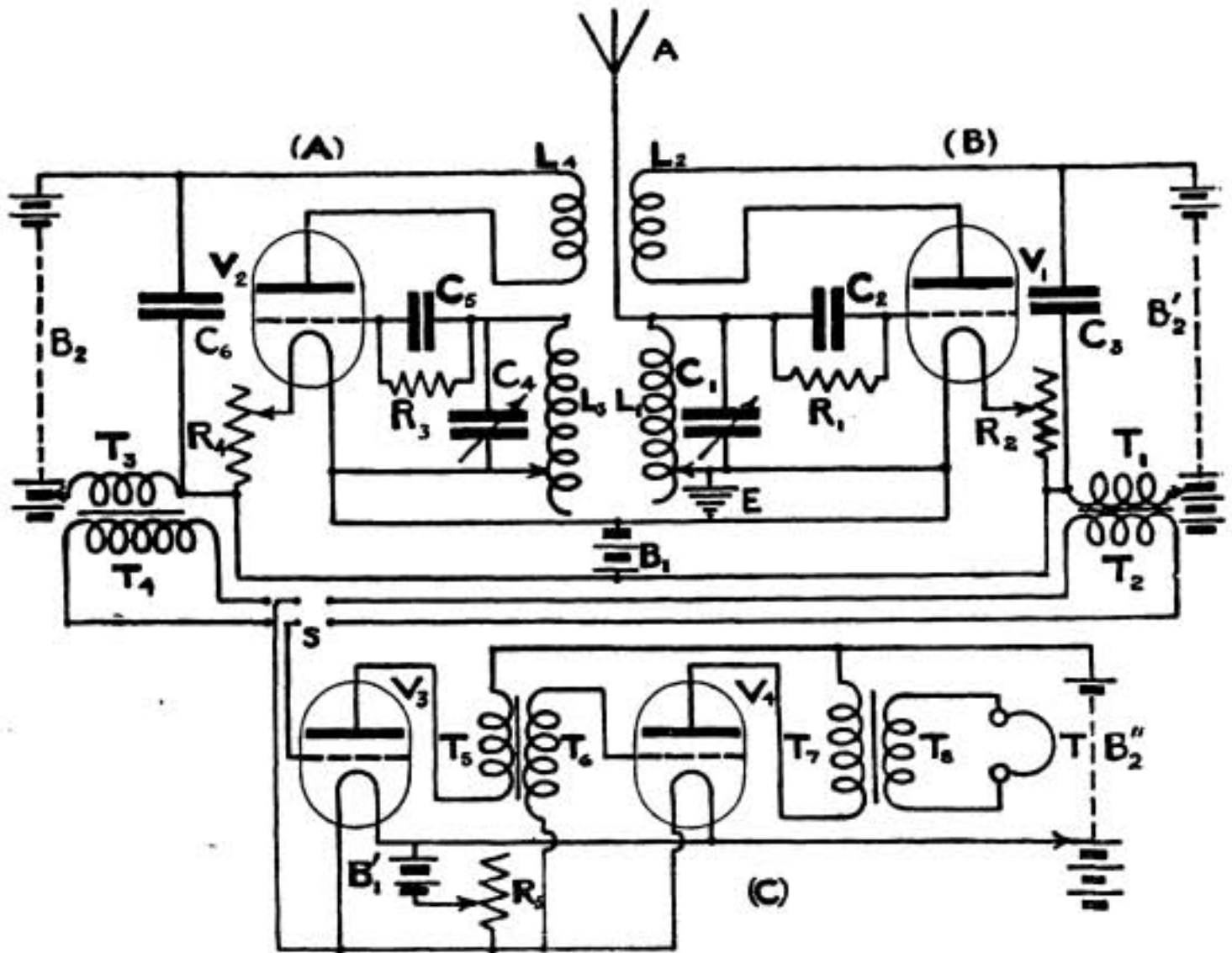
Fig. 1.

usual. For listening in on the " standby " position the circuit (B) is used as a self-heterodyne, and in this connection it should be noted that for a beat note to be produced, the aerial circuit must be slightly mistuned. The incoming waves are, therefore, forced into the aerial circuit in spite of the fact that the latter is out of resonance, so that there is a consequent loss in signal strength. An important disadvantage of the self-heterodyne circuit is that it radiates while receiving and may give rise to interference at other stations.

The disadvantage of excessive jamming may be largely overcome by tuning the oscillating (B) circuit to the silent point, decreasing the coupling between L_1 and L_2 or decreasing the filament current of V_1 so as to prevent V_1 from oscillating, and then switching S over to the left and re-tuning on the (A) circuit which is then made to oscillate. Owing to the very loose coupling between L_1 and L_3 spark signals suffer in amplitude to a much greater extent than C.W. signals, while the energy radiated from the aerial is considerably weakened. A further development which leads to much louder signals is to adjust the (B) circuit to the pre-oscillatory or subgenerative condition immediately preceding self-oscillation, by increasing the coupling of the retroactor coil L_2, or the magnitude of the filament current, which latter adjustment is preferable, the incoming continuous waves are now retro-

actively amplified, with the result that louder signals are obtained in the telephones T.

The ratio between the amplitude of the local and incoming oscillations is of great importance. Suppose that the amplitude of the local heterodyne oscillations is L and that of the incoming signals is I, then the amplitude of the beats will vary from a maximum of $L + I$ to a minimum of the difference between L and I. When L is greater than I the average beat current, when rectified, will be proportional to

$$\frac{(L + I) - (L - I)}{2} = I,$$

that is, the signal strength will be proportional to the amplitude of the incoming signals. Hence a nearby station would drown a distant station. If the amplitude of the local oscillations is less than that of the incoming waves the average rectified beat current will be proportional to

$$\frac{(I + L) - (I - L)}{2} = L,$$

that is, the signal strength is proportional to the amplitude of the local current. Under these conditions a very high power station would not give any louder signals than a weak distant station. This effect has been found in practice to be very useful to prevent excessive interference.

The discussion was opened by Dr. J. ERSKINE-MURRAY who thought that the arrangement described might be very useful for ground stations but would probably be too complicated for aircraft work. He also expressed interest in the explanation given of the effect of the relative magnitude of the local and heterodyne oscillations.

Major N. HAMILTON, Mr. BASIL BINYON, Mr. PHILIP R. COURSEY, Mr. R. C. CLINKER, and Mr. BROADWOOD discussed the radiation from such circuits from various points of view. The question was also raised as to the relative magnification of a heterodyne note and a spark signal note by the note magnifier of the (C) circuit. In connection with the measurement of the frequency of continuous waves Mr. R. C. CLINKER described the double click method recently outlined by Dr. L. W. Austin. Mr. BROADWOOD suggested that it might be possible to use the receiving valve only as a detector and then to pass on the rectified energy from this valve to react with a separate circuit which may be made to oscillate at an acoustic frequency, and thus obtain a species of low-frequency heterodyne. Such an arrangement might avoid some of the difficulties of the heterodyne radiation.

Mr. SCOTT-TAGGART in reply pointed out that the circuit described was not intended to eliminate heterodyne radiation but merely to reduce it, and dealt with the relative merits of self-heterodyne and separate heterodyne arrangements.

He also outlined a slight modification of the circuits with a view to lessening the number of separate batteries required.

Review of Radio Literature.

1. Abstracts of Articles.

88. The Calculation of Antenna Capacity. L. W. Austin. (*Journal, Washington Academy of Sciences*, 9, pp. 393—396, August, 1919.)

The predetermination of antenna capacity has until recently been a matter of great uncertainty. The author refers to the most important contributions to the subject, and then deals with the results of recent measurements on various forms of aerials. It was discovered empirically that the capacities of all antennas not too elongated in shape and having their wires not too widely spaced can be very approximately represented by the formula :

$$C = (4 \sqrt{a} + 0\cdot88\, a/h) \times 10^{-5}, \text{ mfds.,}$$

where a = area of aerial ; and h = its mean height, both in metres. When the length l of the aerial is more than eight times its breadth b, an elongation factor must be introduced into the above formula :

$$C = (4 \sqrt{a} + 0\cdot88\, a/h)\, (1 + 0\cdot015\, l/b) \times 10^{-5}, \text{ mfds.}$$

These equations are really the sum of the usual expressions for the capacity of a disc in space and that for a two-plate condenser, disregarding the edge effect. Results correct to 10 per cent. for the antenna top. Capacity of downleads etc. must be added. Formulæ assume that wires are sufficiently close to obtain nearly full capacity for the flat top of the aerial. Comparisons of calculated and observed capacities are given.

89. The Calculation of the Natural Wavelength of Aerials. A. Meissner. (*Jahrbuch der Drahtlosen Telegraphie*, 14, pp. 269—270, August, 1919.)

The author maintains that Howe's method is too complicated and lengthy for practice and does not give accurate results. He prefers the cruder method of multiplying the length measured along the wire from earth to extremity of aerial by a coefficient found by experiment for different types of aerials.

Examples : Vertical wire . . . . $4l$—$4\cdot1l$
Horizontal wire, 1 metre above ground $5l$
Broader aerials . . . . $5l$—$7l$
Old Nauen **T** aerial . . . $5\cdot5l$
Small **T** (ships) . . . . $4\cdot5$—$5\cdot0l$
New Nauen **T** (broad) . . . $5\cdot8l$
T (breadth = l, height = $l/2$ to $l/3$) $9l$—$10l$
Umbrella . . . . . $6l$—$8l$
Ditto, low, with many wires . . $8l$—$10l$

90. AIRPLANE ANTENNÆ CONSTANTS. J. M. Cork. (*Bureau of Standards, Scientific Paper*, No. 341, September, 1919. *Journal of the Franklin Institute*, 188, pp. 556—557, Abstract.)

The purpose of this experimental investigation was to devise a method for measuring the constants of various forms of aerials on aeroplanes. All the measurements were made under conditions of actual flight. The principle of the method involves the use of a continuous-wave valve oscillation generator for exciting the aerial directly and then substituting for the antenna a variable calibrated condenser and a variable calibrated non-inductive resistance. By this means the effective capacity and effective resistance are obtained. From these results the true capacity, inductance and natural wavelength are found graphically. Results were obtained for various forms of fixed wires and for one, two, and four trailing wires of various lengths. The results are summarised in a series of curves. An interesting result of these investigations is that under no circumstances was any rise in effective resistance of the aerial found with increasing wavelength, as compared with the results for aerials on the ground where the total resistance of the aerial first decreases rapidly and then rises again with increasing wavelength. This rise of resistance must therefore be due to the effect of imperfect dielectrics near the aerial such as the earth, etc., which are not present in the case of aeroplane aerials. The effect of covering the wings of the aeroplane with wire network with a view to improving the counter-capacity of the aeroplane was investigated, but the results were not so good as when the counterpoise connection was made to the ordinary metallic frame of the machine.

The method for finding the directional transmitting effect of various aerials is also described in the paper. In order to compare the amounts of energy received, a detector valve with a three-stage low-frequency amplifier was used. A transformer was placed in the plate circuit of the last valve, and its secondary connected to the heater coil of a thermo-couple joined to a D.C. microammeter. This receiving arrangement was found to be free from many of the uncertainties of ordinary audibility meters. A typical directional transmission curve for a trailing wire aerial is included in the paper.

91. RADIATION FROM COMPOUND ANTENNÆ. M. Abraham. (*Archives für Elektrotechnik*, 8, pp. 42—45, July, 1919. *Technical Review*, 5, p. 80, October, 1919, Abstract.)

