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Editor:
PROFESSOR G. W. O. HOWE, D.Sc., M.I.E.E.
Assistant Editor:
PHILIP R. COURSEY, B.Sc., A.M.I.E.E.

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THE
RADIO REVIEW

VOL. I OCTOBER, 1920 NO. 13

Regeneration and Oscillation in Vacuum Tube Circuits through Inter-Electrode Tube Capacity.*

By A. S. BLATTERMAN
(*Radio Engineer, Signal Corps, U.S. Army*).

Early in 1918 the writer suggested the importance of knowledge (then lacking) of the effective impedance between the input electrodes of the three electrode vacuum tube in radio circuits, and preliminary measurements made at these laboratories† showed that the nature and value of this impedance was materially influenced by the load in the plate or output circuit of the tube. Because of the urgency of other work at that time the problem was outlined to the National Bureau of Standards Radio Laboratory and assigned to them by the Signal Corps for investigation. Dr. Miller's paper entitled "The Dependance of the Input Impedance of a Three Electrode Vacuum Tube upon the Load in the Plate Circuit,"‡ covered the results of this investigation and was the first published demonstration of the exact nature and magnitude of the effects taking place within the tube circuits. Since this paper has appeared other authors, notably Nichols§ and Ballantine,‖ have treated the same subject and the importance of the inter-electrodic capacities of the vacuum tube and of the load in its plate circuit when used for reception has been well formulated.

It is the purpose of the present paper to present the matter in a more direct and simple way than has heretofore been done, showing the effects of the different types of loads in the plate circuit of a tube and the conditions necessary for regenerative action and self-oscillation. It will also be shown

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* Received July 3rd, 1920.

† Measurements made by Lieutenant M. C. Batsel and Lieutenant Austin Bailey.

‡ *Bureau of Standards Scientific Paper* No. 351, November 21st, 1919. RADIO REVIEW, Abstract No. 416, June, 1920.

§ H. W. Nichols, "The Audion as a Circuit Element" (*Physical Review*, 13, p. 404, 1919). See also RADIO REVIEW Abstract No. 928 (in this issue).

‖ S. Ballantine, "On the Input Impedance of the Thermionic Amplifier" (*Physical Review*, 15, pp. 409—420, May, 1920). RADIO REVIEW Abstract No. 925 (in this issue).

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that the impedance of the input or supply circuit wherefrom the grid receives its excitation is of great importance, a circumstance not pointed out previously.

It is now well known that an electromotive force E_g acting between the grid and filament of a three electrode tube causes a current to flow in the plate circuit thereof whose phase with reference to E_g depends upon the characteristics of the plate circuit impedance. If this latter is purely resistive the plate current and grid voltage are in phase; if inductive, the current lags; and for capacitive loading the plate current leads the grid voltage. It is also well known that the grid voltage E_g can be exactly replaced, as far as effects in the plate circuit are concerned, by a voltage μ times as great acting within the tube between the plate and filament electrodes. The tube has essentially three capacities within its structure, that between its grid and filament, that between grid and plate, and that between filament and plate. We have to consider these capacities with reference to the operating voltages, namely E_g and the fictitious voltage μE_g, and may thus combine the grid-filament capacity with the impedance of the input circuit Z_i, and the plate-filament capacity with the impedance of the load or output circuit Z_o (see Fig. 1). The capacity C_m between grid and plate thus becomes the only one which is unique. It has common connection between the input or grid side of the tube and the output or plate side, and any reaction of the output on the input must take place through it. The particular matter which it is desired to investigate is the effect of the impedance Z_i and Z_o upon regeneration effects or oscillation of the circuits.

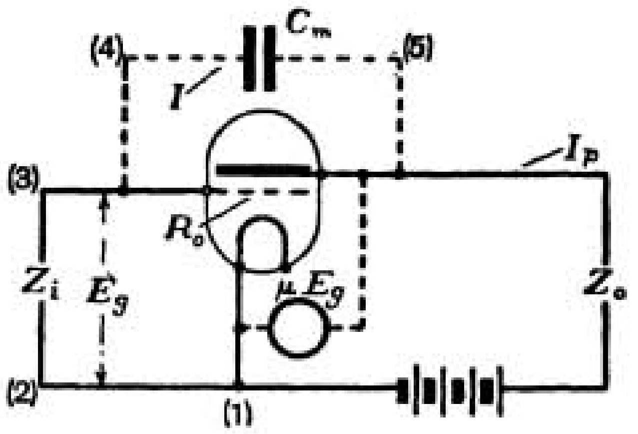

Fig. 1.

Regardless of the circuital arrangement of Z_o, be it a single simple reaction unit or a complex network, it can be always resolved into an equivalent impedance comprising series resistance R_p and reactance X_p, and in general therefore it is only necessary to consider the load as so constituted. We have at once, in vector notation, the plate current as

$$I_p = \frac{\mu E_g}{(R_0 + R_p) + jX_p} \quad \ldots\ldots\ldots \quad (1)$$

in which μE_g is assumed as the reference vector. R_0 is the tube resistance between plate and filament, as usual.

This current develops a reaction voltage across Z_o equal to

$$\begin{aligned} E_Z' &= -(R_p + jX_p)I_p \\ &= -\mu E_g \frac{R_p + jX_p}{(R_0 + R_p) + jX_p} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \end{aligned} \tag{2}$$

which is impressed on circuit 1, 2, 3, 4 and 5 at points (1) and (5). In practical cases the input circuit of impedance Z_i, like the output circuit impedance Z_o may be constituted in any one of several different forms. It may be generically a high resistance, a large inductance or a capacity, as in resistance, inductance or capacity coupled amplifiers, or it may comprise an equivalent series combination or resistance and reactance. In general, it must be considered as an impedance $(R_g + jX_g)$.

The voltage E_Z' therefore experiences an impedance comprising capacity C_m and the supply circuit $(R_g + jX_g)$ in series. Thus the current produced by E_Z' is

$$\begin{aligned} I &= \frac{E_Z'}{R_g + j(X_g - 1/\omega C_m)} \\ &= -\mu E_g \frac{R_p + jX_p}{[(R_0 + R_p) + jX_p]\,[R_g + j(X_g - 1/\omega C_m]} \quad . \quad . \quad . \quad . \end{aligned} \tag{3}$$

We see at once that this current develops a voltage across the input impedance Z_i, and the voltage so developed, appearing as it does between the grid and filament electrodes, combines with the original input voltage E_g either favourably for regeneration and oscillation or in opposition when the action is a counter feedback. The impedance Z_i of the supply circuit, since it gives rise to the feedback voltage, is of fundamental importance therefore. The equation for this voltage is obviously

$$\begin{aligned} E_g' &= I(R_g + jX_g) \\ &= -\mu E_g \frac{(R_p + jX_p)\;(R_g + jX_g)}{[(R_0 + R_p) + jX_p]\,[R_g + j(X_g - 1/\omega C_m)]} \quad . \quad . \quad . \quad . \quad . \quad . \qquad (4) \\ &= -\mu E_g \frac{(a + jb)\;(c + jd)}{(e + jb)\;(c + jf)} \quad . \\ &= -\mu E_g \left\{ \begin{aligned} &\frac{(-ac^2e + abcf + bcde - b^2df - b^2c^2 - bcef - abcd - adef)}{(ec + bf)^2 + (bc + ef)^2} \\ &-j\,\frac{(bc^2e - b^2cf + acde - abdf - abc^2 - acef + b^2cd + bdef)}{(ec + bf)^2 + (bc + ef)^2} \end{aligned} \right\} \qquad (5) \end{aligned}$$

wherein $a = R_p$ $\quad d = X_g$
$b = X_p$ $\quad e = R_0 + R_p$
$c = R_g$ $\quad f = X_g - 1/\omega C_m$

This expression (5) comprises a real and an imaginary term. The imaginary term denotes a voltage acting in time quadrature to the input voltage E_g since this, or rather μ times it, was taken as our reference vector. The real term denotes a voltage either in phase or in exact opposition to E_g depending upon whether its sign is positive or negative. The action is

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counter feedback if the real part of (5) is negative. It is regenerative and favourable for the production of oscillations if the real term is positive. We have at once, therefore, the condition for regenerative action in the general case as

$$abcf + bcde > aec^2 + b^2df + b^2c^2 + bcef + abcd + adef \quad . \quad . \quad (6)$$

Any situation wherein the conditions do not satisfy this relation will either result in the absorption of energy or be critical between absorbing and regenerating action.

There are nine regenerate cases of importance as arising in the design of receiving and amplifying circuits, wherein control of the regenerative feature is desirable and knowledge of the regenerative conditions important. These different cases correspond to arrangements where the supply circuit impedance Z_i is essentially either resistive, inductive or capacitive, and the output impedance Z_o is also either a resistance, an inductance or a capacity.

Case 1.—Z_i = Resistance. Z_o = Resistance. See Fig. 2.

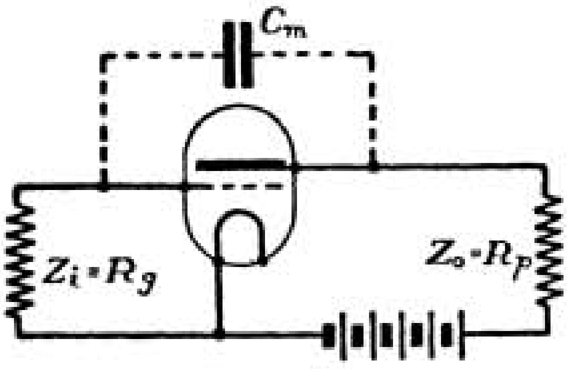

Fig. 2 (*a*).

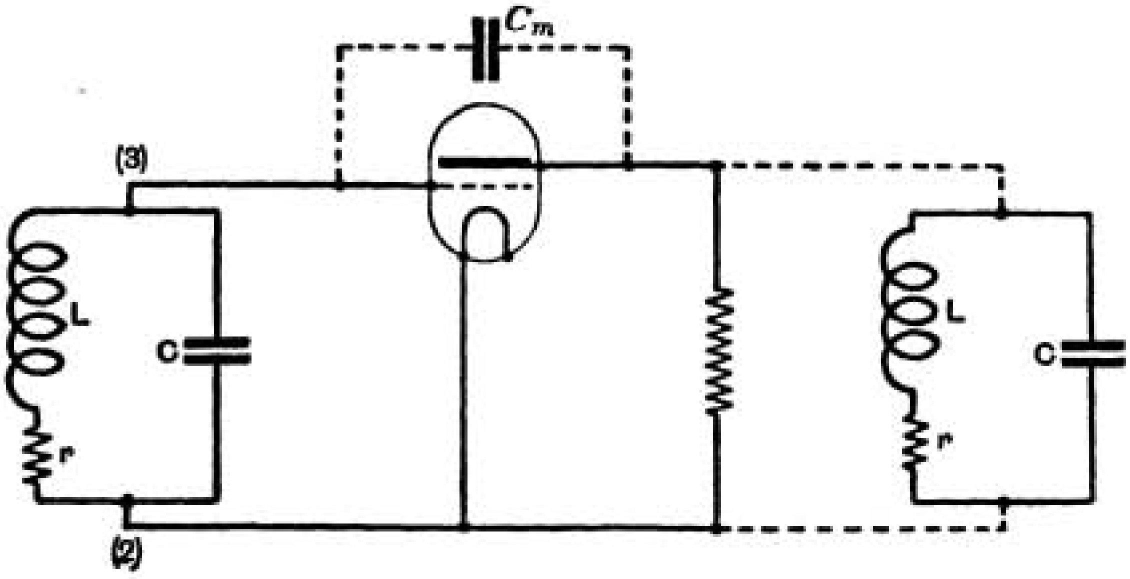

Fig. 2 (*b*).

This corresponds to the case of the resistance coupled amplifier, Fig. 2 (*a*), or to arrangements using tuned circuit input or output as in Fig. 2 (*b*).

In the latter arrangement under this case it is assumed that the adjustments of the circuits *LrC* are for resonance or isochronism or close to these so that the impedance between such points as (2) and (3) is virtually resistive.

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It is desirable to point out here that when such a circuit is tuned so that $\omega L = 1/\omega C$ the impedance of the parallel combination is not purely resistive, but comprises an effective resistance,

$$R_e = \frac{1}{\omega^2 C^2 r} = \frac{L}{Cr} \tag{7}$$

in series with an effective capacity reactance.

$$X_e = -1/\omega C \tag{8}$$

The combination becomes the equivalent of pure resistance at a frequency slightly greater than that producing resonance, namely when

$$\omega = \sqrt{\frac{1}{LC} + \frac{r^2}{L^2}} \tag{9}$$

and it is then

$$\left.\begin{aligned} R_e &= \frac{rL^2}{\omega^2 C^2 L^2 r^2 + r^4 C^2} \\ X_e &= 0 \end{aligned}\right\} \tag{10}$$

The isochronous frequency of the circuit is still different from either of the above frequencies and is given by

$$\omega = \sqrt{\frac{1}{LC} - \frac{r^2}{4L^2}} \tag{11}$$

The circuit is again the equivalent of a resistance and reactance in series whose values are readily calculable but approximate those of (7) and (8). A few calculations will show at once that for most practical circuits the reactance component in either the tuned or the isochronous adjustment is small compared with the effective resistance, and in all cases to be here considered the impedance can be sufficiently well represented by a resistance of value

$$R_e = \frac{1}{\omega^2 C^2 r} = \frac{L}{Cr} \tag{12}$$

In the inequality (6) we have to put for Z_i = resistance, Z_o = resistance

$$b = 0 \qquad d = 0 \qquad f = -1/\omega C_m$$

and get

$$0 > R_p R_g^2 (R_0 + R_p)$$

This is an impossibility, and we see, therefore, that *no feedback is possible with plain resistance in input and output.*

Case 2.—Z_i = Resistance. Z_o = Inductance.

For this condition $a = 0$, $b = \omega L_p$, $d = 0$, $e = R_0$, $f = -1/\omega C_m$ and (6) becomes

$$\omega^2 L_p C_m R_g < R_0 \tag{13}$$

This indicates *that regenerative action may be secured in a circuit having a resistance input and inductive load on the plate and specifies the conditions when such action occurs.*

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Case 3.—$Z_i =$ Resistance. $Z_o =$ Capacity.

For this condition $a = 0, b = - 1/\omega C_p, d = 0, e = R_0, f = - 1/\omega C_m$ and (6) becomes

$$0 > \frac{R_g^2}{\omega^2 C_p^2} + \frac{R_g R_0}{\omega^2 C_p C_m}$$

an impossibility, showing *no regeneration with capacity load and resistance input.*

Case 4.—$Z_i =$ Inductance. $Z_o =$ Resistance.