Assuming that two antennæ radiating synchronously and having their capacity to earth mainly concentrated in the horizontal portions are erected in close proximity, each will induce currents in the other and the energy required to maintain them in oscillation is greater than the sum of the amounts required to maintain each of them individually in oscillation. There is an increased radiation from the antennæ resulting from the superposition of their fields. This increase vanishes when the oscillations of the antennæ are displaced in phase by a quarter of a period. A general expression is

worked out for the sum of the radiations for any phase displacement between the oscillations of the component antennæ, both for the radiations along the earth's surface and also for the total radiation. The case is also considered of two antennæ one of which is excited by the transmitter while the other one is entirely separate but tuned to the same frequency. This shows that if the secondary antenna has a certain resistance and is at a given distance from the primary antenna a complete shadow is thrown by the auxiliary antenna, while radiation from the main antenna is increased in the opposite direction by a species of mirror action. Such a secondary antenna may also be used at a receiving station to screen the main aerial from undesired radiations. The conditions for such screening to be effective are worked out. Two secondary antennæ closely coupled together by their fields and situated at such a distance from a single primary antenna as not to react upon it appreciably, produce the same effect as a single secondary antenna of twice the radiation resistance.

92. RELIABLE METHOD FOR THE APPROXIMATE DETERMINATION OF THE TRUE ANTENNA CONSTANTS. A. Hund. (*Electrician*, 83, p. 470, October, 1919.)

The procedure described was based on the measurement of the wavelengths λ and λ' for the unloaded and coil loaded antenna. The inductance added at the base of the aerial must be sufficient to increase its wavelength to at least twice the fundamental value. The true or static antenna constants are calculated from the formulæ

$$L_A = \frac{3\pi^2\lambda^2}{12\lambda'^2 - \pi^2\lambda^2} L_0 \text{ henrys.} \quad C_A = \frac{10^{-10}}{144} \cdot \frac{\lambda^2}{L_A} \cdot \text{mfds.}$$

where λ is in metres and L_0 in henrys.

This formulæ applies more rigidly as the value of the loading inductance is increased. Many measurements show that this formulæ holds for almost all commercial antennæ to a very close approximation. A table of some typical results is given showing errors not greater than about 2 to 3 per cent. as compared with the theoretical calculated constants.

93. INDUCTANCE, CAPACITY AND RESISTANCE OF COILS AT RADIO FREQUENCY. L. E. Whittemore and J. Breit. (*Physical Review*, 14, pp. 170—172, August, 1919, Abstract of Paper read before the American Physical Society.)

Inductances used in radio circuits may usually be considered as pure inductances shunted by a capacity representing the distributed capacity of the coil. The pure inductances can most conveniently be determined from the values of the apparent inductance as obtained from the capacity which is required to give resonance at certain frequencies. The pure inductance and distributed capacity of the coil may be obtained from the data used for plotting the apparent inductances curve by the use of the following formulæ :

$$C_0 = \frac{(\Sigma C_1)(\Sigma \lambda_1^4) - (\Sigma \lambda_1^2)(\Sigma C_1 \lambda_1^2)}{-N\Sigma\lambda_1^4 + (\Sigma\lambda_1^2)^2}$$

$$L_0 = \frac{0 \cdot 2814 \left[N\Sigma\lambda_1^4 - (\Sigma\lambda_1^2)^2 \right]}{-(\Sigma C_1)(\Sigma\lambda_1^2) + N\Sigma C_1\lambda_1^2}$$

C_0 and C_1 being expressed in micromicrofarads, L_0 in microhenries, and λ in metres. N is the total number of observations from which C_0 and L_0 are calculated. C_1 and λ_1 are corresponding values of the capacity in series with the coil and the resonant wavelength. It is assumed for the derivation of these formulæ that the error in the capacity measurement is constant, and that the percentage of accuracy in the wavelength measurements is also constant. If the coil whose capacity is to be obtained is immersed in a liquid of dielectric constant K, the capacity of the coil C_0 is

$$C_0 = \frac{C_1 - C_2}{K - 1}$$

where C_1 and C_2 are the capacities required to tune the coil to resonance with a certain frequency before and after the coil is immersed in the liquid. The capacity of a coil to earth is important in many cases. If two condensers C_1 and C_2 are joined in series with a coil and the point of connection between the condensers is earthed then for a symmetrical coil its capacity to earth is given by the expression :

$$C_g = 4 \left[\frac{C_1 C_2}{C_1 + C_2} \text{ (max.)} - \frac{C_1 C_2}{C_1 + C_2} \text{ (min.)} \right]$$

The maximum is obtained when $C_1 = C_2$. The minimum value of $C_1 C_2 / (C_1 + C_2)$ is obtained when either C_1 or C_2 is short-circuited. The following empirical expression was found to represent the curve connecting the high frequency resistance of the coil and the wavelength

$$R = A + \frac{B}{(\lambda^2/\lambda_0^2) - 1}$$

Where R is the resistance at wavelength λ, and where A, B, and λ_0 are constants of the coil.

94. STUDY OF ELECTROSTATICALLY COUPLED CIRCUITS. W. O. Lytle. (*Proceedings of the Institute of Radio Engineers*, 7, pp. 427—444, August, 1919.)

This paper deals with the mathematical theory of electrostatically coupled circuits as worked out by L. E. Whittemore of the Physics Department of the University of Kansas. The solution of the problem is worked out by treating the circuits in the same manner as is done with ordinary alternating current problems using the vectorial notation. Two conditions of the circuit are dealt with (1) when they are tuned together after coupling and (2) when they are tuned before coupling together. In the former case it is shown that as the coupling is increased one of the resultant wavelengths approaches infinity and the other approaches zero but in the case when the

circuits are tuned together before coupling one wavelength always remains constant while the second approaches infinity with a steadily reducing energy. This latter case is considered as an ideal condition since it enables a large proportion of the primary energy of a coupled transmitter to be transferred to the secondary and yet to retain in effect a radiation of a single wavelength only. The results of the mathematical investigation were confirmed by means of oscillograms taken with a Braun tube oscillograph using an oscillating arc as generator. The type of coupling employed is
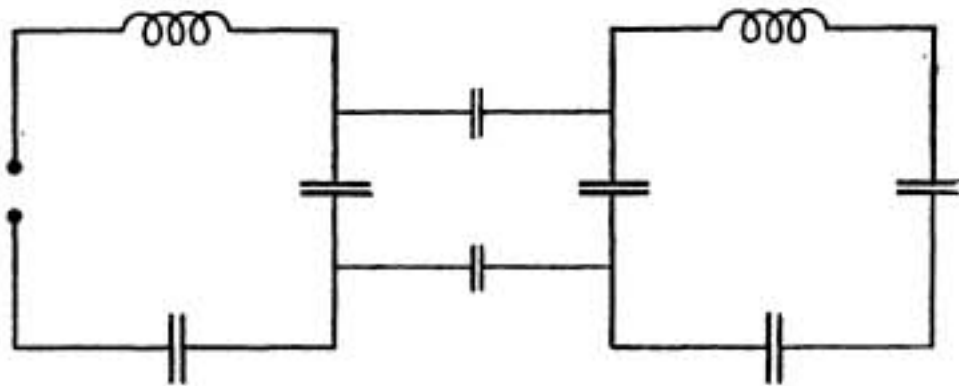

FIG. 1.

indicated in Fig. 1 and couplings up to 92 per cent. were obtainable. The curve of the current in the secondary circuit plotted against percentage coupling as obtained in one of these tests is given in Fig. 2 from which
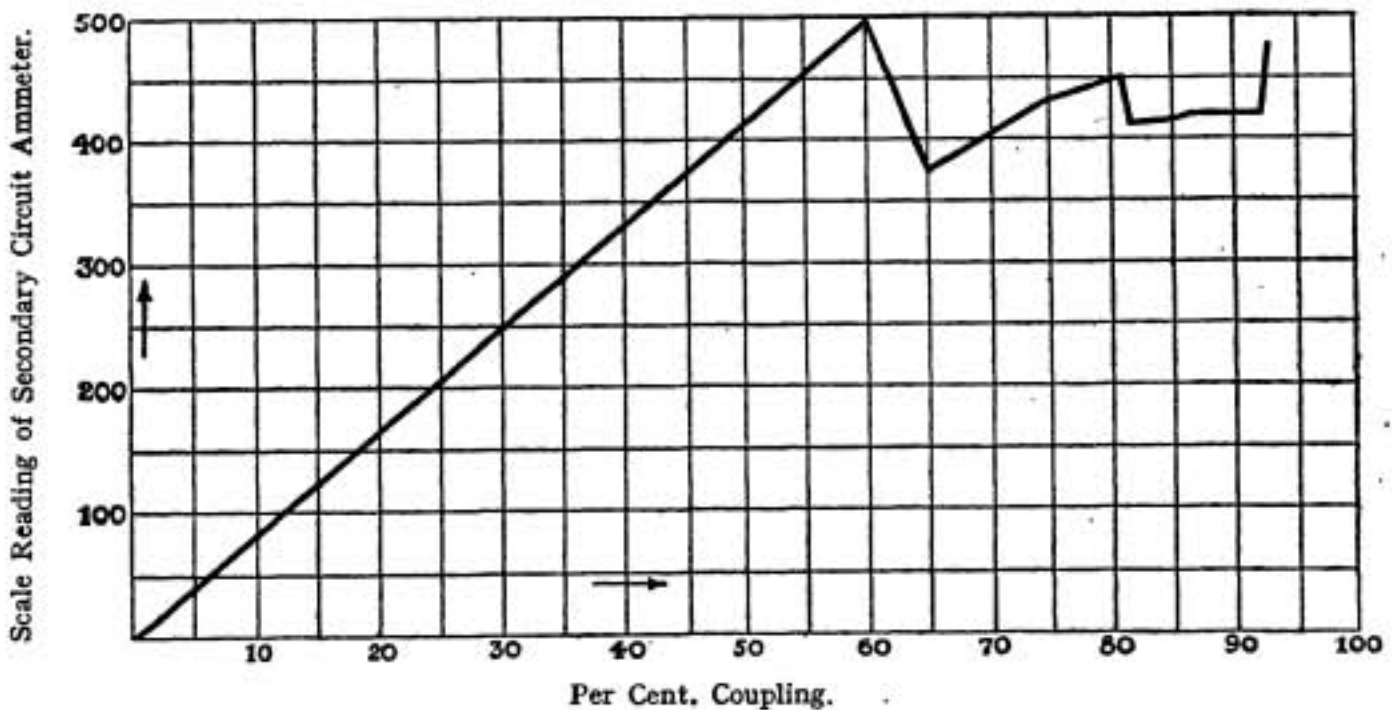

Per Cent. Coupling.

FIG. 2.

it will be seen that three current maxima were found. The first at 60 per cent. coupling was found to correspond with the case when the ratio of the second "coupling wavelengths" was 2 to 1; the second at 80 per cent. coupling corresponds to a wavelength ratio of 3 to 1 and the third at 92 per cent. with a ratio of 5 to 1. That is to say when the ratio of the two resultant frequencies is an integer the secondary current reaches a maximum value.

It is concluded from the experiments that electrostatic coupling should be given a place in practical radio work, firstly because a high percentage coupling can be easily obtained and secondly because when such close coupling is used there is practically only one wavelength in the circuit. A useful application of electrostatic coupling that is mentioned in the paper is that of transmitting on a short wave harmonic on a large aerial without unduly reducing the radiated energy.

95. IMPROVEMENTS IN PRECISION MEASUREMENTS AT RADIO FREQUENCIES. J. H. Dellinger. (*Physical Review*, 14, pp. 181—183, August, 1919, Abstract of Paper read before the American Physical Society.)

This paper briefly reviews, without great detail, the wartime work of the Bureau of Standards on various methods of high frequency measurements.

96. HIGH FREQUENCY MAGNETISATION—THE OLD AND THE NEW POINT OF VIEW. H. Fassbender. (*Jahrbuch der Drahtlosen Telegraphie*, 14, pp. 222—243, August, 1919.)