$b = 0, \quad c = 0, \quad d = \omega L_g, \quad e = R_0 + R_p, \quad f = \omega L_g - 1/\omega C_m$

(6) becomes

$$\omega^2 L_g R_0 C_m + R_p \omega^2 L_g C_m < R_p + R_0$$

$$\omega^2 L_g C_m < 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

Regeneration is possible and occurs when this condition (14) *is satisfied.*

Case 5.—$Z_i =$ Inductance. $Z_o =$ Inductance.

$a = 0, \quad b = \omega L_p, \quad c = 0, \quad d = \omega L_g, \quad e = R_0, \quad f = \omega L_g - 1/\omega C_m$

(6) becomes

$$\omega^2 L_g C_m < 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

as the condition under which regeneration occurs.

Case 6.—$Z_i =$ Inductance. $Z_o =$ Capacity.

$a = 0, \quad b = - 1/\omega C_p, \quad c = 0, \quad d = \omega L_g, \quad e = R_0, \quad f = \omega L_g - 1/\omega C_m$

(6) becomes

$$\omega^2 L_g C_m < 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

Oscillations are therefore possible in this case and under the same conditions as (14) *and* (15). The form of the inequalities (14), (15) and (16) indicates that the reactance of the grid-plate capacity C_m must exceed that of the input grid inductance L_g.

Case 7.—$Z_i =$ Capacity. $Z_o =$ Resistance.

$a = R_p, b = 0, c = 0, d = - 1/\omega C_g, e = R_0 + R_p, f = - \frac{1}{\omega C_g} - \frac{1}{\omega C_m}$

(6) becomes

$$0 > \frac{R_p}{\omega C_g} \left(R_0 + R_p\right) \left(\frac{1}{\omega C_g} + \frac{1}{\omega C_m}\right)$$

This is an impossible condition, and *no regenerative feedback can therefore occur when the input impedance is capacity and the load resistive.*

Case 8.—$Z_i =$ Capacity. $Z_o =$ Inductance.

$a = 0, \quad b = \omega L_p, \quad c = 0, \quad d = - 1/\omega C_g, \quad e = R_0, \quad f = - \frac{1}{\omega C_g} - \frac{1}{\omega C_m}$

(6) becomes

$$0 > \frac{\omega^2 L_p^2}{\omega C_g} \left(\frac{1}{\omega C_g} + \frac{1}{\omega C_m}\right)$$

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which is obviously impossible so that *no regeneration is possible with capacitive input and inductive load.*

Case 9.—Z_i = Capacity. Z_o = Capacity.

$$a = 0,\quad b = -\frac{1}{\omega C_p},\quad c = 0,\quad d = -\frac{1}{\omega C_g},\quad e = R_0,\quad f = -\frac{1}{\omega C_g} - \frac{1}{\omega C_m}$$

(6) now becomes

$$0 > \frac{1}{\omega^2 C_p{}^2} \cdot \frac{1}{\omega C_g}\left(\frac{1}{\omega C_g} + \frac{1}{\omega C_m}\right)$$

and regeneration is impossible, therefore, when the input and load impedance are both constituted as capacitances.

Summary of Cases where Feedback Occurs.

Of the above nine cases, only four present arrangements where regenerative feedback can take place. These are tabulated below with the necessary conditions for the existence of such feedback.

$Z_{input.}$	$Z_{output.}$	Condition for regenerative feedback.
Resistance $= R_g$	Inductance $= L_p$	$\omega^2 L_p C_m R_g < R_0$
Inductance $= L_g$	Inductance $= L_p$	$\omega^2 L_g C_m < 1$
Inductance $= L_g$	Resistance $= R_p$	$\omega^2 L_g C_m < 1$
Inductance $= L_g$	Capacity $= C_p$	$\omega^2 L_g C_m < 1$

Conditions for Maximum Feedback.

The condition for maximum feedback effect can be determined in any general case from (5) by noting that the real part of the latter expression must then be maximum. The condition is determined as usual by equating the first derivative to zero, and solving the resulting equation for the variable used in the differentiation. It is useful to examine the four special regenerative cases presented above in this way.

Case A.—Z_i = Resistance. Z_o = Inductance.

Applying the differentiation to the real part of (5), under consideration that the variable is the plate circuit reactance ($= \omega L_p = b$), and solving, we get as value of this reactance giving maximum feedback

$$b = \omega L_p = e\left\{\frac{c(f^2 + c^2) \pm \sqrt{c^2(f^2 + c^2)^2 + f^2(f^2 + c^2)(f^2 - 3c^2)}}{f(f^2 - 3c^2)}\right\} \quad . \quad (17)$$

or

$$\omega L_p = e\sigma = R_0\sigma \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (18)$$

wherein σ is the bracketed expression, and f, c, and e have the significance

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given above as

$$f = -\frac{1}{\omega C_m} \qquad c = R_g \qquad e = R_0$$

It is evident that this optimum value of ωL_p depends very materially upon the ratio of f to c, that is of the reactance of the grid-plate capacity to the supply circuit resistance. If we let $f = kc$ the value of σ can be written as a function of k

$$\sigma = \frac{(k^2+1) \pm \sqrt{(k^2+1)^2 + k^2(k^2+1)(k^2-3)}}{k(k^2-3)} \quad . \quad . \quad . \; (19)$$

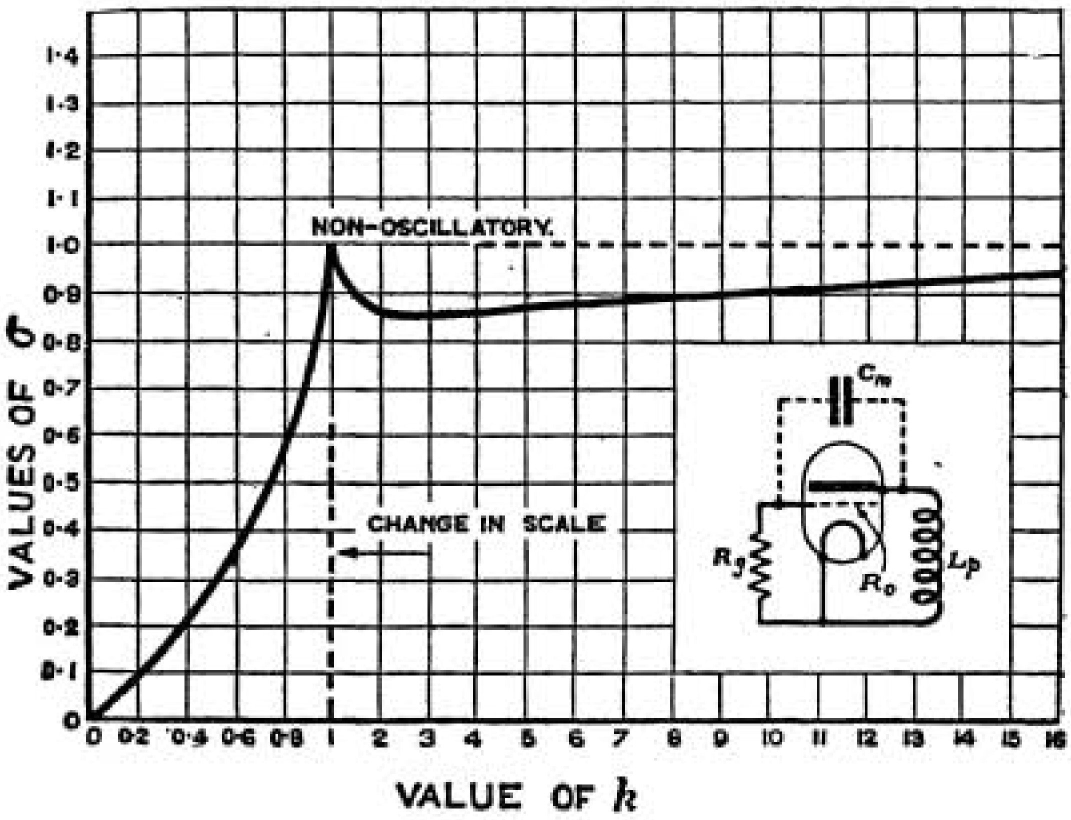

FIG. 3.—CONDITIONS FOR MAXIMUM FEEDBACK.

For oscillation $\omega L_p/k < R_0$ where $k = \frac{1/\omega C_m}{R_g}$.

In Fig. 3 this function is shown graphically for values of k from 0 to 15, and gives at once in terms of R_0 the value of plate circuit reactance required for maximum feedback. It will be noted that (19) is double valued. Only those values are plotted which fall within the feedback condition. When $k = 1$, that is $1/\omega C_m = R_g$, the value of ωL_p for maximum regeneration is just equal to the tube resistance R_0. This case is critical and does not feed back. A smaller value of ωL_p must, therefore, be used and the maximum feedback indicated cannot quite be obtained.

It has been pointed out that the real part of (5) is proportional to the feedback voltage. The value of this component has been calculated for different values of plate circuit load for the present case of resistance in the grid and inductance in the plate, and plotted in Figs. 4 and 5. The plate resistance is taken as 20,000 ohms, which corresponds to the standard Signal Corps type VT-1 receiving vacuum tube. As parameter is used the important ratio k of $1/\omega C_m$ to R_g. Fig. 4 is drawn for several cases where $1/\omega C_m$ is less than R_g, as for high frequencies, while Fig. 5 shows the conditions for $1/\omega C_m$

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greater than R_g as for low frequencies. The largest feedbacks are obtained when $1/\omega C_m$ and R_g are in the neighbourhood of equality with one another.

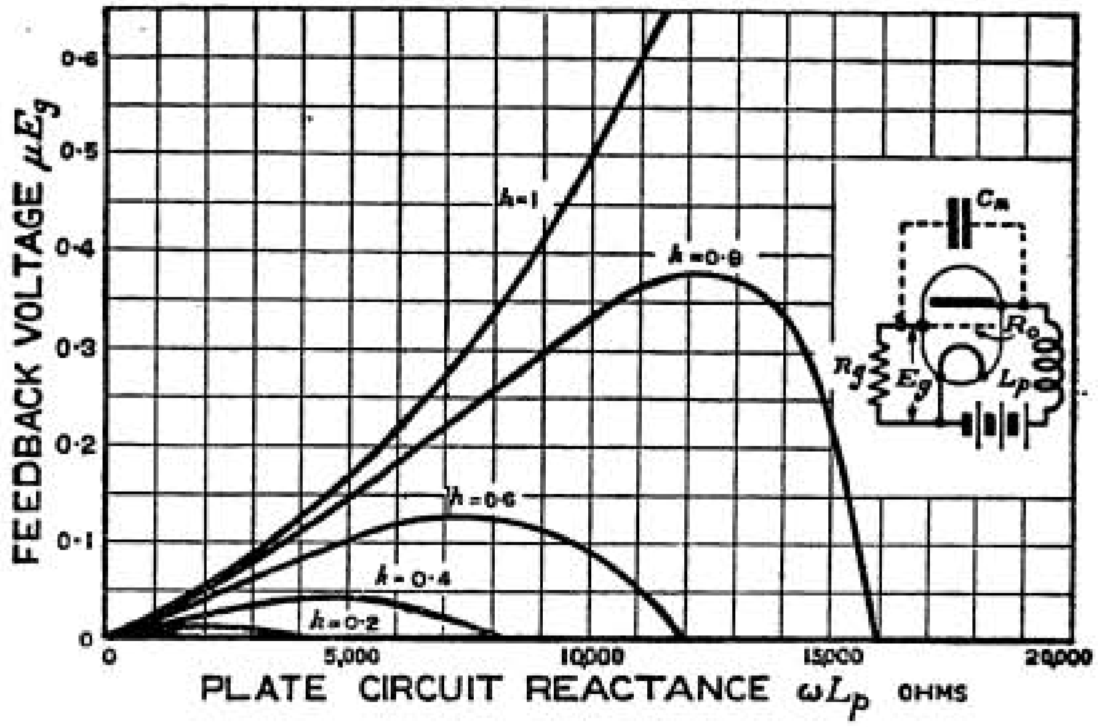

FIG. 4.—FEEDBACK VOLTAGES WITH VT-1 TUBE.

Cases for $1/\omega C_m < R_g$. $k = \frac{1/\omega C_m}{R_g}$ $R_0 = 20,000$ ohms.

For regeneration $\omega^2 L_p C_m R_g < R_0$.

The range of plate circuit load ωL_p over which feedback occurs, increases in general with increase in the ratio of $1/\omega C_m$ to R_g.

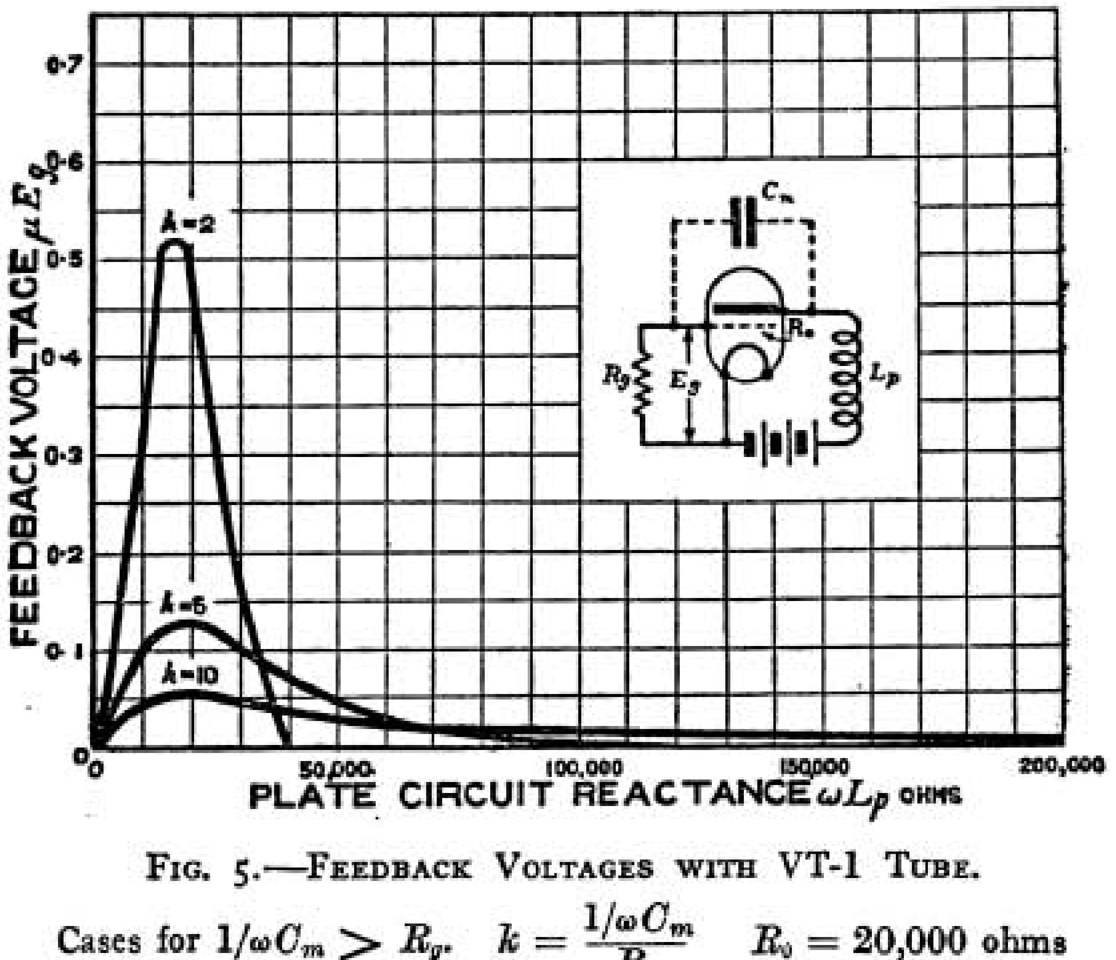

FIG. 5.—FEEDBACK VOLTAGES WITH VT-1 TUBE.

Cases for $1/\omega C_m > R_g$. $k = \frac{1/\omega C_m}{R_g}$ $R_0 = 20,000$ ohms

For regeneration $\omega^2 L_p C_m R_g < R_0$.

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Case B.—Z_i = Inductance. Z_o = Inductance.
In this case the feedback voltage (being the real part of (5)) becomes

$$E_g' = -\frac{b^2 d}{(b^2+e^2)f}\cdot \mu E_g \quad \ldots\ldots\ldots \quad (20)$$

where $b = \omega L_p, d = \omega L_g, e = R_0, f = \left(\omega L_g - \dfrac{1}{\omega C_m}\right) = d - f', f' = \dfrac{1}{\omega C_m}$
(20) can be put into the form (21)

$$E_g' = -\frac{b^2}{(b^2+e^2)\left(1-\dfrac{f'}{d}\right)}\cdot \mu E_g \quad \ldots\ldots \quad (21)$$

It is evident that the ratio of f' to d is important as regards the magnitude

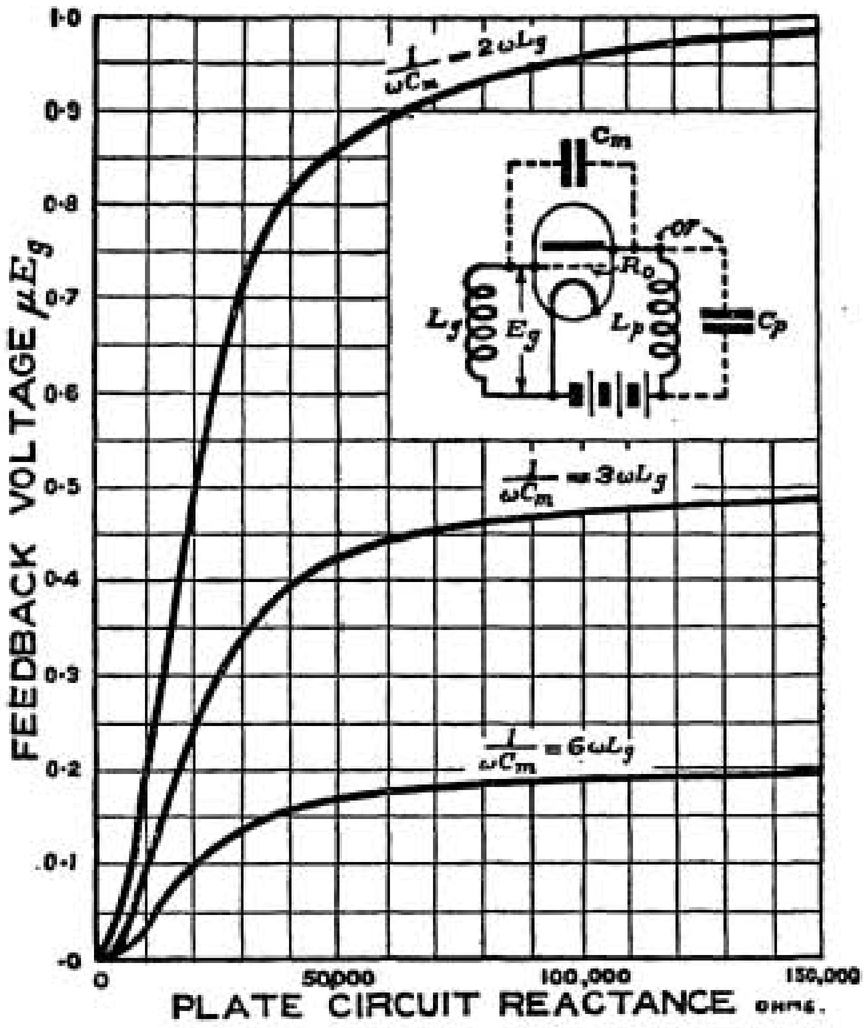

FIG. 6. — FEEDBACK VOLTAGES WITH VT-1 TUBE.
Plate Circuit Reactance = ωL_p or $1/\omega C_p$ ohms.
R_0 = 20,000 ohms. For Regeneration $\omega L_g < 1/\omega C_m$.

of feedback voltage. By (15), however, d must always exceed f' or the reaction will be counter-feedback. For all regenerative values of the ratio f'/d the feedback voltage increases with the plate circuit loading ωL_p ($= b$).

On Fig. 6 is plotted the feedback voltage E_g' as calculated from (21) for different values of f'/d and b. The curves resemble the magnetisation curves of iron in shape. The feedback voltage quickly approaches a limiting value

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and is not greatly increased by increasing the plate reactance beyond a certain point. For these calculations R_0 was taken as 20,000 ohms corresponding to the VT-1 tube.

Case C.—$Z_i =$ Inductance. $Z_o =$ Resistance.

The feedback voltage (real part of (5)) in this case is

$$E_g' = -\frac{ad}{ef} \times \mu E_g = -\frac{a}{e\left(1 - \frac{f'}{d}\right)} \cdot \mu E_g$$

$$= -\frac{R_p}{R_0 + R_p} \cdot \frac{1}{\left(1 - \frac{f'}{d}\right)} \cdot \mu E_g \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (22)$$

This is plotted on Fig. 7 for the VT-1 tube ($R_0 = 20{,}000$ ohms) as function of R_p, and with f'/d as parameter. It is seen that the feedback can be increased by either increasing the plate load R_p or the grid supply circuit reactance ωL_g.

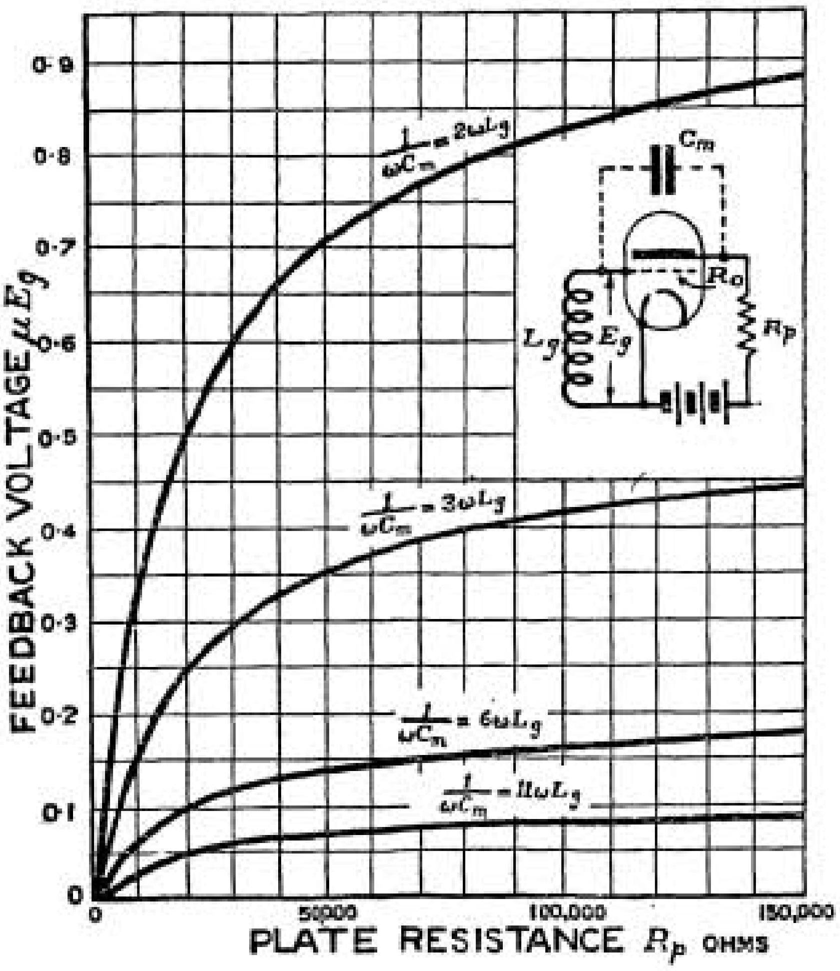

Fig. 7.—Feedback Voltages with VT-1 Tube.
$R_0 = 20{,}000$ ohms. For regeneration $\omega L_g < 1/\omega C_m$.

Case D.—$Z_i =$ Inductance. $Z_o =$ Capacity.

The expression for feedback voltage in this case is identical with that of case B wherein the plate load is an inductance instead of a capacity. The conclusions for case B, and the curves referring thereto (Fig. 6) apply without change to the present situation if the plate circuit inductive reactance of case B ($= \omega L_p$) is now replaced by the capacity reactance $-1/\omega C_p$.

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Local Errors in Radio Direction Finding.*

By J. HOLLINGWORTH, M.A., and B. HOYLE, M.Sc., A.M.I.E.E.

Now that radio direction finding, using multi-turn coils with a length of side of only a few feet, has become a practicable possibility owing to the use of powerful amplifiers, attention is directed to the question of the reliability of such sets under working conditions, and to a closer investigation of the errors which are found to arise. Such errors are of course due to a large number of different causes and some of them may be under the control of the operator, but some are certainly not. It is of great importance that both these types of error should be fully investigated, in order that it may be possible to foretell the conditions under which reasonably accurate work can be expected, and what precautions must be taken to ensure a definite standard of reliability being obtained. At present it is believed that these errors are due to two causes:—

(*a*) Deviation of the waves during their passage through space.

(*b*) Local interferences at the receiving end.

The first of these is probably incurable; it is at present under investigation by various observers, and a large amount of information in the form of observations has been obtained; but it is hardly yet possible to generalise from these, and state in detail the causes of such trouble, and the limitation they enforce upon satisfactory work.

It is the second of these causes which will be dealt with in this paper. There is no doubt that for theoretically perfect reception the receiving station should be at a large distance from anything in the nature of conductors or tuned circuits; but as this is not generally possible, it is important to see what effects may be expected to occur under any particular conditions. This problem has not yet been investigated on its own merits for two reasons.

First, it is in the nature of an error; and so any observer, whose immediate object is the investigation of some other problem, is merely concerned with the question of its elimination. In setting up a direction finding station for accurate measurements the most favourable site available is generally chosen. If, then, a difference is found to occur between the measured and the calculated directions of the various stations, the receiving gear is moved, or the most obvious causes of interference taken away and any errors which cannot thus be eliminated are treated as due to causes beyond control. So long as they are permanent and constant they are not serious, and can be allowed for as soon as the mean error has been determined by a large number of observations. The object in view in this case is always to eliminate the errors, not to examine them; and once the errors have been reduced to an extent which does not interfere with the experiment in hand, no further attention is paid to them. The second reason is that to produce artificially in a measured form all possible disturbing conditions to which a direction finding station might reasonably be expected to be liable in practice, would

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* Received May 14th, 1920.

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require enormous equipment and very great facilities. It seems, therefore, that the most practicable way of investigating this problem is by collecting together the results obtained by different observers during the time when they were setting up their stations and making preparations for their individual experiments. Each observer who finds such errors arising should take particular note of them, and of the methods which he used for their elimination. In this way a body of information could be collected from which it might be possible to deduce general laws. Such observations have been taken in many cases, especially where apparatus has been under design which would be required to work under specially unfavourable conditions; but in reading the literature of the subject the authors have been particularly struck with the enormous diversity of opinion on the magnitude and causes of such errors. They do not suggest that any of these observations are wrong, but that the favourable results obtained in some cases have been due to particular conditions which have not been fully investigated. Naturally, if only a small error is found when experience would seem to suggest that a large one was to be expected, this has been accepted as a fortunate circumstance, and the question of why the errors were unusually small in this particular case has not been investigated further. For instance, one observer states that a large aerial with a leading in wire, 20 feet from the coil even when tuned to the same wavelength as the coil, gave rise to an error not exceeding one-half of a degree; whereas one of the authors has met with a case in which an error of 4° was clearly produced by a tuned aerial at a distance of a quarter of a mile. They suggest therefore, that observers should take particular note of errors occurring in their own experiments, and publish them, so as to provide the body of information mentioned above.

Following out this idea the following paper merely recounts their personal experiences in this matter; and any general inferences which may be drawn from these results are only tentatively put forward.

It will probably be generally admitted that the ordinary local errors may be grouped under one or other of the following four headings; but the line of demarcation is not always very sharp.

(1) Masses of metal.
(2) Large conducting or partially conducting surfaces.
(3) Tuned circuits.
(4) Long distance overhead telegraph and telephone wires.