After reviewing earlier work dealing with the well-known fact that at high frequencies iron appears to have a very low permeability, the author states that the mistaken idea that this is due to molecular inertia or viscosity is not altogether extinct, although magnetic skin effect was investigated by Heaviside in 1892, and by J. J. Thomson in 1893. Fassbender and Hupka have made a number of tests of sheet-iron rings magnetised with high frequency current, and magnetisation curves obtained with a cathode ray oscillograph are reproduced. Owing to eddy currents in the iron neither **H** nor **B** are uniform throughout the iron and the **B—H** curves obtained are meaningless. The author calculates the effective values of **H** and **B** throughout the iron in several cases and finds agreement with experimental results. Some of Alexanderson's results at $f = 200,000 \sim$ are reproduced and reference is made to recent work by Kühn, Osnos, McLachlan and Arkadieff. At radio frequencies there is no appreciable decrease in the actual permeability of iron, any apparent decrease being due to the demagnetising effect of eddy currents. At considerably higher frequencies, however, the author believes that there is evidence of a considerable decrease.

97. ACTIVITIES OF THE REICHSANSTALT DURING 1918. (*Elektrotechnische Zeitschrift*, 40, p. 498, October, 1919.)

The only reference to radiotelegraphy is in connection with the introduction of new standards of wavelength due to the greater accuracy demanded since the introduction of thermionic generators. The basis consists of a number of oscillating circuits with fixed inductance and capacity; from the measured inductance and capacity the wavelength is calculated. These together with the harmonics give fixed points on other wave meters with variable condensers.

98. MEANS FOR DETECTING SMALL ELECTRIC CURRENTS.   J. S. E.
     Townsend. (*British Patent* 130429, February, 1918.
     Patent accepted, August 7th, 1919.)

An incandescent lamp used as a current indicator for a wave meter is rendered more sensitive to small currents by priming with a small direct current, so as to bring the lamp nearly to the point where incandescence commences.

99. AN ARRANGEMENT FOR SETTING UP OSCILLATIONS OF SINGLE FREQUENCY ONLY.   E. Bellini. (*French Patent* 493249, January, 1916. Published August 2nd, 1919.)
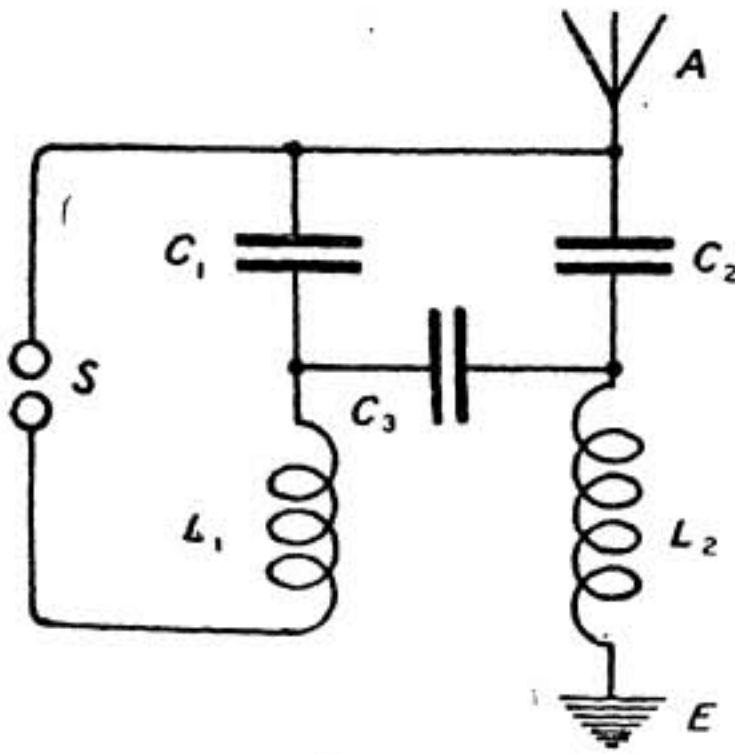
A number of arrangements are described for the use of a combined electric and magnetic coupling between two circuits.   One of these circuits may be the transmitting or receiving aerial circuit. It is claimed that oscillations of a single frequency only may be set up by this means.   One arrangement for transmitting is indicated in Fig. 3.   An analogous arrangement may be used for receiving. See also RADIO REVIEW, Abstract No. 22.*

FIG. 3.

100. ELECTRODYNAMIC AMMETER FOR ALL FREQUENCIES.   Compagnie Générale de Radiotélégraphie. (*French Patent* 493297, March, 1916.   Published August 5th, 1919.)

101. THERMAL ARRANGEMENT FOR THE ACCURATE MEASUREMENT OF CURRENTS OF HIGH OR LOW FREQUENCY.   D. du Rousset. (*French Patent* 493456, July, 1916.   Published August 9th, 1919.)

A special construction of thermal ammeter.

102. THE INDUCTANCE OF SINGLE LAYER RECTANGULAR COILS. G. W. O. Howe. (*Radio Review*, 1, pp. 124—126, December, 1919.)

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* Some experimental investigations of these circuits are described in RADIO REVIEW. Abstract No. 94.

103. SIMPLIFIED INDUCTANCE CALCULATIONS WITH SPECIAL
    REFERENCE TO THICK COILS. P. R. Coursey. (*Wireless
    World*, 7, pp. 380—385, October, 1919.)
Abstract of paper read before the Physical Society of London, giving
an extension of Nagaoka's formula for single layer solenoids in the form of
a set of curves applicable to thick and multilayer coils.

104. A NOTE ON THE COMPARISON OF INDUCTANCE, OR OF AN
    INDUCTANCE AND A CAPACITY, BY AN ELECTROMETER
    METHOD. A. W. Smith. (*Physical Review*, 14, pp. 356—
    360, October, 1919.)
This method makes use of an electrometer whose quadrants are connected
across a condenser in series with the inductance to be measured and whose
needle is joined to the centre point of a high non-inductive resistance shunting
the condenser and inductance. It is shown that the deflection of the electro-
meter is proportional to the inductance, to the square of the current and
inversely proportional to the capacity. Experimental verification of these
relations is given. The method is most sensitive when working near the
resonant frequency of the capacity-inductance circuit, but the results are
independent of the frequency and wave form of the A.C. supply. The results
were found to be in agreement with measurements on an A.C. bridge.

105. A HIGH EFFICIENCY I KW. TRANSMITTER. (*Everyday
    Engineering Magazine*, 7, pp. 360—362, September, 1919.)
This paper describes a new quenched gap set constructed by the Inter-
national Radio Telegraph Company. Views of the instruments are given.
The efficiency measured on an 8-ohm aerial is 51·2 per cent.

106. RADIOTELEGRAPHIC AND TELEPHONIC STATIONS. T. G. Simp-
    son. (*French Patent* 492850, December, 1916. Published
    July 19th, 1919.)
The claims cover a transmitting apparatus for radio communication com-
prising an oscillating circuit, an aerial and earth connection, and a charging
circuit for the spark gap, the connections of which are made at nodal points
in the oscillating circuits. Alternatively the connections may be made
near the nodal points so that the oscillating currents have a small tendency
to traverse the spark gap.

107. IMPROVEMENTS IN HIGH-FREQUENCY OSCILLATION GENERA-
    TORS. V. Bouchardon. (*French Patent* 493222, November,
    1918. Published August 2nd, 1919.)
The object of the invention is to combine the advantages of C.W. trans-
mission with those of spark systems. It consists in the use of the same
generating apparatus for feeding the two transmitting arrangements using
sparks or three-electrode valves. A polyphase supply may be employed

with the same number of valves as phases. The change from damped to C.W. transmission can be effected rapidly by suitable switches.

108. Producing Electric Oscillations. J. Bethenod. (*British Patent* 126019, November, 1915.)

Electric oscillations are produced by means of a vacuum tube having a cathode, two anodes, and two auxiliary plate electrodes for oscillating the cathode-ray beam from one anode to the other by means of an alternating electrostatic field. The alternating electric field is produced by the action of the tube itself, and is derived from a secondary circuit coupled with the discharge circuits through the two anodes. The frequency of the oscillations is determined by the natural oscillation frequency of this secondary circuit.

109. Spark Gap for High Frequency. Compagnie Générale de Radiotélégraphie. (*French Patent* 493336, March, 1916. Published August 6th, 1919.)

A rotary spark gap arrangement.

110. Lowenstein's Quenched Gap. (*Wireless Age*, 6, p. 19, September, 1919.)

An illustrated description of a quenched gap due to F. Lowenstein, of which each unit takes the form of two concentric metallic cylinders. The spark gap is between the inner and outer cylindrical surfaces.

111. Improvements in Radiotelegraphic Apparatus. L. M. Cockaday. (*French Patent* 493433, November, 1918. Published August 8th, 1919. *Wireless Age*, 7, p. 31, October, 1919.)

The arrangement consists of a transformer with its primary connected to a supply circuit (preferably D.C.) through a make-and-break contact. The spark gap fed from the secondary of this transformer is preferably mechanically coupled to the make-and-break.

112. Low Potential Radio Frequency Arc. C. W. Noller. (*Radio Amateur News*, 1, pp. 70—71, August, 1919.)

A special arc apparatus for low power short wave work and suitable for use on a 110-volt supply circuit. The arc consists of two tungsten electrodes operating in a liquid consisting of alcohol or petrol, mixed with a 10 per cent. solution (by volume) of ammonia. Two or more shunt oscillation circuits are connected across the arc tuned to lower frequency harmonics of the required oscillation frequency. Wavelengths down to 100 metres with a power of 80 watts upwards are possible. Great steadiness is claimed. The complete arc is mounted in a metal container with cooling flanges, and the normal p.d. between the electrodes is 55 volts when operating in a 110-volt circuit. Overall efficiency to aerial circuit = 24 per cent.

113. A new Striking Arrangement for Arc Oscillation Generators. D. du Rousset. (*French Patent* 493366, March, 1916. Published August 7th, 1919.)

114. The Development of Arc Radio Transmitters. A. L. Anderson and H. F. Elliott. (*Electrical World*, 74, pp. 452 —456, August, 1919.)

A general description is given of the types of arc apparatus manufactured by the Federal Telegraph Co., with illustrations of a 5-kw. and a 200-kw. arc. The usual sizes that are manufactured are 5, 20, 30, 60, 100, 200, 350, 500, and 1,000 kw., the rating being reckoned on the D.C. input. The efficiencies of these sets range between 33 per cent. and 50 per cent. For ship work sizes up to 30 kw. are customarily used with wavelengths between 1,000 and 5,000 metres ; while the larger sizes are reserved for large land stations, working on wavelengths of 2,000 to 15,000 metres. The arcs are joined directly in the aerial circuit, and are usually fed with direct current at 500 to 600 volts. The requisite strength of the magnetic field is a function of the power, frequency and nature of gaseous atmosphere surrounding the arc, and it is stated that definite mathematical " design " relations exist between these factors although they are not given in the article. With the smaller arcs (<100 kw.) open magnetic circuits are used, but for the largest sizes closed cores are employed to obtain the necessary magnetic field strength. For the smaller arcs alcohol is usually employed to provide the hydrocarbon atmosphere ; but in the larger sizes and to obtain considerable power on short wavelengths kerosene is used. This material increases the aerial current when the magnetic field is weak, but is apt to give a deposit of soot in the arc chamber. Coal gas is preferable.

Three types of signalling arrangements are described. (1) the compensation method, in which the signalling key short-circuits a few turns of the aerial inductance ; (2) the coupled compensation method, in which the key short-circuits a small loop coupled to the aerial inductance ; and (3) the ignition key signalling system, in which the arc is mechanically short-circuited through a resistance between the signalling periods. The second method is the most preferable ; with small powers (5 kw.) one loop and short circuiting key is used, for larger sizes several loops are employed, each fitted with an electro-magnetically operated short circuiting key. For a 100-kw. arc twelve such loops and keys are required. The third method is only suitable for very small power units.

115. Arc Lamp for the Production of Electrical Oscillations. L. Mauclaire, A. Garbarini, G. Gautier. (*French Patent* 493769, December, 1916. Published August 21st, 1919.)

In the arrangement of arc described a central electrode of carbon or other good conducting material is surrounded by a hollow metallic ring forming the second electrode through which a cooling liquid is circulated.

Q

116. RECTIFYING HIGH-TENSION ALTERNATING CURRENTS. S.
     Cohen. (*Electrical World*, 74, pp. 573—575, September,
     1919.)

A practical application of the rectifying properties of a point-plate spark
gap for obtaining high-tension direct current. Best results with Copper-
Aluminium or Iron-Aluminium electrodes, with a jet of gas through the centre
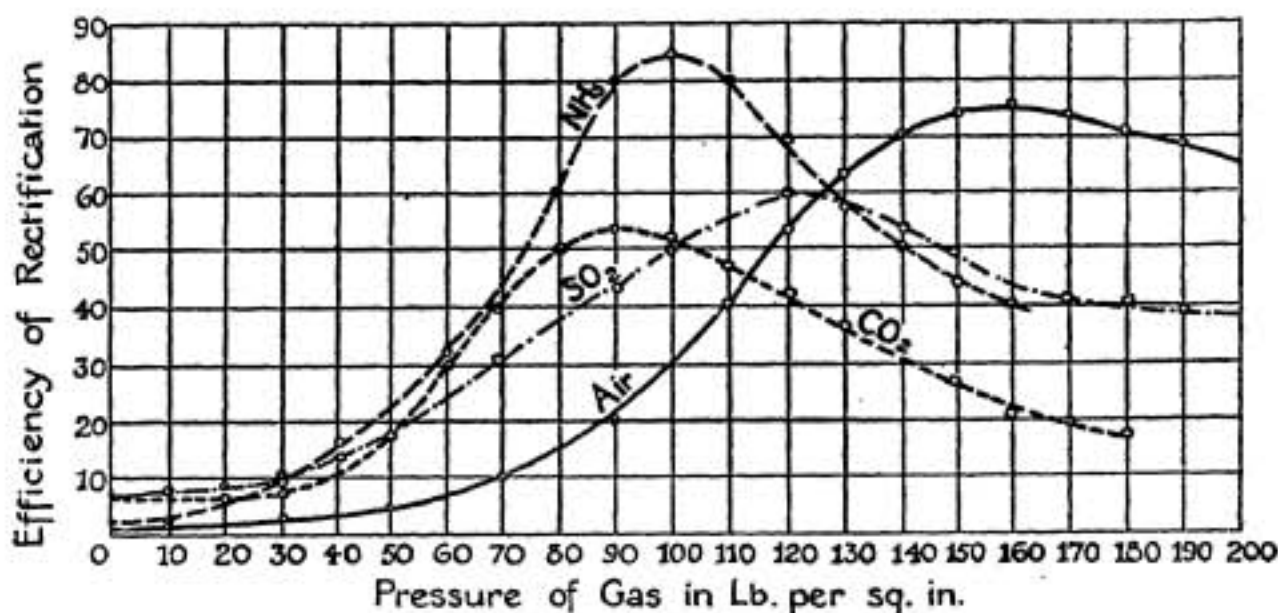of the copper or iron electrode. The effect of various gases on efficiency is

FIG. 4.

shown in Fig. 4. The use of a rotating disc for the aluminium-electrode
increases the stability.

117. THE GENERATION OF HIGH-TENSION DIRECT CURRENT. M.
     Schenkel. (*Elektrotechnische Zeitschrift*, 40, pp. 333—334,
     July, 1919; also *German Patent* 310356.)

A special arrangement of cascaded valve rectifiers is described for obtaining
H.T. direct current from an A.C. supply. The arrangement is sketched in
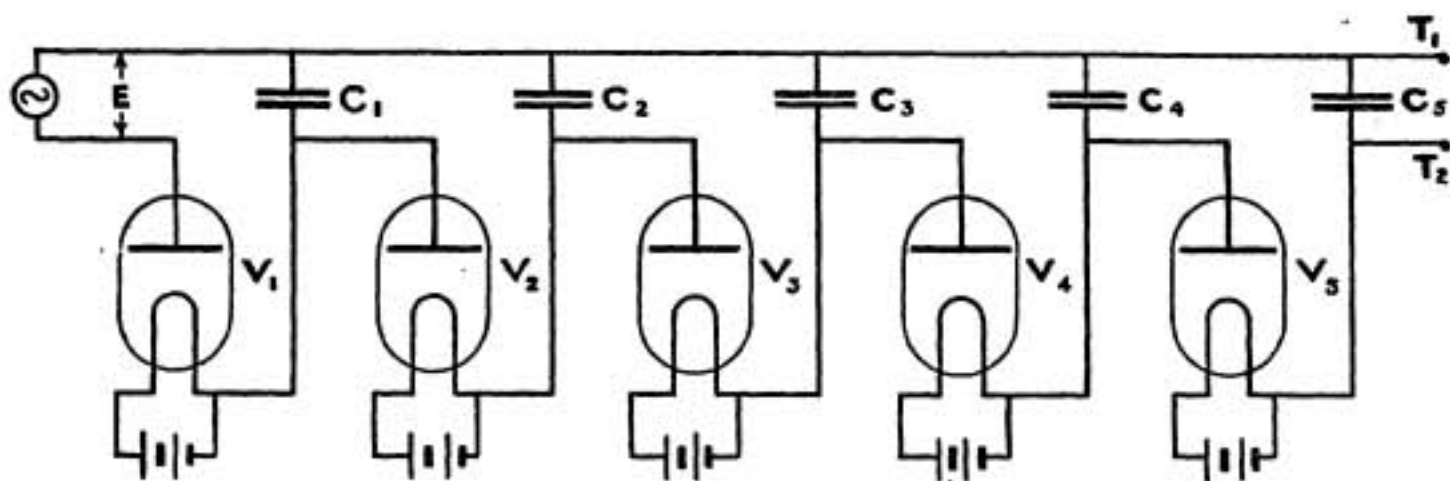Fig. 5. The first valve V_1 rectifies the A.C. supply and charges up the

FIG. 5.

condenser C_1 to approximately $1.4\,E$ volts D.C. In the reverse half-cycle when no current passes through the valve, the supply voltage E is added to the voltage of condenser C_1 across the valve terminals. This voltage is applied to valve V_2 and condenser C_2 so that the latter is charged to a voltage of $2.8\,E$, and so on for the other valves. With five valves as shown the D.C. voltage between $T_1 T_2$ becomes $7.0\,E$. The maximum voltage obtainable in this manner is limited solely by the insulation of the system. The capacity of the condensers must be proportioned to the working voltage of each and to the output current to be obtained from the system.

118. ARRANGEMENTS FOR RECTIFYING ALTERNATING CURRENTS BY MEANS OF VALVES. M. Latour. (*French Patent* 493662, August, 1917. Published August 19th, 1919.)

This refers to the use of A.C. for heating the filaments of rectifying valves. (See also Abstract No. 119.)

119. RECTIFYING ALTERNATING CURRENTS. M. Latour. (*British Patent* 131697, August, 1917. Patent accepted, September 4th, 1919.)

For rectifying an A.C. supply the secondary winding L_1 of transformer T is connected to two valves $V_1 V_2$ in opposite directions, condensers $C_1 C_2$
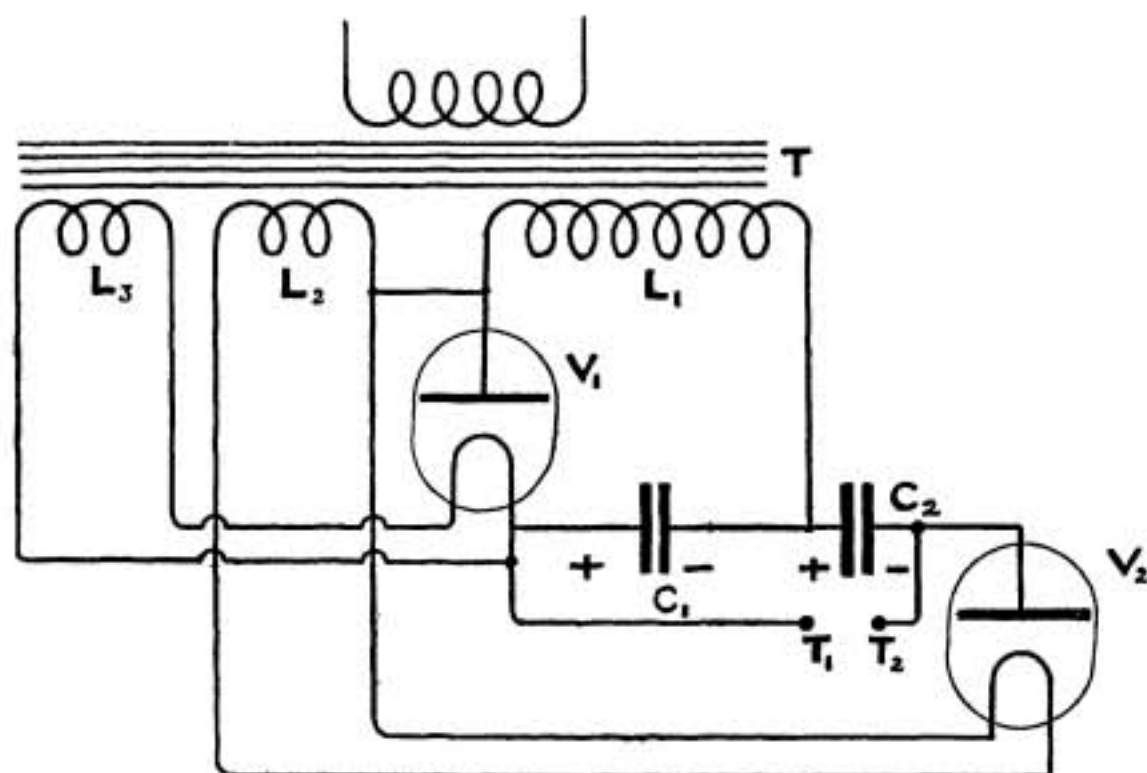

FIG. 6.

being included in the circuits as shown. The valve filaments are heated by auxiliary winding $L_2 L_3$ on the same transformer. The D.C. circuit is joined to $T_1 T_2$ so that the D.C. supply is drawn from the two condensers $C_1 C_2$ in series.

Q 2

120. Producing Electric Oscillations. G. Bethenod. (*British Patent* 130614. July, 1918.)

An addition to British Patent 128575 (Radio Review Abstract No. 23) providing for: the connection of the secondaries of the separate coupling transformers in parallel or in series-parallel instead of in series, the connection of all the alternator windings and transformer primaries in a simple series circuit, and the earthing of the mid-points of the alternator windings and transformer primaries.

121. Improvements in Radio Signalling Systems. L. de Forest. (*British Patent* 131361, June, 1917. Patent accepted, August 28th, 1919.)