Section 1. Masses of Metal. (Especially iron; the extreme case being that of an iron ship.)—In this case an error appears to be always present, the order of it being not more than 10° under ordinary conditions. Such an error, so long as it is not affected by movable metal parts, can always be obtained by actual measurement and a correction chart supplied for directional work. It is only in the case where the movements of such parts produce changes in the correction that directional work becomes impossible. Experience seems to show that this correction is not seriously affected by the movement of any piece of metal-work of reasonable size, provided that it is some feet from the coil. As an instance of this may be taken the case of a coil inside the fuselage of an aeroplane and a coil on or above the deck of a

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battleship. In one particular instance of the former case where the coil was at the same level as the petrol tanks and only 4 or 5 feet from them, there was nothing in the general shape of the error curve to suggest that these large masses of metal, though close to the coil, were producing any individual effect. When, however, two bombs and two Lewis guns were mounted on the plane, the latter not more than 18 inches from the coil, obvious " humps " became visible on the correction curve. In the case of a two-engined aeroplane no special irregularity is noticed when one engine is nearly in line with the incoming waves. In the case of a battleship, if the coil is fitted in the space between the funnels about 30 feet above the deck, the necessary correction is uninfluenced by the movement of the guns. In this case, however, the error, though permanent, is large; and it has been found that by use of large coils on the Bellini-Tosi method, this permanent error is very much reduced. This again suggests that the errors produced are confined to a small space in the neighbourhood of the source of disturbance.

Variable errors have at times been obtained in aeroplanes; but are generally considered to be due to bad bonding of the bracing wires, which form large closed loops whose resistances vary with the state of the bond.

Section 2. Large Conducting Surfaces.—It is somewhat difficult to draw the line between (1) and (2). In this paper group 2 is intended to refer to the case of iron buildings in the immediate neighbourhood of the coil; or to the case of a coil used in or on a permanent building containing the usual metal-work. Under ordinary conditions no visible errors appear due to this cause, and two cases of this can be instanced. It was required to determine the correction curve of a flying boat at an aerodrome where the only firm ground in the neighbourhood available for the purpose was a space practically surrounded by large iron hangars at a distance of 50 to 100 yards. On a first inspection it was thought that this position was impracticable for the purpose, owing to deflection of incoming waves by the buildings; and that the boat would have to be tested at sea, which was not desired, owing to the many special difficulties of such an operation. On testing, however, with a small portable coil having an accuracy of 1°, receiving from stations in all directions, no measurable errors were noticed. In another case, a coil was mounted at the top of a building on a flat portion of a metallic roof, and, though it was quite unsymmetrically situated, no errors were visible. Inside an iron building it is a different matter, though the deviation does not appear to be very serious if the building is completely enclosed with metal-work; but in a metal shed with one end open, the waves from all stations appear to be deflected along the axis of the shed. Of course in ordinary circumstances no coil would be used in such conditions. In one case it was noticed that a copper mine caused bearings passing in the neighbourhood of it to be deflected about 3° and in another case such an effect is suspected, though the evidence is not conclusive.

Section 3. Tuned Circuits.—This heading includes both external circuits tuned to the same or nearly the same wavelength, and also radiation from parts of the receiving circuit itself. When using a transformer amplifier any movement of this may make considerable difference in the bearings,

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unless the amplifier is shielded or several feet from the coil. The objection to the former method is, that such shielding must be bulky and heavy, and if it is brought too close to the radiating coils of the amplifier, sufficient energy is absorbed from them to reduce the amplifying power considerably. It also tends to form a mass of metal in the immediate neighbourhood of the coil such as has been dealt with in section (1). The latter method involves the use of long leads, which, if close together, increase the capacity of the tuned circuit and if far apart tend to pick up energy on their own. Closed coils tuned to the same wavelength appear to have a serious effect at a distance of several feet; open aerials at a much greater distance. In the case of a coil underneath an aerial tuned to the same wavelengths as the aerial, incoming waves were deflected up to 45° in the direction of the aerial. With the coil slightly to one side of the aerial, all signals whose true direction was within 15° of the line from the coil to the leading-in wire of the aerial were deflected so as to appear to come directly from the leading-in wire. This wire was at a distance of about 150 yards from the coil. No visible effect is produced if the aerial is tuned to a wavelength greater than twice the wavelength of the coil, or if the aerial is insulated, or earthed in an untuned condition. In the case of an aerial at some distance (see Fig. 1) the following results have been obtained.

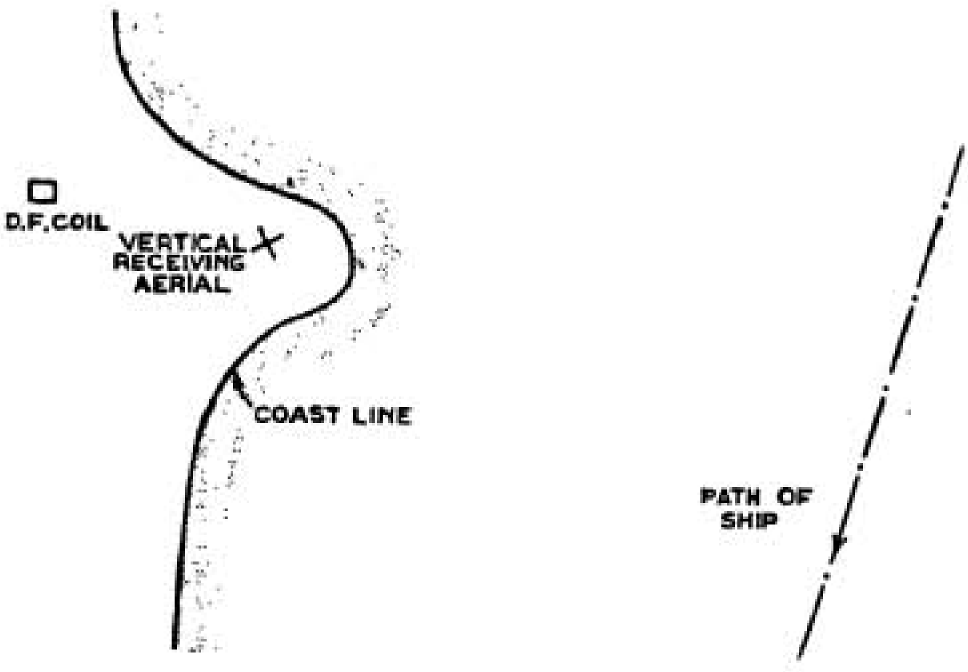


Fig. 1.

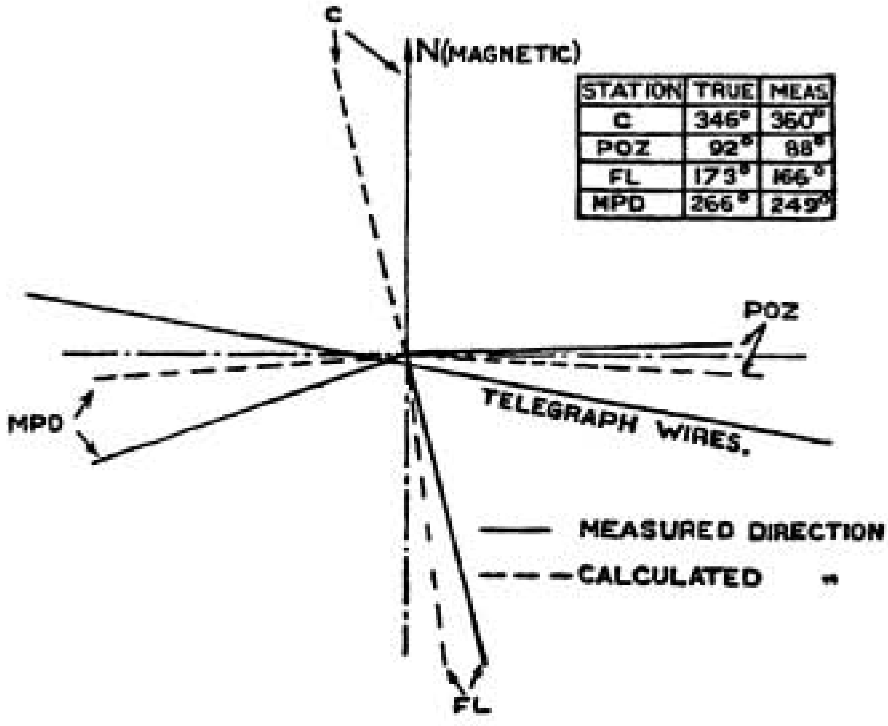
The coil was at a distance of a quarter of a mile from the aerial, and both were working on the same wavelength of 600 metres. Ships passed on the far side of the station from the aerial. When the observed angle subtended by the ship and aerial at the coil was about 4°, tuning in the station shifted the apparent bearing of the ship exactly on to the station. As before, no effect was noticed with an untuned aerial, whether earthed or insulated, proving that this effect was really due to the aerial, and not to any other local cause. This effect would of course diminish rapidly with increase of the angle subtended at the coil between the directions of the aerial and of the incoming waves, and it is probably due to this fact that the very large discrepancies of opinion which are referred to above have arisen. More information on this subject is required.

Section 4. Telegraph and Telephone Lines.—This is probably the most difficult case of all, from which to draw definite conclusions. It is not possible to remove or modify the arrangements of the wires in order to see to what extent they are the actual causes of the disturbances, and it is also impossible to obtain their electrical constants.

In certain definite cases very serious effects have been observed but there is nothing to show the limits within which such effects are likely to occur. The effect does not appear to be particularly due to single wire lines with an earthed return, as one of the worst cases noticed, which will be referred to in detail later, was that of a field telephone line wired with twin flexible not deliberately earthed at any point.

In many cases, however, sufficient capacity to earth is probably introduced through the telephone instruments themselves, especially if they are fitted with any kind of lightning protector, to make it possible for the line to be treated for W/T purposes, as if it were earthed at the end.

It is also uncertain whether the effect that occurs is due to the absorption of energy by the closed loop, or to a slight and very flat tuning effect which would give rise to re-radiation.



STATION	TRUE	MEAS
C	346°	360°
POZ	92°	88°
FL	173°	166°
MPD	266°	249°

Fig. 2.

The characteristic effect of the former is that the incoming signal is deflected in such a way as to make it appear to come from a direction more nearly at right-angles to the wire than its true direction, owing to the absorption by the wire of the component of the wave in the direction of its length while the component at right-angles to the wire remains unaltered. On the other hand the effect of re-radiation on a circuit close to the source is to increase this component and so turn the direction of the signal towards the direction of the wire as in the case of a coil to a tuned aerial. As far as is known very little organised attention has been devoted to this problem, but the following two illustrations of results obtained are given.

The first was obtained in an odd half hour while waiting for a certain station to start working for a special test. It was not possible to devote further time to it and the results were not followed up. A small directional coil being available, it was placed on the ground at various distances from a line of wires carrying about half a dozen ordinary post office circuits. In one direction these wires extended for several miles, in the other direction in about half a mile they crossed the mouth of a river by means of a submarine cable. Consequently at this end the capacity to earth was very high and for wireless purposes they may be considered to have been earthed. Several stations were sending from various directions and measurements were taken as is shown in Fig. 2.

The diagram is practically self-explanatory. The coil was on the north side of the wires at a distance of about 2 yards from the line of poles which were of the usual height. It shows that very large errors were produced; and with one exception, FL, the tendency was to divert all the directions towards the normal to the wires, but it is quite unsafe to generalise from such a small number of results. The coil was afterwards moved to a distance of 7 yards from the line of wires, but at that time only one station, POZ, was sending, and from a single result little information can be obtained.

Another interesting case is shown in Fig. 3. Four small temporary huts used for wireless purposes were linked up as in the drawing by a field telephone set, the wiring consisting entirely of twin wire carried either on temporary poles or on hedges. In hut A, there was a three line exchange and also the coil with which the tests were made. By operating this exchange the bearing could be shifted into almost any direction required. If all the lines terminating at A were left open the effect was quite small, but if hut B were switched to hut D, the direction of signals from Paris was shifted 14°.

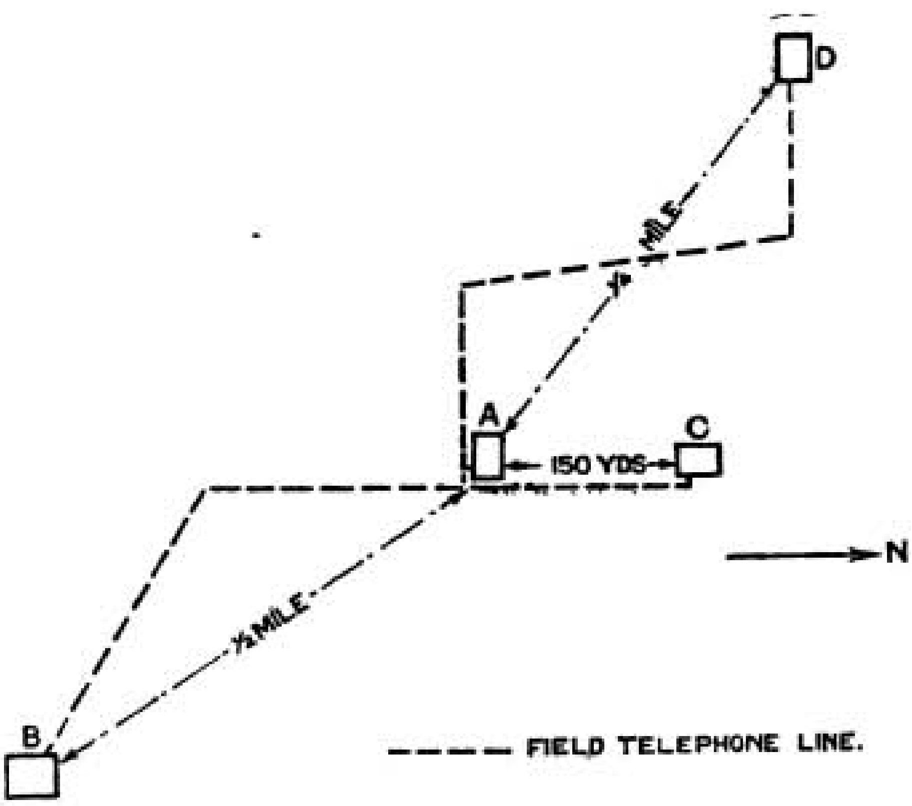


Fig. 3.

Other arrangements of the switchboard produced different deflections, none of which were quite so serious, but still were sufficient to make work impossible. A hut used for directional purposes nearly always required a telephone for convenience in operating and reporting, and this seems to show that for safety it is necessary that telephone lines must run underground for at least several hundred yards from the hut. The magnitude of the results is so difficult to foretell that it is necessary to err on the side of extreme caution.