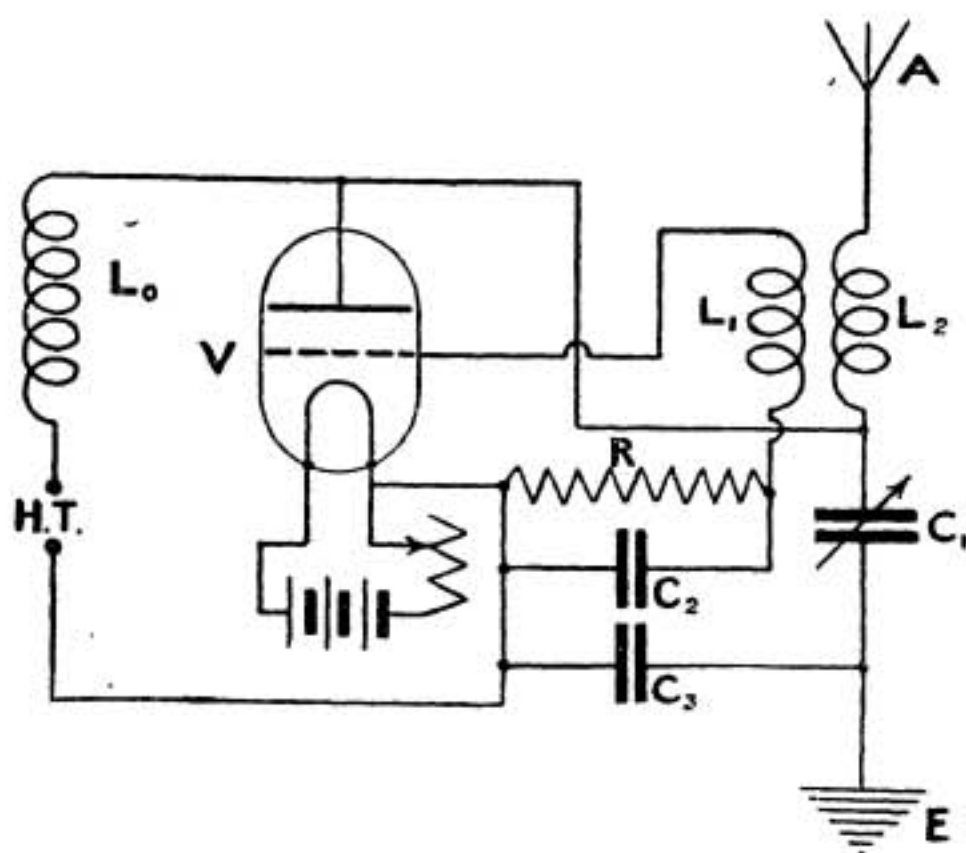An arrangement of 3-electrode valve for transmission, as indicated in

Fig. 7.

Fig. 7. The signalling arrangement is joined in series with the grid-circuit resistance R.

122. Arrangements for Radiotelegraphic and Radiotelephonic Transmitters using High-Frequency Amplifiers. Société Française Radioélectrique. (*French Patent* 493821, August, 1916. Published August 22nd, 1919.)

An arrangement of transmitter in which the oscillations are generated either in one or in a group of three-electrode valves and subsequently amplified by additional valve amplifiers before connection to the transmitting aerial. Transformers or other couplings may be used between the valves. Provision

is made for the use of the same set of valves for either transmission or reception purposes by means of a suitable switch for effecting the necessary changes of connection.

123. A Relay Arrangement for Indicating the Failure of Vacuum Tube Filaments. M. Latour. (*French Patent* 493204, October, 1917. Published July 29th, 1919.)

A differential relay is used of which one winding is connected in series with the valve filament and the other with a shunt circuit connected across the supply battery.

124. An Arrangement for the Use of Two or more Oscillation Generators for Undamped Waves. D. du Rousset. (*French Patent* 493458, July, 1916. Published August 9th, 1919.)

125. The Pliotron Oscillator. W. C. White. (*Electrical Experimenter*, 7, p. 232, July, 1919.)

Describes two uses of the pliotron oscillator. (1) For the production of relatively large current, and (2) the production of relatively large voltage, the energy involved in each case being of the order of 150 watts or less.

126. "Hello, Europe!"—via Radio. C. M. Ripley. (*Electrical Experimenter*, 7, p. 210, July, 1919.)

A detailed description of the New Brunswick, N.J., wireless station.

127. Improvements relating to Electron Discharge Devices. The General Electric Co., U.S.A. (*British Patent* 130400, February, 1918. Patent accepted, August 7th, 1919.)

In a high-vacuum tube acting as a "negative resistance," the stream of electrons is subjected to a magnetic field, so as to vary the number impinging on the third electrode. The magnetic field is provided by a coil surrounding the tube and coaxial with the filament. Varying currents passed through this coil are amplified by the device. The tube may serve as a radiotelephone transmitter, by employing its "negative resistance" to set up oscillations in the usual manner, and modulating these by speech currents passed through the outer coil.

128. Improvements relating to Wireless Signalling Systems. The General Electric Co., U.S.A. (*British Patent* 130369, February, 1918. Patent accepted, August 7th, 1919.)

A wireless transmitting apparatus employing modulated continuous waves has the aerial tuned to a frequency equal to the sum or difference of the wave frequency and the modulating or amplitude pulsation frequency, and the circuit of the source of oscillations tuned to the frequency of the source. When several modulating frequencies are employed (see Radio Review Abstract No. 30) the aerial is tuned to the wave frequency plus the highest

modulating frequency. For speech currents the aerial is tuned to the wave frequency plus the mean speech frequency (800 to 1,000∿).

129. Improvements relating to High-Frequency Electric Installations. G. A. Beauvais. (*British Patent* 131018, March, 1918. Patent accepted, August 21st, 1919.)

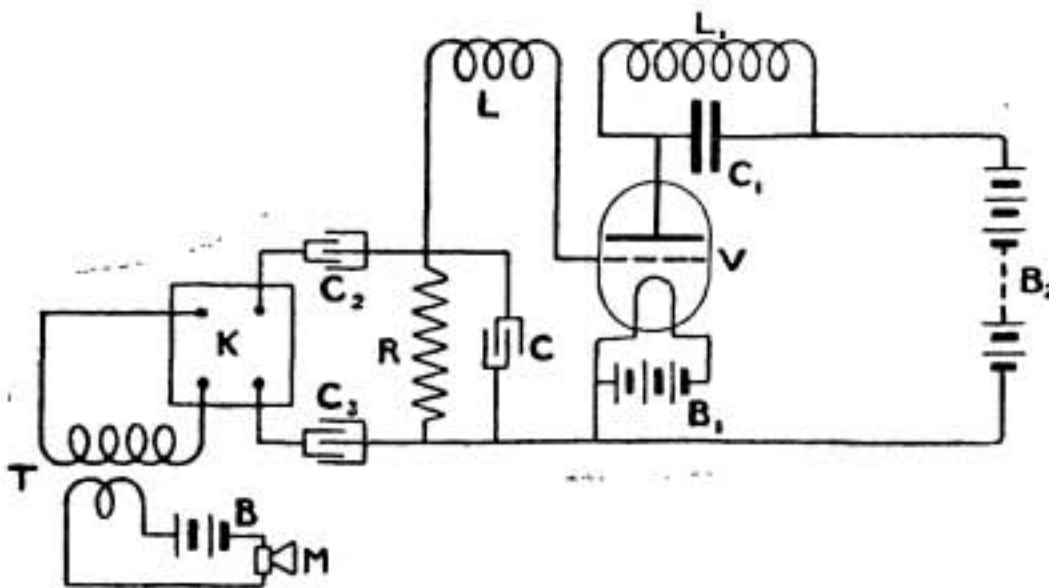In a system for producing electric oscillations using a three-electrode valve, a resistance shunted by a condenser is placed in the grid circuit of the valve, and the potential at the terminals of the resistance is varied by the action of a microphone or by an independent oscillating circuit. The modulations produced by the microphone may be first amplified by an additional valve before they are applied to control the p.d. on the grid

Fig. 8.

circuit resistance of the oscillating valve. One arrangement is shown in Fig. 8. V is the oscillation valve and R the resistance in its grid circuit. K represents the amplifier between the microphone M and the resistance R. $C_2 C_3$ are blocking condensers. In alternative arrangements the resistance R is replaced by the " internal - resistance " of a second valve, V_1, Fig. 9, upon the grid of which the microphone modulations are impressed. This second valve (V_1) is shunted by the condenser C_1, just as the resistance R (Fig. 8) is similarly shunted. Additional intermediate valve amplifiers may also be used. For telegraphic purposes this second " control " valve may
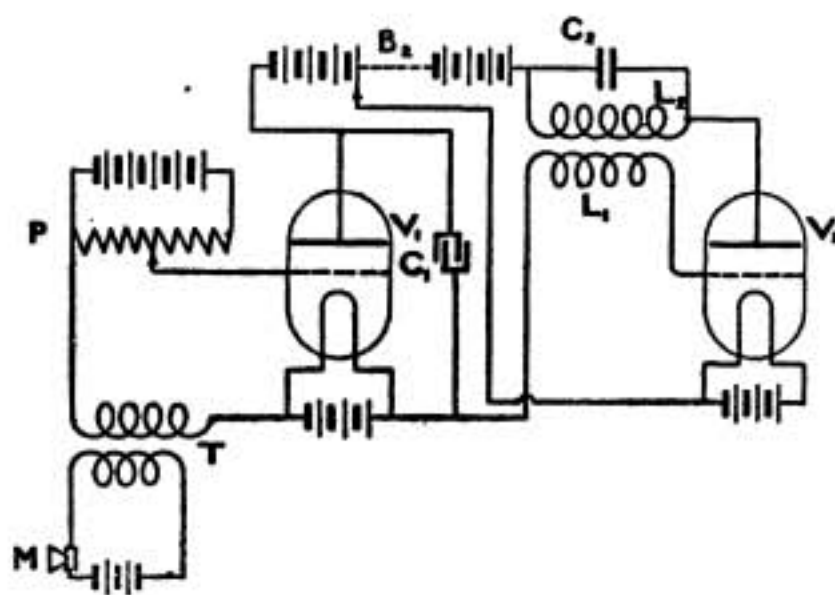

Fig. 9.

be arranged to generate oscillations of musical frequency.

130. Continuous Current Machines specially applicable to Wireless Telephony. J. Bethenod. (*French Patent* 493492, August, 1916. Published August 9th, 1919.)

131. A NEW MODULATION ARRANGEMENT FOR WIRELESS TELE-
    PHONY.   D. du Rousset.   (*French Patent* 493457, July,
    1916.   Published August 9th, 1919.)

For the modulation of the transmitting antenna current a number of
separate microphones are employed each connected to a small loop coupled
to the aerial circuit.   The microphones are all arranged to be influenced by
a common mouthpiece.

132. IMPROVEMENTS RELATING TO RADIOTELEPHONE TRANS-
    MISSION SYSTEMS.   General Electric Company (U.S.A.).
    (*British Patent* 131553, March, 1919.   Patent accepted,
    August 28th, 1919.)

A radiotelephone transmitter is described for which the oscillatory energy
is generated in a single valve V_1, Fig. 10, and thence passes through three
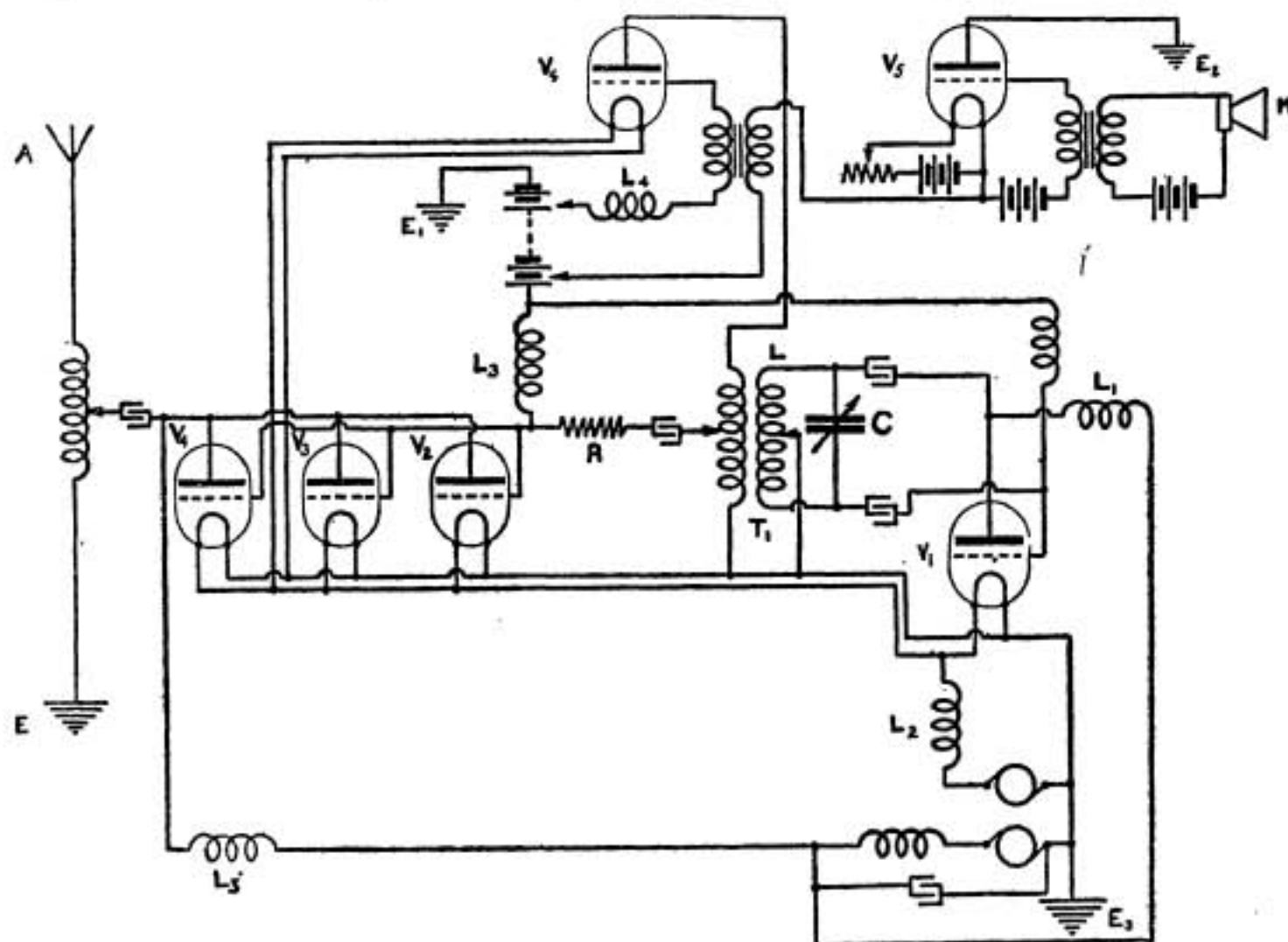
FIG. 10.