To summarise, one may say that local variations may be due to a large number of causes· Some of these are permanent and consequently not so serious, but others, like the one last described, may vary without the knowledge of the operator and so lead to totally wrong inferences. Of course when a large permanent directional station is being erected it is generally possible to choose a site free from such troubles, but at the same time it is of great value to know the conditions under which it is possible to take temporary measurements with a reasonable degree of accuracy.

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An Elementary Method of Deducing the Effect of Resistance in Damping Oscillations.*

By E. GREEN, M.Sc.

If a circuit consisting of inductance L, capacity C, and resistance R is set in oscillation and afterwards left to itself the resultant variation of the current with time is as shown in Fig. 1. The usual method of determining the ratio of current amplitudes after any number of oscillations is by reference to the equation for current

$$i = I_0 \epsilon^{-bt} \cos pt$$

which in turn is obtained from the solution of a certain differential equation. But it is possible to find the ratio of current amplitudes from more elementary considerations with a fair degree of accuracy.

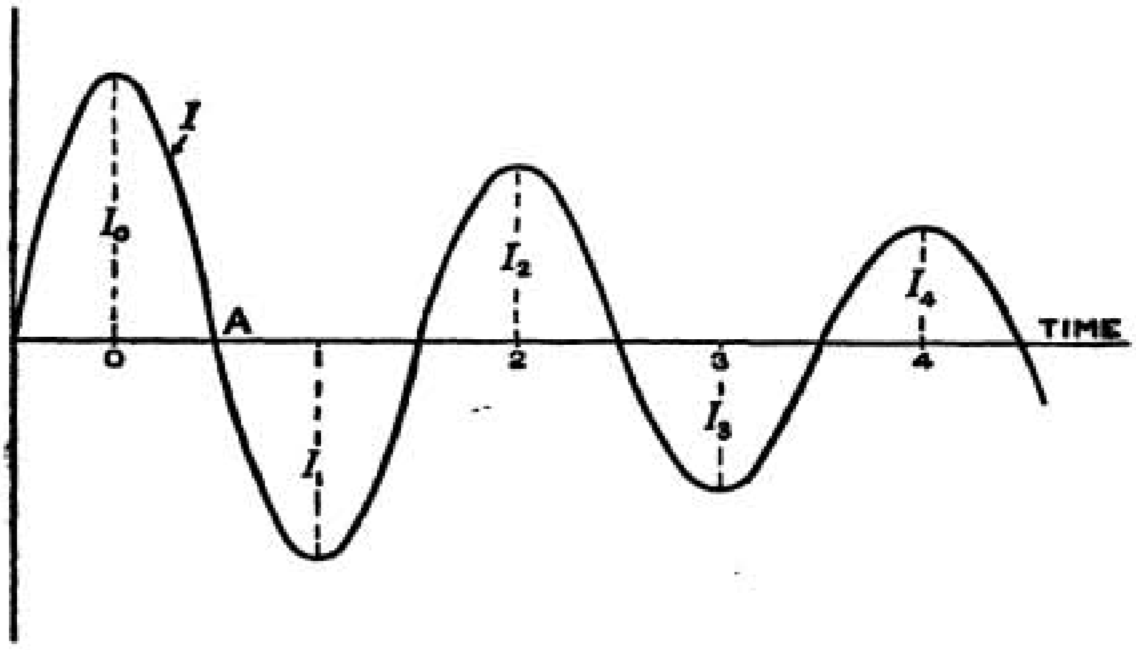

FIG. 1.

At the instants represented by 0, 1, 2, etc., when the current is a maximum, the voltage across the condenser is zero and the whole of the energy is concentrated in the inductance.

$$\text{Energy in circuit at } 0 = \tfrac{1}{2}LI_0^2$$
$$\text{,, \quad ,, \quad } 1 = \tfrac{1}{2}LI_1^2, \quad \text{etc.}$$

Between these two points the energy lost in resistance must be $\tfrac{1}{2}LI_0^2 - \tfrac{1}{2}LI_1^2$.

Let T = the time of one complete oscillation so that times from 0 to A and A to 1 are each $T/4$.

During the time 0 to A we can regard the current as a sinusoidal one with a maximum value I_0; and from A to 1 as having a maximum value I_1.

$$\therefore \text{ Resistance losses from 0 to A} = \tfrac{1}{2}RI_0^2 \times \frac{T}{4} = \frac{RT}{8}I_0^2.$$

$$\text{Similarly resistance losses from A to 1} = \frac{RT}{8}I_1^2.$$

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$$\therefore \tfrac{1}{2}LI_0^2 - \tfrac{1}{2}LI_1^2 = \frac{RT}{8}I_0^2 + \frac{RT}{8}I_1^2,$$ which on rearranging becomes

$$\tfrac{1}{2}LI_0^2\left\{1 - \frac{RT}{4L}\right\} = \tfrac{1}{2}LI_1^2\left\{1 + \frac{RT}{4L}\right\}.$$

Put $\frac{RT}{4L} = \delta$ which is the logarithmic decrement per half period, so that

$$\tfrac{1}{2}LI_0^2\{1 - \delta\} = \tfrac{1}{2}LI_1^2\{1 + \delta\}.$$

$$\therefore \frac{I_1}{I_0} = \sqrt{\frac{1-\delta}{1+\delta}} = k.$$

When R, L and T are known, δ and therefore k can be determined. The same reasoning holds good in the case of I_1 and I_2, etc.

$$\therefore \frac{I_1}{I_0} = \frac{I_2}{I_1} = \frac{I_3}{I_2} = \ldots\ldots = k$$

Hence $\frac{I_n}{I_0} = \frac{I_1}{I_0} \times \frac{I_2}{I_1} \times \ldots\ldots = k^n$ and can be determined.

It is of interest to see how closely these results agree with the more accurate formula.

$$\frac{I_1}{I_0} = \sqrt{\frac{1-\delta}{1+\delta}} = 1 - \delta + \tfrac{1}{2}\delta^2 - \tfrac{1}{2}\delta^3 + \ldots\ldots$$

From the accurate formula

$$\frac{I_1}{I_0} = \epsilon^{-\delta} = 1 - \delta + \tfrac{1}{2}\delta^2 - \tfrac{1}{6}\delta^3 + \ldots\ldots$$

Hence the error by the approximate method is of the order of $\frac{1}{3}\delta^3$.

δ	Error.
0·1	0·03 per cent.
0·2	0·3 ,,
0·3	1 ,,

The approximate formula is therefore accurate enough for all practical cases. It should be remembered however that in finding the value of k^n the percentage error will be approximately n times as large.

The chief interest of the approximate method lies in its showing clearly from the energy relations how the various constants of the circuits affect the damping.

[In applying the strictly accurate decrement formula to circuits containing a spark-gap, the assumptions made are so incorrect that the further assumption made in the above note is quite permissible.

We might point out however that in a damped oscillation the voltage across the condenser is not zero when the current is a maximum. The current begins to decrease as soon as the rate of energy transfer from the condenser to the magnetic field falls below the rate of energy dissipation in the circuit; at this moment $Ci\frac{dv}{dt} = i^2R$ and v cannot be zero.—EDITOR.]

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Measurement of the Field Strength at Leghorn of the Annapolis Signals. The Need for Further Research.

By THE EDITOR.

In August, 1919, measurements were made at the radiotelegraphic laboratory of the Italian Navy at Leghorn with the object of determining the strength of the electromagnetic field produced there by the transmitting station at Annapolis, U.S.A. The method adopted by Professor Vallauri was as follows:—Two single-turn vertical coils, triangular in shape and having each an area of 1,404 square metres, were supported by masts in such a way that one was in the great-circle plane through Leghorn and Annapolis, whilst the other was at right-angles thereto. The signals were therefore received only on the former, and, as tests with amplifiers proved, no trace of the signals could be detected on the latter. The receiving circuits are shown in Fig. 1. The primary circuit consists of one of the triangular aerials, eight

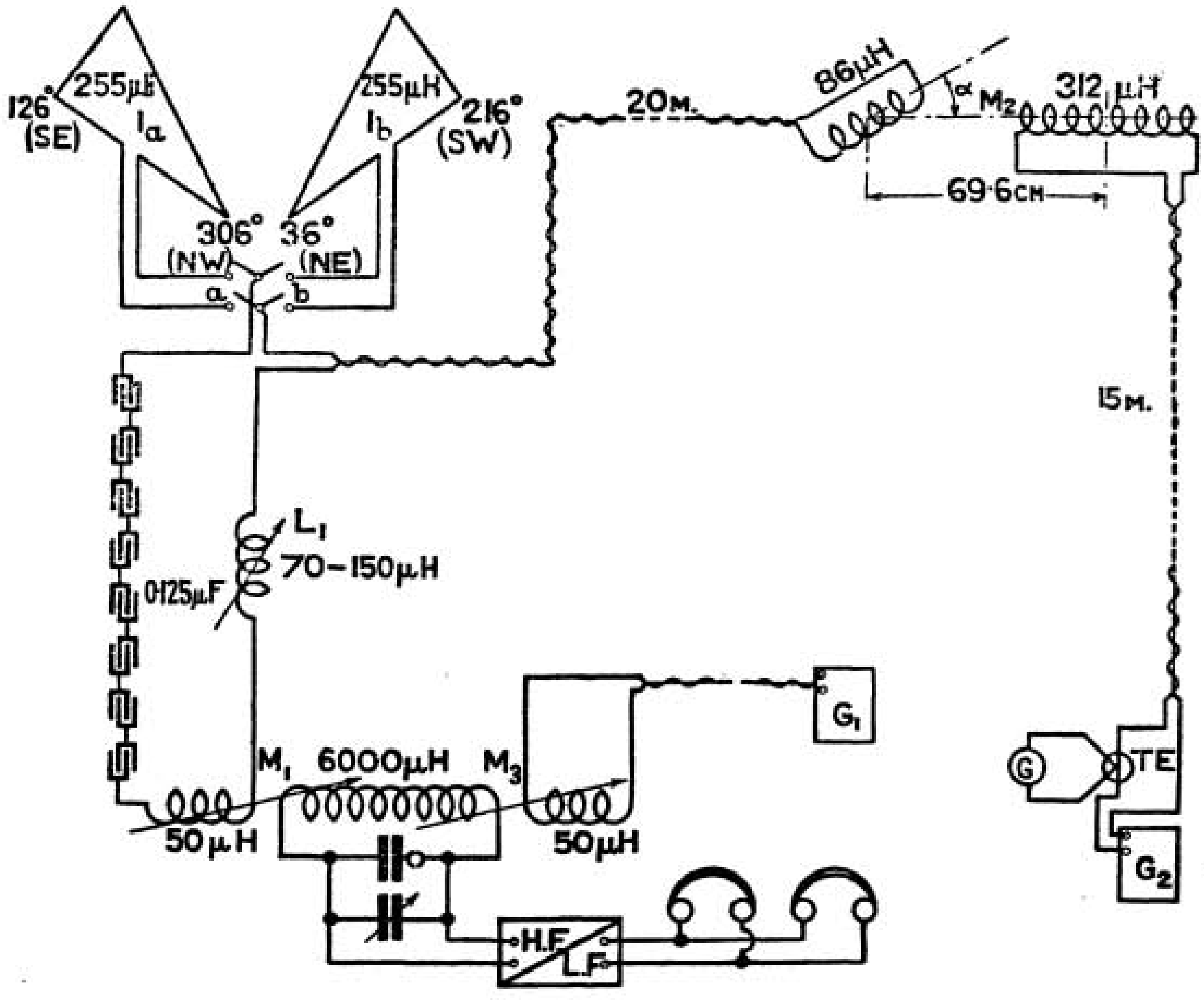

FIG. 1.

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condensers of 1 μF in series, a coupling coil of 50 μH, a variable inductance of 70—150 μH and a second coupling coil of 86 μH. The secondary circuit consists of an inductance of 6,000 μH, with the necessary condensers, across which is connected the amplifying detector set with six high frequency and two low frequency stages. G_1 is an oscillating valve set for independent heterodyne reception, whilst G_2 is a similar set, the output current of which is measured by means of the thermo-junction TE and galvanometer G. This current passes through the coil of 312 μH, which forms the primary of the variable and carefully calibrated mutual inductance M_2, of which the coil of 86 μH forms the secondary.

With the switch a b in one position and G_2 out of action, the signals from Annapolis are received and their pitch and intensity adjusted by means of the heterodyne generator G_1; with the switch in the other position, Annapolis cannot be heard, but G_2 is started up and its frequency adjusted until the same note is obtained in the receivers; the mutual inductance M_2 is then adjusted until the signals are equal in strength to those received from Annapolis, when the switch a b is in the other position. Knowing the value of the mutual inductance M_2 and the current in its primary coil, the E.M.F. induced in the aerial circuit can be calculated. With the switch a b in the other position the same E.M.F. must be produced by the Annapolis signals, and from the area of the aerial the strength of the electromagnetic field can be calculated. Precautions must be taken to ensure that no interference occurs due to mutual inductance between various parts of the circuits. Most of the measurements were made when the transmitting key at Annapolis was held down.

The effective height h of the Annapolis aerial is 0·107 km. and the current 280 amperes; hence $hI = 30$. The distance between Annapolis and Leghorn is 6,917 km.; the wavelength employed 17·3 km. Austin and Cohen had found that the received current was obtained by multiplying the value calculated on the assumption of a plane conducting earth and an ideal atmosphere of infinite extent by the exponential factor $\epsilon^{-0{\cdot}0015 D/\sqrt{\lambda}}$. **Professor Vallauri's measurements gave values of the electromagnetic field varying from 6 to 18 times as great as those calculated by the Austin-Cohen formula.** In view of this discrepancy Professor Vallauri sent us particulars of his experiments and data; we came to the conclusion that the results were probably correct, since, on trying various alternatives to the Austin-Cohen factor, we found that Vallauri's results were in excellent agreement with the exponential factor suggested by L. F. Fuller (*Proceedings of the American Institute of Electrical Engineers*, 34, pp. 567—585, April, 1915), viz., $\epsilon^{-0{\cdot}0046 D/\lambda^{1{\cdot}4}}$. We communicated this fact to Professor Vallauri, who has now published his results with the values calculated by the two methods in parallel columns (*L'Elettrotecnica*, 7, pp. 298—300, June 15th, 1920). Using the measured values of the field strength, he calculates the value of the product hI of the Annapolis aerial, which we know to be about 30. He gives 31 observations made at different times during the day and night; using Fuller's formula the calculated values vary between 24 and 75, whereas the Austin-Cohen formula

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gives values between 170 and 530, that is, about ten times the measured value. The Austin-Cohen formula would therefore lead to values 100 times too great for the necessary power required to produce the received signals.