amplifying valves in parallel $V_2 V_3 V_4$ before coupling to the aerial.   Modula-
tions from the microphone M are amplified by the valve V_5 and impressed
upon the grid circuit of the modulating valve V_6.   The plate circuit of this
valve is connected to the secondary of the transformer serving also to
couple the oscillation valve with the main amplifiers.   Circuit L C is tuned
to the oscillation frequency of V_1.   The resistance R between the secondary
of T_1 and the amplifying valves $V_2 V_3 V_4$ serves to prevent these amplifiers

setting up sustained oscillations. The choke coils L_1 L_2 L_3 L_4 L_5 are to prevent the passage of high-frequency currents into the low-frequency circuits. They are adjusted so that their natural frequencies are as nearly as possible the same as the high-frequency oscillations, so that they offer increased impedence to the passage of the currents of this frequency.

133. Developments in Wireless Telephony. F. B. Jewett. (*Radio Amateur News*, 1, p. 71, August, 1919.)

A general article summarising recent progress.

134. Recent Progress in Radiotelephony. C. Schmitt. (*L'Électricien*, 49, pp. 187—188, October, 1918.)

A short article reviewing the various types of transmitters available for radiotelephony, including the various arrangements of spark gaps suitable for very high frequencies.

135. Transatlantic Wireless Telephony. J. A. Fleming. (*Electrician*, 83, p. 463, October, 1919, Abstract. *Wireless World*, 7, pp. 499—501.)

Report of a lecture describing recent achievements.

136. A Review of Radiotelephony. (*Electrical Experimenter*, 7, p. 326, August, 1919.)

A very brief historical account of radiotelephonic development. Diagrams are given of a U.S. battleship set and a U.S. signal corps set.

137. Improvements relating to Audion Amplifying Apparatus. M. Latour. (*British Patent* 131362, October, 1917. Patent accepted, August 28th, 1919.)

In a cascade amplifier using three-electrode valves—particularly for radiotelephone transmission purposes, for amplifying the speech currents—each successive stage either has larger valves or has a greater number of valves in parallel. Higher anode voltages may also be used on successive stages. It is recommended that the microphone should be connected in one arm of a balanced bridge, across one diagonal of which the H.F. source is joined, while across the other diagonal a transformer is connected for coupling to the input grid circuit of the above cascade amplifier.

138. Wireless Telephony over 140 Kilometres. (*Elektrotechnische Zeitschrift*, 40, p. 512, October, 1919.)

The Telefunken Company report that telephonic communication was maintained between a station in Nuremberg and an airship up to a distance of 140 km.

139. The Auto Radiophone. A. H. Grebe. (*Radio Amateur News*, 1, pp. 58—59, August, 1919.)

Radiotelephone apparatus used on a motor car, which carries its own aerial structure enabling the set to be used while in motion.

140. Improvements relating to Electromagnetic Wave Sig-
        nalling Systems.   N. Lea. (*British Patent* 130520,
        November, 1918.   Patent accepted, August 7th, 1919.)

The proposed ar-
rangement for a wire-
less telephone trans-
mitter is indicated in
Fig. 11.   The potential
on the grid leak R of
the oscillating valve
V_1 is used to determine
the mean grid poten-
tial of the control valve
V_2.   Transformer T is
used to apply the
modulating potential
to the grid circuit of V_2
from a transmitting
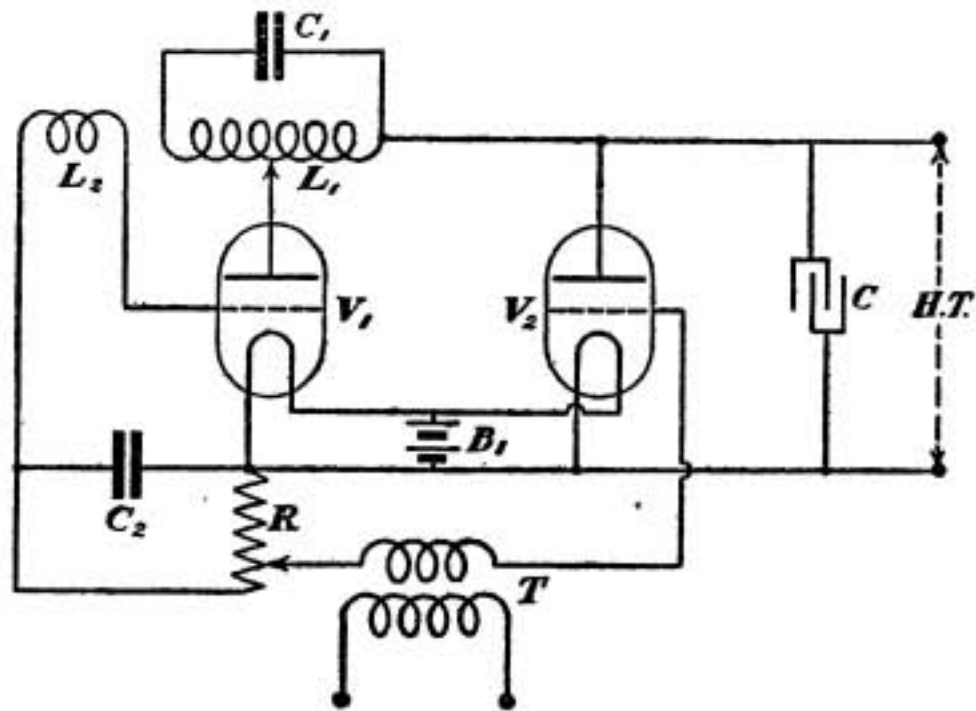microphone or other
control circuit.

Fig. 11.

141. Copper Conductors for Lamps and other Vacuum Tubes.
        Société Nihon Denki Kogyo Kabushiki Kaischa.   (*French
        Patent* 492967, November, 1918.   Published July, 1919.)

A thin tube of copper is sealed through the glass for connection purposes.

142. The Design, Pumping and Testing of Audion Tubes.
        C. Murray. (*Electrical Experimenter*, 7, p. 235, July, 1919.)

143. Improvements in the Construction of Vacuum Tubes.
        Société Française Radioélectrique. (*French Patent* 493258,
        February, 1916.   Published August 5th, 1919.)

The invention consists in placing the tube during exhaustion in a high-
frequency alternating magnetic field so that the lines of magnetic force are
as nearly as possible perpendicular to the surface of the electrodes.   In
this manner the electrodes behave as short-circuited secondaries to the coil
producing the magnetic field, so that they are rapidly heated by the currents
induced in them.

144. Theory and Practical Attainments in the Design and
        Use of Radio Direction-Finding Apparatus using
        Closed Coil Antennæ.   A. S. Blatterman. (*Journal of
        the Franklin Institute*, 188, pp. 289—36·, September, 1919.)

A very comprehensive paper of seventy-three pages, recording a large
amount of experimental work and discussion of results.   The points investi-
gated are :—

(1) Best size of loop and number of turns for given wavelength.
(2) Effect of spacing the turns.
(3) Effect of size and kind of wire.
(4) Effect of insulation.
(5) Best size of tuning condenser.
(6) Effect of walls of building.
(7) Effect of dead turns on coil.

The voltage across the tuning condenser, *i.e.*, the voltage acting on the detector, is inversely proportional to the effective resistance of the coil, other things being equal; therefore this resistance was determined in all cases by exciting the loop circuit which included a thermo-galvanometer from an undamped tuned circuit and inserting known resistances. From the effective resistance R the " reception factor " NAL/λ^2R was calculated; N = turns, A = area, L = inductance, λ = wavelength. Both R and the reception factor are plotted against the wavelength for a great number of coils from 3 feet 6 inches up to 15 feet square, from 5 to 80 turns, and from $\frac{1}{4}$ inch up to $1\frac{1}{8}$ inch spacing. There is a value of λ for which the reception factor is a maximum; for shorter wavelengths R increases so rapidly that λ^2R increases. Curves and tables are given from which one can decide upon the best design for any given wavelength.

The second part of the paper is devoted to the directional characteristics of the loops. The deviation of the polar curve from the simple double circle is due to :—

(1) the displacement current effect,
(2) the antenna effect, and
(3) the shape effect.

(1) Owing to displacement currents from turn to turn there is a P.D. across the tuning condenser when the plane of the coil is normal to the signalling direction. The polar curve therefore has no zero value but merely two minimum points.

(2) The whole coil acts like an antenna, and, owing to one side having a lower capacity to earth than the other, *viâ* the filament battery and the operator's body, a P.D. is produced across the tuning condenser. Since this effect is unaffected by rotating the coil, it makes the two loops unsymmetrical and enables the operator to decide not only the line but the point of the compass from which the signal is coming.

(3) The so-called shape effect is merely the effect of the shape of the coil on the antenna effect.

For accurate work these various effects should be kept as small as possible. Pancake type coils have never such a sharp minimum as coils of the solenoid type. The results were checked by a number of experiments in the field. Beneficial results were obtained by arranging wires above the coil and using them as an earthed electrostatic shield. This improved the sharpness and symmetry without noticeably diminishing the strength of the signals. This is unnecessary if the loop and apparatus are raised 15 or 20 feet above the ground. The grounded shield reduced certain kinds of atmospherics.

In conclusion it is mentioned that in their seven-bulb amplifiers the U.S. Signal Corps use iron-core intervalve transformers even in the radio frequency stages, the iron is stated to be 0·0015 inch thick.

145. Improvements in Receiving Arrangements for Wireless Direction Finding. Société Française Radioélectrique. (*French Patent* 493453, July, 1916. Published August 9th, 1919.)

Improvements in receiving arrangements for wireless direction finding comprise the use of a rectangular aerial with perpendicular diagonals which can be turned around a vertical diagonal. The turns of wire in this loop aerial are arranged parallel to one another and at least 2 cm. apart. It is recommended that all the apparatus as well as the operator should be very carefully insulated from one another and from the ground and that their relative positions should remain unchanged during a measurement.