Over what range of distances and wavelengths Fuller's factor is applicable there is not sufficient data to decide. For a wavelength of about 3·5 km. both formulæ give the same result, for longer wavelengths the Fuller formula is the more optimistic, whereas for shorter wavelengths the reverse is the case. In our last issue we gave tables and curves of the power required for long distance transmission based on the Austin-Cohen formula. We have recalculated the tables on the assumption that Fuller's formula is applicable throughout, and the results are embodied in Tables I. and II.

On comparing these tables with those given in our last issue, it will be seen that if Fuller's exponential be assumed, the calculated power required to cover distances of 5,000 to 10,000 km. is a mere fraction of that calculated

TABLE I.

Aerial power in kilowatts to give 0·37 microvolts per centimetre ($\beta = 0{\cdot}1$).

λ_m	D = 1,000 km.					
	γ = 0·5	γ = 0·75	γ = 1	γ = 2	γ = 3	γ = 5
0·5	—	—	—	2,230	140	45·5
1·0	—	—	405	8·07	5·8	9·8
2·5	14·1	1·26	0·585	0·695	1·47	5·0
5·0	0·234	0·124	0·126	0·388	1·06	4·26
10·0	0·051	0·052	0·071	0·313	0·94	4·02

λ_m	D = 2,000 km.						D = 3,000 km.					
	γ = 0·5	γ = 0·75	γ = 1	γ = 2	γ = 3	γ = 5	γ = 0·5	γ = 0·75	γ = 1	γ = 2	γ = 3	γ = 5
0·5	—	—	—	—	—	2,130	—	—	—	—	—	56,000
1·0	—	—	—	948	155·5	99	—	—	—	63,500	2,340	562
2·5	—	207	27·4	7	9·9	25·8	—	—	720	39·8	37·6	75
5·0	11	2	1·3	2·2	5·15	18·7	288	18·1	7·25	7·0	14·1	46·4
10·0	0·51	0·35	0·4	1·43	4·03	16·7	2·89	1·32	1·27	3·65	9·76	39

λ_m	D = 5,000 km.						D = 10,000 km.			
	γ = 0·5	γ = 0·75	γ = 1	γ = 2	γ = 3	γ = 5	γ = 1	γ = 2	γ = 3	γ = 5
1·0	—	—	—	—	290,000	10,050	—	—	—	—
2·5	—	—	274,000	710	298	346	—	291,000	16,400	4,930
5·0	110,000	835	129	39	58	155	53,000	773	617	1,000
10·0	52	10·4	7·05	13·2	31·5	116	159	101	183	555

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Table II.

Optimum wavelength and minimum aerial power in kilowatts to give 0·37 microvolts per centimetre ($\beta = 0{\cdot}1$).

D km.	$\lambda_m = 1$			$\lambda_m = 2{\cdot}5$			$\lambda_m = 5$			$\lambda_m = 10$		
	γ	λ	P	γ	λ	P	γ	λ	P	γ	λ	P
1,000	2·5	2·5	5·6	1·25	3·125	0·5	0·75	3·75	0·12	0·5	5·0	0·05
2,000	4·75	4·75	99	1·5	3·75	6·5	1	5·0	1·28	0·75	7·5	0·34
3,000	6·0	6·0	510	2·5	6·25	36	1·5	7·5	6·0	1·0	10·0	1·27
5,000	—	—	—	3·0	7·5	298	2·0	10·0	38	1·15	11·5	6·5
10,000	—	—	—	6·0	15·0	4,740	2·5	12·5	600	2·0	20·0	100

on the assumption that the Austin-Cohen factor is applicable. Here then is a subject for international research; the experiments described above show that the requirements in the way of aerials and instruments are very modest. There need be no fear of overlapping; in our present state of knowledge the more overlapping there is the better. There are two distinct lines of research: firstly, to determine what strength of electric field it is necessary for signals to have to enable them to be read at all times in spite of atmospheric disturbances, and secondly to determine the law according to which electromagnetic waves of various lengths are propagated around the earth. The former will depend on the locality, on the direction of the transmitting station, on the type of aerial and devices employed for eliminating interference, on the wavelength and speed of working, and on the interpretation of the words "at all times." The latter line of research will involve considerations of diurnal and seasonal variations, the nature of the surface and the direction of propagation with respect to the parallels of latitude. Until such researches have been carried out, the design of long distance wireless systems on scientific lines is obviously impossible.

The British Association for the Advancement of Science.

The annual meeting of the Association was held at Cardiff from August 24th to August 28th. The only paper bearing directly on radiotelegraphy was read before Section G (Engineering) by Professor Howe, on "The Efficiency of Aerials and the Power required for Long-distance Transmission." This covered the same ground as the editorial articles in our August and September issues and in this number. In Section A (Mathematics and Physics) Professor Whiddington read a paper on the measurement of small changes of length by means of the variation in the capacity of an air condenser when the distance between the plates is changed.

The change of capacity can be detected by using two separate oscillating valve circuits, one containing the experimental condenser and the other a fixed condenser. Any change of the capacity will cause a change of frequency and therefore a change in the beat note in a receiving circuit coupled to both oscillating circuits.

Professor S. Chapman read a paper entitled, "Terrestrial Magnetism, Auroræ, Solar Disturbance, and the Upper Atmosphere." Although dealing with the ionisation of the atmosphere from the point of view of its effects on terrestrial magnetism, the paper will prove of interest to those interested in the physics of long-distance wireless transmission and atmospheric disturbances.

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Review of Radio Literature.

1. Articles and Patents.

859. ON ARTIFICIAL LINES. J. Bethenod. (*Radioélectricité*, 1, p. 128, August, 1920.)

Considerable interest has recently been expressed in the use of various forms of filters, or filtering circuits, for eliminating, or at least reducing, the effects of disturbances, such as atmospherics, in wireless receiving. The author points out that these circuits are merely special cases of ordinary artificial lines, and proceeds to deduce the filtering action of such lines, taking a general case with inductance and resistance in the shunt paths, and resistance and capacity in the series circuit, employing the ordinary electrical theory of branched circuits. He concludes that in effect such circuits are equivalent to a series of ordinary inductively coupled circuits having coefficients of mutual inductance equal to the self-inductances of the shunt branches. From this point of view the presence of resistances are a disadvantage. The favourable action of the filters can only be obtained by a series of adjustments of each branch in turn, and the author is of the opinion that the equivalent series of inductively coupled circuits may possess advantages from the point of view of ease of adjustment.

860. ANTENNA CONSTANTS AND THE WAVELENGTHS OF ANTENNÆ. A. Press. (*Revue Générale de l'Électricité*, 7, pp. 547—552, April 24th, 1920. *Science Abstracts*, 23B, p. 323, Abstract No. 636, June 30th, 1920—Abstract. *Technical Review*, 6, p. 588, July 6th, 1920—Abstract.)

The author first points out the variation of the inductance per unit length of an aerial with the height of the point considered above the ground. An expression is given for this function, and from a consideration of curves plotted therefrom it is shown that the mean values of the inductance in henrys per cm. for a vertical and for a horizontal wire may be written in the following forms :—

$$L_1 = 4{\cdot}6 \times 10^{-9}\left\{\log_{10}\frac{2h_1}{a} - 0{\cdot}3\right\} \quad \text{(vertical)}$$

and

$$L_2 = 4{\cdot}5 \times 10^{-9}\,.\,\log_{10}\frac{2h_1}{a} \quad \text{(horizontal).}$$

The differential equations are developed for an inverted L type of aerial and an expression is derived for the equivalent impedance of the aerial as a whole. This last may be written in the form

$$Z_0 = -j\,\frac{1}{2\pi f(C_1 h)}.\Gamma \quad \text{ohms.}$$

where f is the frequency, C_1 is the capacity per unit length of the vertical portion, h is the overall length of the aerial and Γ represents the following function :—

$$\Gamma = \frac{L_2}{L_1}\cdot\frac{\pi}{2}\cdot\frac{\lambda_0}{\lambda}\cot\frac{\pi}{2}\cdot\frac{\lambda_0}{\lambda} = \frac{L_2}{L_1}\cdot\frac{2\pi h}{\lambda}\cot\frac{2\pi h}{\lambda}$$

For long wavelengths the equivalent impedance Z_0 becomes that of a pure capacity while for short wavelengths (less than the fundamental λ_0) Z_0 represents a pure inductance. Curves are given for the function Γ and also for the ratio of L'/l_0 where L' is the inductance added in

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series at the base of the antenna and l_0 is the inductance per unit length of the vertical portion multiplied by the total length of the aerial.

The method of determining the equivalent inductance and capacity of an aerial as outlined by Eccles, in which wavelength measurements are made with an added inductance in series with the aerial, is critically discussed, and finally a calculation is given for the ratio L_2/L_1 for a multi-wire aerial, L_2 being the inductance per unit length of the horizontal portion and L_1 the corresponding quantity for the vertical portion. This ratio is shown to approximate to the value

$$1 + \frac{0{\cdot}3}{\log_{10}\frac{2h_1}{a} - \frac{N-1}{N}\,.\,\log_{10}\frac{s}{a} - \frac{K_n}{N}}$$

where h_1 is the height of the horizontal portion above the ground, N is the number of wires in parallel, a is the radius of each wire, s is the width of the aerial and K_n is a factor dependent upon the number of wires. The values for this factor are tabulated below :—

N	K_n	N	K_n	N	K_n	N	K_n
		6	1·18	11	2·22	16	2·85
2	0	7	1·43	12	2·37	17	2·95
3	0·308	8	1·66	13	2·51	18	3·04
4	0·621	9	1·86	14	2·63	19	3·14
5	0·906	10	2·05	15	2·74	20	3·24

Some sample calculations illustrating the formulæ are included at the end of the article.

861. ABSOLUTE MEASUREMENT OF FREQUENCY OF ELECTRICAL OSCILLATIONS. J. Tykocinski-Tykociner. (*Science Abstracts*, 23A, p. 356, Abstract No. 909, June 30th, 1920—Abstract.)

See also RADIO REVIEW Abstract No. 328, May, 1920.

862. HIGH FREQUENCY RESISTANCE OF WIRES AND COILS. G. W. O. Howe. (*Science Abstracts*, 23B, p. 295, Abstract No. 585, June 30th, 1920—Abstract.)

See RADIO REVIEW Abstract No. 582, August, 1920.

863. THE LOW-FREQUENCY CYCLE IN MUSICAL SPARK TRANSMITTERS. F. F. Martens and G. Zickner. (*Jahrbuch Zeitschrift für drahtlose Telegraphie und Telephonie*, 15, pp. 266—288, April, 1920.)

A theoretical and experimental investigation of the conditions controlling the operation of a quenched spark transmitter with either one or two sparks per cycle. The wave forms of the currents and voltages were determined by means of a cathode ray oscillograph. A bibliography of the subject is given.

864. DIELECTRIC CONSTANT OF MARBLE. (*Zeitschrift für Instrumentenkunde*, 40, p. 119, June, 1920.)

A report of tests made at the Reichsanstalt. Natural marble absorbs moisture and its capacity depends on the frequency ; if paraffined before thorough drying it is even worse, but if thoroughly dried in vacuum (48 hours at 160°) and then paraffined its dielectric constant of 8·4 was independent of the frequency between $f = 146$ and $f = 572{,}000$.

865. SKIN EFFECT IN SQUARE WIRES. A. Press. (*Radio Review*, 1, pp. 466—467, June, 1920.)

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866. Measurements of the Electromagnetic Field due to an Aeroplane Transmitter. R. Baldus and R. Hase. (*Jahrbuch Zeitschrift für drahtlose Telegraphie und Telephonie*, 15, pp. 354—391, May, 1920.)

Signals were sent out from an aeroplane and the received strength determined at a ground station. A large number of experiments were made to determine the effects of distance, height, direction of flight, type of plane and aerial employed. Both vertical and horizontal receiving aerials were tried.

867. Reliable Method for the Approximate Determination of True Antenna Constants. A. Hund. (*Science Abstracts*, 23B, p. 63, Abstract No. 130, January, 1920—Abstract.)

See Radio Review Abstract No. 92, January, 1920.

868. Harmonic Oscillations in Directly Excited Antennas used in Radiotelegraphy. L. Lombardi. (*Science Abstracts*, 23B, pp. 107—108, Abstract No. 202, February, 1920—Abstract.)

See Radio Review Abstract No. 278, April, 1920.

869. Reinforced Harmonics in High-power Arc Transmitters. F. A. Kolster. (*Science Abstracts*, 23B, p. 112, Abstract No. 214, February, 1920—Abstract.)

See Radio Review Abstract No. 279, April, 1920.

870. An Oscillating Source for Radio Receiver Investigations. J. Weinberger and C. Dreher. (*Science Abstracts*, 23B, p. 163, Abstract No. 328, March, 1920—Abstract.)

See Radio Review Abstract No. 275, April, 1920.

871. Notes on the Measurement of Wavelength and High Frequency Inductance and Capacity. D. Williams. (*Wireless World*, 7, p. 582, January, 1920.)

The "double click" method of measurement is described.

872. On Measurement of Signal Strength. W. H. Eccles. (*Science Abstracts*, 23B, p. 166, Abstract No. 335, March, 1920—Abstract.)

See Radio Review Abstract No. 19, November, 1919.

873. The Measurement of High Frequency Resistance. (1) Comparison of Different Types of Winding. L. M. Clement. (*Everyday Engineering Magazine*, 9, pp. 156—158, May, 1920.)

A number of measurements are summarised in the form of curves relating to different types of windings. The advantages of banked windings as compared with ordinary layer windings are well illustrated.

874. Conductivity and Dielectric Coefficient of Dielectrics at High Frequencies. G. E. Bairsto. (*Revue Générale de l'Électricité*, 7, p. 153D, May 15th, 1920—Abstract.)

See Radio Review, 1, Abstract No. 473, July, 1919.

875. Applications of the Cathode Ray Tube in Radio Work. L. E. Whitmore and L. M. Hull. (*Revue Générale de l'Électricité*, 7, pp. 173D—174D, May 29th, 1920—Abstract.)

See Radio Review Abstract No. 181, February, 1920.

876. An A.C. Zero Method of Determining the Grid Sensibility of Amplifying Valves. W. Schottky. (*Telegraphen- und Fernsprech-Technik*, 9, pp. 31—32, May, 1920.)