146. Improvements in Reflectors in Wireless Telegraphy and Telephony. C. S. Franklin and Marconi's Wireless Telegraph Company. (*British Patent* 128665, August, 1917. Patent accepted July 3rd, 1919.)

Electromagnetic waves are transmitted in, or received from, a desired direction, by parabolic reflectors comprising two or more sets of rods, strips, or wires arranged on the parabolic surface around the aerial as focus, each rod being tuned to the aerial. The focal distance is preferably one-quarter of the wavelength. The length of each rod is preferably about a half wavelength, but may be greater or less if a condenser or inductance is inserted. For short waves, no earth connections are necessary; but for long waves the aerial and lower rods of the reflector are preferably earthed.

147. Direction Finding by Wireless Telegraphy. H. R. Sankey. (*Electrical Review*, 85, pp. 509—512, 539—540, October, 1919. *Engineer*, 128, pp. 388—391.)

An abstract of a lecture delivered at the Shipping and Engineering Exhibition, Olympia, dealing in a general manner with D.F. apparatus, with illustrations of recent Marconi-Bellini-Tosi apparatus. A map of D.F. stations open for public service in the British Isles is given.

148. Apparatus for the Concentration of Electric Waves in a Single Direction or upon a Fixed Point. L. Rota and E. Binetti. (*British Patent* 131392, June, 1918. Patent accepted, August 28th, 1919.)

An addition to British patent 128624,* describing certain constructional details relative to the inner and outer cylinders referred to in that specification.

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* Radio Review Abstract No. 42.

149. SHORT WAVE RECEPTION AND TRANSMISSION ON GROUND WIRES (SUBTERRANEAN AND SUBMARINE). A. H. Taylor. (*Proceedings of the Institute of Radio Engineers,* 7, pp. 337—362, August, 1919.)

This paper gives an historical review of the work of the U.S. Navy Research Department on the possibility of effective long distance reception with underground aerials. The most important property of these aerials demonstrated in the course of these experiments is the much greater ratio of signal strength to X-strength than is obtained with ordinary elevated aerials. These aerial systems were found to be markedly directional towards waves travelling in line with the length of the wires. The best length of wire was found to be independent of the direction from which signals impinged on the receiving station, and independent of the nature of the surrounding soil providing that it is reasonably damp. The best length also depends inversely upon the capacity per unit length of the wire used. Wire lengths from 100 to 2,000 feet were experimented with. The importance of very good insulation of the wires is particularly emphasised as tending to eliminate atmospheric interference. To such an extent is this the case that with very good insulation it has been found quite practicable to receive through strong local thunder storms. Reception is found to be enormously superior when the wires are buried in fresh water or wet soil than when suspended above the ground. Reception on these buried wires was found to follow the same law of diurnal and seasonal variation as is found on ordinary aerials. Signal strength fell off very rapidly after immersion of the wires in salt water, but in fresh water on long wavelengths no measurable decrease in signal strength was found down to a depth of 60 feet. Earthing of the wires at the outer ends reduced the signal strength by approximately 50 per cent. Continuous wave transmission from these aerials over a range of thirty-six miles was found possible using only 0.8 of an ampere in the buried aerial.

150. IMPROVEMENTS IN WIRELESS SIGNALLING SYSTEMS. J. H. Rogers, H. H. Lyon, F. S. Hill. (*French Patent* 493539 and 493540, November, 1917. Published August 12th, 1919.)

This relates to low horizontal " earth " antennæ placed either close to or just below the surface of the earth or water.

151. SOME MODERN VACUUM TUBE CIRCUITS AND THEIR OPERATION. J. Scott-Taggart. (*Wireless Age,* 7, pp. 25—27, October, 1919.)

The circuits described are :—

(1) A " standby " and " tuned " continuous wave receiver ;
(2) A circuit for general reception ;
(3) A highly-selective receiving circuit ;
(4) A simple continuous-wave transmitter and wireless telephone.

For descriptions of (1) and (2) see Radio Review, 1, pp. 181—183, and Abstract No. 170, January, 1920, respectively.

(3) is a two-valve amplifier, each valve having regenerative coupling with each circuit tuned.

(4) is a simple direct-coupled transmitter using a single valve, with anode and grid inductances in series in the aerial circuit.

152. The Six-String Einthoven Galvanometer. (*Engineering*, 108, p. 255, August, 1919.)

An illustrated description.

153. Amplifier Detector for Wireless Telegraphy. L. N. Brillouin and G. A. Beauvais. (*French Patent* 493332, March, 1916. Published August 6th, 1919.)

The leading features of this amplifier are: (1) that each valve simultaneously acts as amplifier and detector; (2) that the amplification is independent of the wavelength since no resonance is involved; (3) atmospherics and similar disturbances as well as extra strong signals are amplified less than weak signals. The circuits shown are those of an ordinary resistance-capacity coupled amplifier with a condenser in the grid circuit of the first valve.

154. The Edison Effect and the Audion. (*Telegraph and Telephone Age*, p. 483, October, 1919.)

Refers to early experiments on the Edison effect and on flame conductivity.

155. The Thermionic Detector. H. J. van der Bijl. (*Popular Science Monthly*, 95, pp. 132—140, October, 1919.)

A popular account of the uses of the valve.

156. Audion-Crystal Receiver for Destroyers. (*Everyday Engineering Magazine*, 8, pp. 40—42, October, 1919.)

A description with illustrations of a receiver used on U.S. destroyers, adapted for reception of spark signals on a crystal, or on a single detecting (three-electrode) valve and provided with return-coupling for C.W. reception.

157. Battleship Type Receiver. (*Radio Amateur News*, 1, pp. 56—57, August, 1919.)

Illustrations and circuit diagrams of valve receiving apparatus.

158. Multiple Conical Loose Coupler. J. G. Merne. (*Radio Amateur News*, 1, pp. 67—68, August, 1919.)

A receiving tuner with the primary and secondary on coaxial conical formers.

159. How Radio " Sigs." are Photographed. (*Electrical Experimenter*, 7, p. 231, July, 1919.)

Describes an invention due to C. A. Hoxie, for the photographic reception and recording of wireless messages at 600-words per minute.

160. " B " Batteries for Vacuum Tubes. W. P. Schulte.
     (*Everyday Engineering Magazine*, 7, pp. 364—365,
     September, 1919.)
Tests are described and curves given for the U.S. Navy type and Signal
Corps type of H.T. batteries for use with valve receivers.

161. The Problems of Vacuum Tube Circuits. L. M. Clement.
     (*Everyday Engineering Magazine*, 7, pp. 367—369, Septem-
     ber, 1919.)
A continuation of the previous articles describing multi-valve amplifiers.
Views of Western Electric Company's instruments are given.

162. Improvements relating to Audions, Lamp Relays, or
     Amplifying Apparatus. M. Latour. (*British Patent*
     129660, October, 1916. Patent accepted July 24th, 1919.)
A further addition to Patent No. 127318, in which the receiving apparatus
described in that patent is modified by first amplifying the received oscilla-
tions by means of a series of three electrode vacuum tubes with their circuits
coupled through transformers with iron cores, then rectifying the amplified
oscillations by any known apparatus, and finally amplifying the resulting
low frequency current by a second series of three electrode vacuum tubes.

163. Improvements relating to Audions, Lamp Relays, or
     Amplifying Apparatus. M. Latour. (*British Patent*
     129661, October, 1916. Patent accepted July 24th, 1919.)
A further addition to Patent No. 127318. High frequency iron core
transformers, employed in connection with vacuum tube amplifiers have
the cross section of the iron in the parts of the core external to the coils
greater than the cross section of the iron inside the coils. The coils described
are wound in several layers with considerable spacing between the layers.
The turns on each layer may further be spaced apart when necessary. This
arrangement of the coils is adopted to reduce the electrostatic or capacity
effects in the transformer windings.

164. Improvements relating to Audions, Lamp Relays, or
     Amplifying Apparatus. M. Latour. (*British Patent*
     130103, April, 1916. Patent accepted July 31st, 1919.)
Vacuum tube relay apparatus of the kind described in British Patent
127318, comprising a series of valves for amplifying in successive stages, is
provided with a common battery for supplying the plate filament circuits
of the various tubes, and a separate common battery for heating the filaments.
The currents to be amplified are supplied through an iron-cored transformer
to the grid of the first valve. The plate circuit of this valve acts through
the second transformer on to the grid of the second tube, and so on. The
plate circuit of the last tube acts through a transformer on to the output
circuit.

165. IMPROVEMENTS RELATING TO AUDIONS, LAMP RELAYS, OR
    AMPLIFYING APPARATUS. M. Latour. (*British Patent*
    130012, November, 1916. Patent accepted July 31st,
    1919.)

The receiving apparatus for wireless telegraphy and telephony comprises
one or more three-electrode valves for high frequency amplification, a valve
for rectifying or detecting the amplified oscillations, and one or more
additional valves for amplifying the resulting low frequency current. The
plates of all the tubes are connected to a common high tension battery. The
specification describes the use of iron core transformers for all stages, radio
frequency as well as low frequency. The grid circuit of the detecting valve
includes a condenser shunted by a high resistance leak in the usual manner.
The connection of a condenser between the grid and the filament of the last
low frequency valve is claimed to reduce the tendency to arcing in the valve.

166. IMPROVEMENTS RELATING TO AUDIONS, LAMP RELAYS, OR
    AMPLIFYING APPARATUS. M. Latour. (*British Patent*
    130022, December, 1916. Patent accepted July 31st,
    1919.)

A further addition to British Patent 127318, dealing with a series of vacuum
valve amplifiers connected in cascade with iron core inter-valve transformers.
A tuned circuit is provided at each stage with the object of increasing the
selectivity. The transformer cores are provided with air gaps, and the
secondary of each inter-valve transformer is shunted by a condenser to give
resonance to the desired frequency. The receiving aerial is not tuned to this
frequency, so that oscillations set up therein by atmospherics are not rein-
forced by the amplifiers. A similar arrangement may be used for low
frequency amplification by tuning the transformer secondary circuits to the
note frequency instead of to the radio frequency.

167. A NEW INSTRUMENT FOR PRODUCTION OF UNDAMPED WAVES.
    (*Everyday Engineering Magazine*, 7, p. 366, September,
    1919.)

An oscillating valve apparatus for 200 to 25,000 metres wavelength.

168. CRYSTAL DETECTORS. Société Française Radioélectrique.
    (*French Patent* 493454, July, 1916. Published August 9th,
    1919.)

169. IMPROVEMENTS IN RELAY AMPLIFIERS FOR RADIOTELE-
    GRAPHIC AND TELEPHONIC RECEPTION. A. J. B. Tauleigne.
    (*French Patent* 493489, July, 1916. Published August 9th,
    1919.)

An electromagnetically operated microphonic relay magnifier.

170. A Non-Radiating Wireless Receiving Circuit for the Reception of Damped and Undamped Waves. J. Scott-Taggart. (*Electrical Review*, 85, p. 614, November, 1919.)