The resistance x is adjusted until the alternator of telephonic frequency gives no sound in the telephone receiver T (see Fig. 1). Now $\delta i_p = \delta v_g \frac{\partial i_p}{\partial v_g} + \delta v_p \frac{\partial i_p}{\partial v_p}$.

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For no sound in the telephone, neglecting the resistance of the plate battery, $\delta v_p = 0$, $\therefore \delta i_p = \frac{\partial i_p}{\partial v_g} . \delta v_g$ but the A.C. grid potential $\delta v_g = \delta i_p \times x$, $\therefore \partial i_p / \partial v_g = 1/x$.

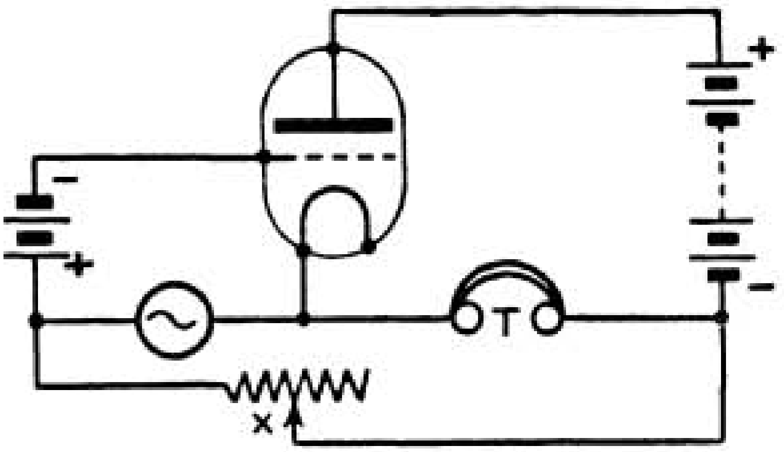

FIG. 1.

It is to be noted that by grid sensibility the author means the slope of the plate-current—grid-voltage characteristic.

877. THE CALIBRATION OF WAVEMETERS BY MEANS OF HIGHER HARMONICS.

R. von Ettenreich. (*Jahrbuch Zeitschrift für drahtlose Telegraphie und Telephonie*, 15, pp. 236—240, March, 1920. *Science Abstracts*, 23B, p. 360, Abstract No. 695, July 31st, 1920—Abstract.)

The frequency of a moderately high frequency generator, say 5,000 cycles per second is determined accurately by ordinary means. It is loosely coupled to the wavemeter by an intermediate non-oscillating circuit containing a rectifier, *e.g.*, a crystal detector. This causes a great number of harmonics which can be used to calibrate the wavemeter.

878. BUZZER FOR WIRELESS TELEGRAPHY.

C. Lorenz. (*German Patent* 301743, July 22nd, 1917. Patent granted October 1st, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, p. 503, June, 1920—Abstract.)

An electromagnetic buzzer the coil of which is provided with a closed yoke.

879. SPARK TRANSMITTERS.

Société Française Radio-Électrique. (*French Patent* 502159, March 18th, 1915. Published May 6th, 1920.)

The specification describes means of arranging spark producers for wireless telegraphy consisting of n spark producers in parallel. The discharges obtained at the said spark gaps are controlled so that each gap furnishes p/n discharges per second, p being the total number of discharges per second in the oscillating circuit. The control of the spark gaps is such that the discharges join up in the oscillation circuit and produce a frequency of discharge equal to p. No drawings are appended to the specification.

880. APPARATUS FOR PRODUCING ELECTRIC OSCILLATIONS.

M. Deutsch. (*British Patent* 137564, December 19th, 1918. Patent accepted January 22nd, 1920.)

This specification deals with apparatus for the production of high frequency oscillations in which a vibrating make-and-break contact is shunted by an oscillating circuit including a condenser and the primary winding of a transformer. Provision is made for a part only of the electromagnet winding operating the vibrating contact to be included in the circuit when an A.C. supply is used, whereas the whole winding is employed with a D.C. supply.

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881. QUENCHED GAP OPERATION. H. J. Tyzzer. (*Everyday Engineering Magazine*, 9, pp. 154—155, May, 1920.)

Deals with the use of quenched spark gaps fed from an induction coil for short-wave transmission.

882. ELECTRIC ARC OSCILLATION GENERATORS. P. O. Pedersen. (*British Patent* 136762, May 29th, 1919. Convention date, March 4th, 1919. Patent accepted, December 24th, 1919.)

With a view to increasing the efficiency of an arc oscillation generator particularly in cases when it is used in conjunction with aerials of small capacity, it is proposed to limit the movement of the arc on the cathode by means of appropriate local cooling, or by special shaping of the cathode and positioning with respect to the anode, or by the provision of appropriately placed jets through which gas (such as hydrogen, coal gas, alcohol, etc.) may be blown on to the arc. The cathode may also be water cooled if desired or may be cooled locally by contact with an auxiliary water-cooled tube so that its temperature may be adjusted to give any desired high ignition voltage.

883. VALVE TRANSMITTING APPARATUS. General Electric Company, U.S.A. (*British Patent* 139640, March 26th, 1919. Patent accepted March 11th, 1920.)

The essential features of the arrangement described are indicated in Fig. 2, which aims at enabling the ratio of capacity to inductance in the oscillating circuit to be adjusted to the value at which the valve operates most efficiently independently of the value of the aerial capacity. For this purpose the filament of the valve V is joined to the centre earthed point

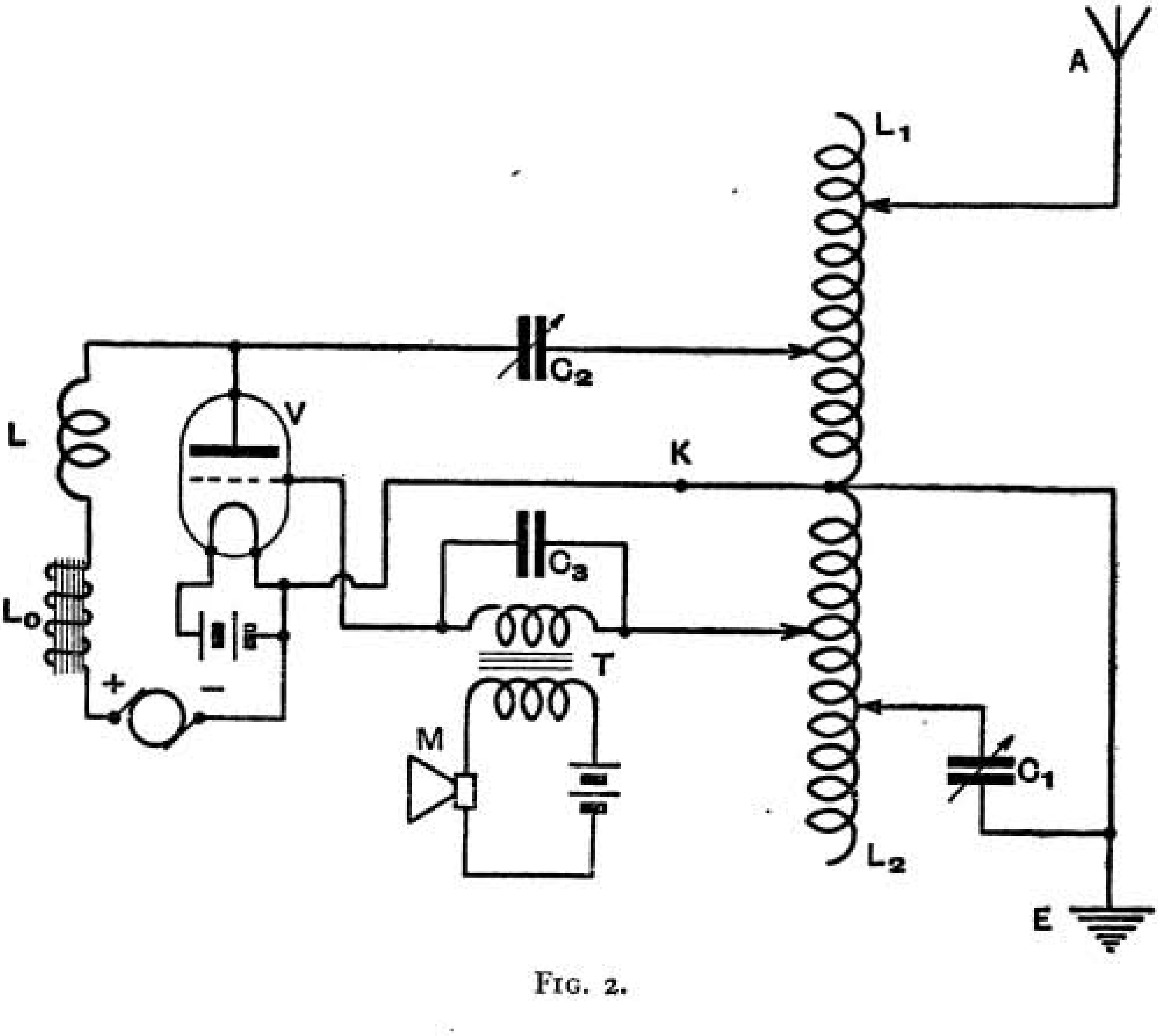

FIG. 2.

of the inductance L_1 L_2 which provides the reaction coupling between the grid and anode circuits of the valve as indicated. The aerial tapping should be made to the part of the coil which is included in the plate circuit and an auxiliary condenser C_1 is similarly connected to a tapping on the grid side to the coil and adjusted so that the capacity of the aerial circuit is compensated for. For radiotelephone transmission the transmitting microphone is coupled to the grid circuit through the transformer T in the usual manner. The direct current supply circuit for the valve includes the iron core choke L_0 and a special choke inductance L which is so designed as to be in resonance for the oscillation frequency so that it offers an almost infinite impedance to the passage of currents of that frequency. For telegraphic signalling the transformer T may be omitted and the signalling key connected at K while the iron core choke L_0 may also be omitted.

884. VALVE OSCILLATION GENERATORS. E. O. Scriven. (*British Patent* 140449, March 18th, 1920. Convention date, June 4th, 1917. Patent not yet accepted but open to inspection.)

In a three-electrode valve arranged for generating oscillations with a usual arrangement of reaction coupling, a high resistance is connected in series with the plate circuit so that the current in that circuit is maintained practically constant in spite of the slight alterations in the conditions of operation of the valve, etc. This resistance may be replaced by a large choking inductance so that the harmonics in the oscillation may be emphasised in the output circuit which supplies an amplifying valve. Currents of higher frequency than the fundamental may be obtained by providing the output circuit of this amplifying valve with a number of parallel branch circuits tuned respectively to the harmonic frequencies of the fundamental oscillations.

885. THERMIONIC VALVE OSCILLATION GENERATORS. R. V. L. Hartley. (*British Patent* 141046, March 30th, 1920. Convention date, June 1st, 1915. Patent not yet accepted but open to inspection.)

The circuit described for the generation of oscillations by means of a triode valve is the well-known one in which the reaction between the anode and grid circuits is provided by a condenser connected between the anode and the grid, there being no mutual induction between the inductances in the anode and grid circuits. See RADIO REVIEW, 1, pp. 577—584, September, 1920.

886. TRANSMITTERS. J. Bethenod. (*French Patent* 501512, December 31st, 1918. Published April 16th, 1920.)

The specification describes a method of coupling an aerial to a high-frequency alternator and the patent corresponds to British Patent 128575.*

887. HIGH FREQUENCY INDUCTOR ALTERNATORS. E. F. W. Alexanderson. (*British Patent* 141745, April 16th, 1920. Convention date, June 22nd, 1915. Patent not yet accepted but open to inspection.)

In a high frequency alternator of the well-known Alexanderson type provision is made for the connecting together of the non-magnetic slot filling plugs on the rotor by connecting rings to form short circuited windings for minimising the effect of armature reaction. The widths of the stator and of the rotor teeth should be such that as the rotor rotates the number of rotor teeth opposite any stator tooth alternates between $\frac{1}{2}(n+1)$ and $\frac{1}{2}(n-1)$ where n is any odd integer greater than one. In the example quoted in the specification $n = 3$ and the number of inductor teeth opposite the stator teeth varies between one and two. The frequency of the induced current is then three times the frequency that would be obtained if the rotor and stator teeth had the same pitch. This specification appears to cover the same ground as British Patent 13904/1915.

888. HIGH FREQUENCY VARIABLE RELUCTANCE ALTERNATORS. M. Osnos. (*L'Elettrotecnica*, 7, pp. 228—229, May 5th, 1920—Abstract.)

Abstract of paper from the *Jahrbuch der drahtlosen Telegraphie*, 13, p. 270, November, 1918, dealing with the Cail-Hermer and Guy alternators.

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* RADIO REVIEW Abstract No. 23, Nov. 1919.

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889. HIGH FREQUENCY ALTERNATOR WINDINGS. E. O. Turner. (*British Patent* 136215, November 14th, 1918. Patent accepted December 15th, 1919. *L'Électricien*, 51, p. 284, July 1st, 1920—Abstract.)

This specification relates to A.C. generators with a large number of field poles and provides for the use of an armature winding in which the pitch differs slightly from the pole pitch. The object of this arrangement is to overcome the distortion of the wave form usually obtained in machines having only one slot in the rotor per pole on the stator. In such machines there is usually no room for the insertion of more slots per pole if space is to be left for the windings themselves. By making the pole pitch on the rotor slightly different to the pole pitch on the stator, the E.M.F. induced in any one conductor is slightly different in phase from the E.M.F. induced in the next similarly disposed conductor of the same phase winding. If necessary some of the slots on the rotor may be left blank in order to obtain this type of winding, so that part only of the rotor periphery is utilised.

890. HIGH FREQUENCY MODULATING APPARATUS. R. A. Heising. (*British Patent* 140807, March 26th, 1920. Convention date, November 14th, 1914. Patent not yet accepted but open to inspection.)

For the modulation of a high frequency current it is proposed to include the plate circuit of a three-electrode valve in series with the output circuit of an amplifier connected to a source of high frequency oscillations. By modulating the potential of the grid of the controlling valve the amplitude of the high frequency current pulses flowing through the plate circuit of this valve may be controlled, and thus the oscillations in the aerial or other apparatus which is coupled to that circuit may likewise be modulated.

891. HIGH FREQUENCY MODULATING APPARATUS. H. J. van der Bijl. (*British Patent* 141732, April 15th, 1920. Convention date, August 1st, 1915. Patent not yet accepted but open to inspection.)