In the receiving arrangement described two three-electrode valves are used. The first of these serves merely as a high-frequency amplifier and the second as a detector (Fig. 12). A return coupling is provided between the anode circuit of the second valve and its grid circuit for use in C.W.
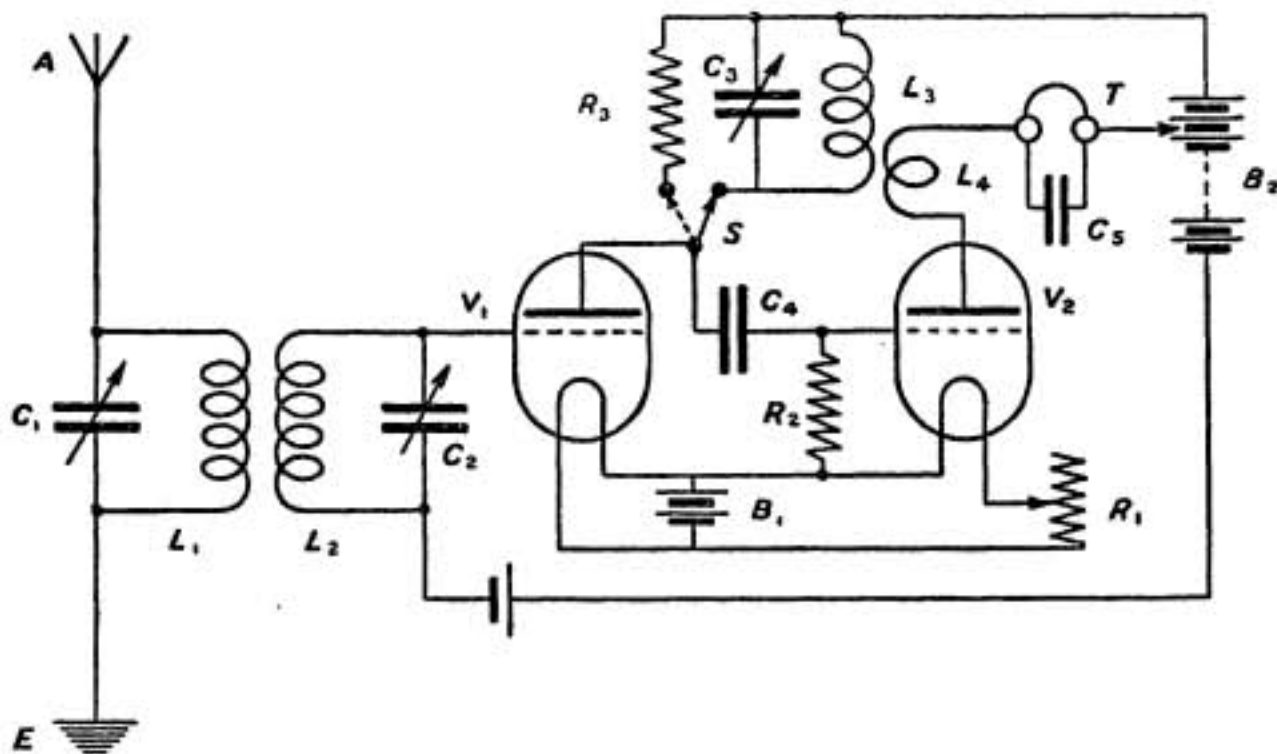

FIG. 12.

reception. For reception of spark signals the tuned circuit $C_3 L_3$ is replaced by a resistance R_3. When the arrangement is used for heterodyne reception only the valve V_2 should be oscillating while V_1 should prevent the return of oscillatory energy to the receiving aerial circuit A, E.

171. Receiving Apparatus for Wireless Telephony. Société Française Radioélectrique. (*French Patent* 493924, February, 1917. Published August 26th, 1919.)

For the reception of speech in a wireless telephone installation a local source of oscillation is used as in the usual manner of heterodyne reception. In order to avoid disturbance of the speech by the beat frequency the wavelength of the local oscillations should be adjusted to coincide as nearly as possible with that of the incoming signals. Best results are obtained when the two wavelengths are exactly the same.

172. Receiving Arrangement for Wireless Telegraphy. Société Française Radioélectrique. (*French Patent* 493820, August, 1916. Published August 22nd, 1919.)

A wireless receiving arrangement in which the coupling between the detector and aerial circuits is effected by means of an iron-cored transformer.

173. AN AERIAL ARRANGEMENT FOR WIRELESS TELEGRAPHY AND TELEPHONY. M. Latour. (*French Patent* 493063, October, 1919; published July 30th, 1919. *British Patent* 132101, October, 1917; published September 11th, 1919.)

The antenna current is divided between a number of earth plates by means of appropriate connections between these plates and the aerial circuit. The connections from the earth plates may be made to various points on the inductance in the aerial circuit or alternatively separate inductances may be joined in each earth lead. The object of the arrangement is to reduce the ohmic losses of the earth connection.

174. THE DISTANT CONTROL OF ELECTRICAL APPARATUS BY WIRELESS TELEGRAPHY. E. H. and K. A. Widegren. (*French Patent* 492928, December, 1916. Published July 25th, 1919.)

This control involves the continuous transmission of groups of electromagnetic waves in which the ratio of the length of the various groups to the intervals between them is variable at will in order to produce different effects at the receiver.

175. HIGH-FREQUENCY CURRENTS ON WIRES. J. O. Mauborgne (Signal Corps, U.S.A.). (*Journal Franklin Institute*, 188, pp. 91—93, July, 1919. *English Mechanic*, 110, p. 26, August, 1919, Abstract. *Post Office Electrical Engineers' Journal*, 12, pp. 153—155.)

The application of standard radio apparatus to multiplex wire telephony has been necessitated by the large number of wireless sets ordered for wartime requirements that are now lying idle. Using apparatus designed for ground stations of aircraft type for communication with aeroplanes, successful speech over existing telephone lines has been secured over sixty miles, using an input high-frequency current to the line of 60 milliamperes at 600,000 $\sim$ (500 m. wavelength). The normal " radio " range of these sets was about ten miles.

176. THE THREE-ELECTRODE VALVE AND RADIO COMMUNICATIONS. (*La Nature*, 47, pp. 103—110, August, 1919.)

A general well-illustrated account of the various uses of a three-electrode valve for radio work. The general principle of its mode of operation is given, leading up to its employment as a detector, oscillation generator, amplifier. heterodyne receiver—or wireless telephone transmitter.

177. THE SPEED OF ELECTRICITY. A. E. Kennelly. (*Wireless Age*, 6, p. 11, August, 1919.)

A general account of Maxwell's theory, and dealing with the speeds of propagation of free electromagnetic waves, and of waves guided along wires or along the conducting surfaces of the earth or sea.

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178. ON THE TRANSMISSION OF SPEECH BY LIGHT. A. O. Rankine. (*Proceedings of the Physical Society of London,* 31, pp. 242—268, August, 1919. *Electrical Review,* 85, p. 81, Abstract.)

This paper describes a lengthy research carried out for the Admiralty Board of Invention and Research. It deals chiefly with the modulation of a fixed beam of light in accordance with the sound or speech waves to be transmitted. The transmitter specially developed in this research consists in principle of two parallel grids through which the light is passed. Between the two grids the beam is reflected at a small mirror mechanically connected to the transmitting diaphragm. In this manner the image of the first grid is moved over the second so that more or less light is emitted from the second grid in accordance with the speech form. The grids were 7 inches diameter and the bars and spaces each $\frac{1}{10}$ inch wide. A selenium receiver was used, and a speaking range of $1\frac{1}{2}$ miles has been secured. The articulation is particularly good.

In the discussion on the paper other methods of modulation were dealt with, together with some considerations of the efficiency of the method.

179. ON THE USE OF THE TRIODE VALVE IN MAINTAINING THE VIBRATION OF A TUNING FORK. W. H. Eccles. (*Proceedings of the Physical Society of London,* 31, p. 269, August, 1919.)

2. Review of Books.

A GUIDE TO THE STUDY OF THE IONIC VALVE, showing its development and application to Wireless Telegraphy and Telephony. By W. D. Owen, A.M.I.E.E. (London: *Sir Isaac Pitman & Sons, Ltd.* Pp. vii. + 59. Price 2s. 6d. net.)

This little booklet is a series of brief notes upon the various aspects of the valve, and upon the various uses to which the valve may be put, and is admitted to be such by the author who states in the Preface that they " were originally compiled for the guidance of a little circle of enthusiasts whose interest in the ionic valve was stimulated by repeated references in the technical Press to its numerous applications and wonderful achievements." To any one unacquainted with wireless work, but engaged in other branches of electrical or physical science and therefore familiar with ordinary electrical nomenclature this booklet may appeal, but to the true seeker after knowledge of valve work its scope is too limited and the treatment far too brief. In short its function is to state simply what a valve is and what it can do rather than to contribute new matter to the knowledge of the subject —as an instance, the whole fields of " Continuous Wave Telegraphy " and of

" Reception of Continuous Waves," are discussed in two " chapters " of about 175 words each.　The title of the booklet appears to be rather too ambitious and comprehensive.

A few criticisms may be made against the clarity of some of the statements —for example on pp. 3, 19, 30, 35 and 38, but otherwise the treatment is clear, and a useful feature is a number of references to fuller literature on the subject.

P. R. C.

ALTERNATING CURRENT WORK: An Outline for Students of Wireless Telegraphy.　By A. Shore, A.M.I.E.E.　(London: *The Wireless Press, Ltd.*　Pp. ix. + 163.　Price 3s. 6d. net.)

Correspondence.

THE OSCILLATING TRIODE.

To THE EDITOR, THE " RADIO REVIEW."

SIR,—Mr. R. C. Clinker in his letter to you of the 1st inst. does not call into question the truth of the expression I used, but merely prefers to throw it into a slightly different form.

There are of course two ways of regarding the amplification produced by a valve—from either the standpoint of E.M.F. or current.　The latter is the simpler at first sight, though for many purposes the former is preferable.

As Mr. Clinker points out it is the *current* factor of amplification which is implied in my remarks.

R. WHIDDINGTON.

The University, Leeds,
　　November 20th, 1919.

To THE EDITOR, THE " RADIO REVIEW."

SIR,—Permit me to support Mr. R. C. Clinker's plea that the amplification parameter of a triode should be expressed as the simple ratio of the E.M.F. liberated in the anode circuit to that applied in the grid circuit in the ordinary mode of employment.　I urge this, not only because it gives a figure of merit that is independent of the nature of the apparatus connected to the electrodes of the tube, but also because it is nearer the physics of the matter. The physics may, I think, be summarised as follows :—When one applies say 100 volts between the hot filament and the anode of a small triode the moving electrons between cathode and anode create by their mutual repulsion a back E.M.F. of, say, 50 volts which is rather analogous to the back E.M.F. of polarisation in electrolysis ; if now one increases the potential of the grid relative to the filament by say 1 volt one finds that, say, 10 volts of the back E.M.F. are cancelled.　Therefore 10 volts of the anode battery are

liberated for propelling current. The number 10 is in this case the voltage factor of the tube, sometimes called the amplification factor. I prefer the term "voltage factor" because we may some day find step-down tubes useful, though at present only step-up tubes are widely used. Amplification is a word only applicable strictly to step-up triodes.

While writing I should like to refer to the choice of a symbol for the voltage factor. Langmuir used k, but as in wireless literature k has always been used for the co-efficient of coupling I have myself used the letter g. Sometimes m is used but, again, m is the universal symbol for the mass of an electron and therefore appears in that sense in the theory of all ionic tubes. The International Electrotechnical Commission have suggested that mere numbers should be represented by lower-case Greek letters. Almost the only Greek letters not allocated by the Electrotechnical Commission or the Physical Society of London to important electrical quantities are Upsilon, capital (Υ), and lower case (υ), Xi, lower case (ξ), Nu (ν), and Pitau (ϖ).

It would be interesting to have your readers' views upon the best symbol for this most important parameter of the triode.

W. H. Eccles.

City and Guilds Technical College,
    Finsbury, E.C. 2.
        December 9th, 1919.

ERRATA.

(Note.—*Any notices of errata that may be found necessary from time to time will always be inserted in this position in the* Review.)

Page 77 (November), *line* 2, *the formula should read,*

$$\frac{\partial i_a}{\partial e_g} = g \frac{\partial i_a}{\partial e_a}.$$

Page 104, *line* 24, *for* " positive electrons " *read* " positive ions."

Page 104, *line* 32, *for* " high cathode " *read* " high temperature cathode."

Page 122 (December). Fig. 13. *The ordinate scale should be marked* γ_s *not* γ ; *and the formula beneath this figure should read,*

$$\gamma_s = \tan^{-1}\left[\tan\phi \cdot \tanh\frac{\Delta\phi}{2\pi}\right]$$

Page 132, *line* 3, *should read,*

$$\frac{di_a}{de_l} = \frac{3}{2} A' y e_l^{\frac{1}{2}}.$$