A triode valve used as an amplifier is arranged for modulating the high frequency output oscillations by coupling to its grid circuit both the modulator (microphone or signalling key) and the source of high frequency oscillations. The output circuit of the amplifying valve is coupled to the transmitting aerial circuit. For best results the potential applied to the grid circuit by the signalling current should be from three to ten times as much as that from the high frequency source.

892. GASEOUS TELEPHONE TRANSMITTERS. R. A. Engler. (*Electrical Experimenter*, 7, pp. 1154—1155 and 1200—1202, March, 1920.)

The author describes telephone transmitters suitable for wire or wireless work in which a magnet attached to the diaphragm is used to vary the conductivity of a tube containing ionised gas through which the current to be modulated is passed. The ionisation may be obtained from an auxiliary arc, from a hot filament, by X-rays and by any other well-known method. Various modifications are described including one in which it is suggested that the magnet attached to the transmitting diaphragm may be used to vary the position of the grid wire in a three-electrode tube.

893. TELEPHONE RELAYS. J. B. Pomey. (*Revue Générale de l'Électricité*, 7, pp. 665—669, May 15th, 1920. *Technical Review*, 6, p. 589, July 6th, 1920—Abstract.)

This article describes a number of different arrangements of telephone repeaters dealt with in various French and other patents. Both single-way and two-way repeaters are described.*

894. TELEPHONE RECEIVERS. S. G. Brown. (*British Patent* 134353, November 9th, 1918. Patent accepted November 6th, 1919.)

Special constructional arrangements for telephone receivers are described.

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* See also RADIO REVIEW Abstract No. 515, July, 1920.

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895. TELEPHONE TRANSMITTERS. P. L. Jensen. (*U.S. Patent* 1332973, January 2nd, 1918. Patent granted March 2nd, 1920.)

In conjunction with a microphone transmitter in which the diaphragm is exposed to noise vibrations on both sides, means are provided for supporting the mouthpiece at the correct distance from the speaker's mouth by means of suitably shaped pads and an attachment to speaker's head.*

896. TELEPHONE REPEATERS. B. Gherardi and F. B. Jewett. (*Annales des Postes, Télégraphes et Téléphones*, 9, pp. 68—135, March, 1920.)

A reproduction of a paper read before the American Institute of Electrical Engineers. See RADIO REVIEW Abstract No. 228, March, 1920, for abstract.

897. TELEPHONE REPEATERS. M. Latour. (*British Patent* 140506, December 5th, 1918. Convention date, December 5th, 1917. Patent accepted April 1st, 1920.)

Various arrangements of three-electrode valve repeaters for telephone lines are described and formulæ are given for calculating the best arrangements and windings for the coupling transformers.

898. A ONE-TUBE RADIOTELEGRAPH AND RADIOPHONE TRANSMITTER. P. H. Boucheron. (*Electrical Experimenter*, 8, pp. 57 and 107—109, May, 1920.)

Constructional details are given for a transmitting set employing any ordinary receiving type of three-electrode tube.

899. SOME LONG-DISTANCE RADIOTELEPHONY TESTS. R. F. Gowen. (*Electrical Experimenter*, 7, pp. 1281 and 1326, April, 1920.)

Details are given of some long-distance tests made by the de Forest Radio Telephone Company using a 1 kW. three-electrode valve transmitter. A range of 1,500 miles was obtained using less than 300 watts.†

900. A HIGH POWER WIRELESS TELEPHONY INSTALLATION. F. P. Swann. (*Wireless World*, 8, pp. 76—79, May 1st, 1920. *Technical Review*, 6, p. 548, June 22nd, 1920—Abstract.)

See also RADIO REVIEW Abstract No. 901 for further reference to the same apparatus.

901. WIRELESS TELEPHONE PROGRESS. (*Electrician*, 84, pp. 568—570, May 21st, 1920. *Technical Review*, 6, p. 558, July 6th, 1920—Abstract.)

Describes the latest developments of wireless telephone transmitting apparatus by Marconi's Wireless Telegraph Company. A 6 kW. and a 15 kW. set are described and illustrated.‡

902. THE ACTION OF THE WIRELESS TELEPHONE. R. A. Mallett. (*Model Engineer*, 42, pp. 484—485, May 20th; pp. 500—502, May 27th; pp. 536—541, June 10th; pp. 560—562, June 17th; pp. 578—580, June 24th, 1920.)

A brief *résumé* of the principles of operation of the wireless telephone apparatus including descriptions of several leading circuits using three-electrode valves.

903. APPARATUS FOR CONTROLLING ELECTRICAL ENERGY IN SIGNALLING SYSTEMS. C. D. Ehret. (*La T.S.F. Moderne*, 1, pp. 61—62, May, 1920—Abstract.)

See RADIO REVIEW Abstract No. 340, May, 1920.

904. CONSTRUCTION OF A SIMPLE RADIO TELEPHONE. E. S. Rogers. (*Radio Amateur News*, 1, p. 343, January, 1920.)

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* See also RADIO REVIEW Abstract No. 341, May, 1920.

† See also RADIO REVIEW Abstracts Nos. 614 and 618, August, 1920.

‡ See RADIO REVIEW Abstract No. 900, this issue, for further references.

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905. DUPLEX WIRELESS TELEPHONY. General Electric Company, U.S.A. (*British Patent* 141386, October 30th, 1916. Patent accepted April 22nd, 1920.)

Describes an arrangement for duplex wireless telephony using separate aerials for transmission and reception at each station, and with a telephone circuit connected to the two aerials *via* a telephone exchange and a magnetic modulator. Different frequencies are used for transmission and reception.

906. WIRELESS TELEGRAPH STATIONS. H. J. J. M. de R. de Bellescize. (*British Patent* 134497, May 24th, 1919. Convention date, January 22nd, 1919. Patent accepted November 6th, 1919.)

In a duplex or multiplex wireless station using a main transmitting aerial in conjunction with one or more distant receiving aerials it is proposed to link up the receiving sets with the transmitting station direct so that the incoming messages are received at the transmitting station. For this purpose the receiving apparatus may be coupled through some form of repeater to a telephone line connecting the two stations. It is suggested that a convenient repeater for this purpose would be some form of microphone repeater in which the incoming signals after detection influence acoustically a microphone connected to the telephone line between the two stations. By this means the complete receiving apparatus may be enclosed in a metallic box and the acoustic vibrations made to affect the microphone through a perforated or gauze window.

907. SIMULTANEOUS SENDING AND RECEIVING. E. F. W. Alexanderson. (*Génie Civil*, 76, p. 195, February 14th, 1920. *Revue Général de l'Électricité*, 7, p. 132D, April 24th, 1920—Abstract.)

See RADIO REVIEW Abstract No. 75, December, 1919.

908. WIRELESS SIGNALLING SYSTEMS. Siemens and Halske Akt. Ges. (*British Patent* 142846, May 5th, 1920. Convention date, April 24th, 1918. Patent not yet accepted but open to inspection.)

This specification deals with a system of radio signalling in which a definite group frequency is employed distinct from the wave frequency and the signalling or tone frequency, the group frequency being intermediate in value between the other two frequencies. In the case of a C.W. transmitter the term tone frequency would be taken to refer to the time period of the shortest signalling dot and in the case of musical spark telegraphy to refer to the period of the audible tone. In order to secure the maximum effects at the receiver it is desirable that the group frequency and the damping of the circuits at the transmitter and receiver should be such that the oscillations in the transmitting aerial are just able to build up to their maximum amplitude in the period of each group and similarly that the oscillations induced in the receiving circuits are also able to build up to their maximum amplitude during the time period of each group.

The group frequency may be obtained by modulation of the amplitude of the high-frequency oscillations set up in the transmitting aerial by any well-known means. At the receiver the aerial and secondary circuit coupled thereto are tuned to the wave frequency and the resulting oscillations then rectified by means of a suitable detector. The output circuit of this detector is tuned to the group frequency and the damping of the circuit is adjusted so that the oscillations of the group frequency set up therein are just enabled to build up to their maximum amplitude in the duration of the shortest signalling dot used, or during the tone period in the case of musical spark telegraphy. These oscillations of the group frequency may be rectified by a second detector the output of which may either directly influence a telephone receiver or may be transferred to a third circuit tuned to the audible tone frequency in the case of musical spark telegraphy.

It is stated to be preferable that the group frequency be made equal to the geometric mean between the wave frequency and the signal or tone frequency, since the damping factors of all circuits may then be as high as possible with a minimum loss of energy.

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909. Electric Discharge Apparatus. H. C. Rentschler. (*British Patent* 139514, February 27th, 1920. Convention date, February 27th, 1919. Patent not yet accepted but open to inspection.)

A special three-electrode valve is described in which the grid is maintained at a positive potential with respect to both the plate and the filament, the plate being at a smaller positive potential with respect to the filament. Argon or a metallic vapour which exhibits the phenomenon of resonance potential is used in the valve. It is stated that the apparatus may be used as a detector, amplifier or frequency doubler, and that its mode of operation depends upon the varying conditions of the impact of the electrons on the gas molecules with the potential applied to the grid.

910. Electric Discharge Apparatus. H. C. Rentschler. (*British Patent* 139518, February 27th, 1920. Convention date, February 27th, 1919. Patent not yet accepted but open to inspection.)

An addition to British Patent 139514 (Radio Review Abstract No. 909) describing a similar three-electrode valve with the positions of the electrodes and the value of the grid and plate voltages adjusted so that the maximum effect due to resonance potential of the gas molecules occurs when the anode current is just beginning to diminish owing to secondary emission of electrons from its surface.

911. Electric Discharge Apparatus. P. Schwerin. (*British Patent* 143262, May 14th, 1920. Convention date, November 1st, 1916. Patent not yet accepted but open to inspection.)

For the purpose of maintaining cool the anode of a thermionic valve it may be constructed in the form of a tube through which a cooling liquid such as water or oil may be circulated. The tube may be arranged in the form of a helix in the case of a cylindrical type of valve or in the form of a zig-zag in the case of a flat type of valve. The ends of the tube may be brought out through the seals at the ends of the valve for the purpose both of introducing the cooling liquid and for making connection to the anode.

912. Electric Discharge Apparatus. H. W. Weinhart. (*British Patent* 143519, May 17th, 1920. Convention date, November 1st, 1915. Patent not yet accepted but open to inspection.)

An addition to British Patent 143262 * providing for an alternative arrangement for cooling the anode of a triode valve. It is proposed to construct the anode in the form of a cylindrical tube one end of which opens outside the valve and is sealed to the walls of the valve, while the inner end of the tube is closed and a smaller tube is passed up the centre of the main anode tube so that circulating water or oil for cooling purposes may be passed up the central tube returning by the angular space between the two tubes. The grid is wound around the anode tube and insulated from it while the filaments are supported on the outside of the anode and grid by means of suitable glass supports.

913. The Manufacture of Amplifying Vacuum Tubes. E. Rüchardt. (*Science Abstracts*, 23B, pp. 170—171, Abstract No. 343, March, 1920—Abstract.)

See Radio Review Abstract No. 286, April, 1920.

914. Vacuum Valves. S. Dushman. (*British Patent* 139748, July 30th, 1919. Convention date, March 4th, 1919. Patent not yet accepted but open to inspection.)

A special construction for three-electrode valves is described in which the cylindrical anode is provided with heat radiating fins extending outwards from its outer surface in a radial direction. These fins may also be employed for supporting the anode.†

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* See Radio Review Abstract No. 911.

† See also Radio Review Abstract No. 916.

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915. THERMIONIC VALVE APPARATUS. Siemens-Schuckertwerke. (*British Patent* 141706, April 12th, 1920. Convention date, January 27th, 1917. Patent not yet accepted but open to inspection.)

In the apparatus described the cathode is in the form of a cylindrical tube placed inside and concentric with the cylindrical anode and heated by electronic bombardment from a filament placed within it. It is stated that with four amperes through the internal filament, and with a voltage of 630 volts between the filament and the cathode, the cathode tube will be maintained at a temperature of about 2000° C.

916. THERMIONIC VACUUM VALVES. General Electric Company, U.S.A. (*British Patent* 140166, February 10th, 1919. Patent accepted March 25th, 1920.)

A special construction of cylindrical anode is described provided with external projecting strips for attachment to the supports.*

917. IMPROVEMENTS IN THREE-ELECTRODE VACUUM TUBES. J. Erskine-Murray. (*Science Abstracts*, 23B, p. 110, Abstract No. 206, February, 1920—Abstract.)

See RADIO REVIEW Abstract No. 351, May, 1920.

918. NOTES ON THE PHYSICS OF THE THERMIONIC VALVE. T. G. Petersen. (*Wireless World*, 7, pp. 566—572, January; pp. 638—644, February; pp. 686—690, March, 1920. *Technical Review*, 6, p. 342, April 13th, 1920—Abstract.)

The author first summarises the kinetic theories leading up to the emission of electrons from hot metals in a vacuum and thence to the reasons for the use of tungsten filament for such purposes. The effect of the grid is considered in detail by graphical methods showing the potential gradient between the filament and the anode. The effect of altering the grid diameter and mesh is shown by these curves as well as the influence of the distance between the anode and the filament. A summary is given of the methods by which the operating constants—plate current, amplification factor, internal resistance, etc., may be determined from the structural dimensions; and finally various methods of exhaustion are summarised. This last section includes a description of the Langmuir condensation pump and of the method of freeing the electrodes and glass from absorbed gases by electronic bombardment.

919. HARDENING AND SOFTENING OF IONIC TUBES. W. H. Eccles; C. L. Fortescue and C. B. Bryan; B. S. Gossling. (*Technical Review*, 6, p. 301, March 30th, 1920—Abstract.)

See RADIO REVIEW, 1, pp. 103—104, November, 1919; p. 160, December, 1919; and pp. 261—264, February, 1920.

920. EFFECT OF THE POTENTIAL DROP ALONG THE FILAMENT OF A VALVE ON ITS SENSITIVENESS AS A DETECTOR. E. Green. (*Science Abstracts*, 23B, p. 222, Abstract No. 434, April, 1920—Abstract.)

See RADIO REVIEW, 1, pp. 276—278, March, 1920, for original paper.

921. THE OSCILLATING TRIODE. R. C. Clinker; R. Whiddington; W. H. Eccles. (*Radio Review*, 1, pp. 159—160, December, 1919; pp. 211—212, January, 1920.)

922. AN INVESTIGATION OF THE INTERNAL ACTION OF A TRIODE VALVE. W. H. Eccles. (*Science Abstracts*, 23B, p. 171, Abstract No. 344, March, 1920—Abstract.)

See RADIO REVIEW Abstract No. 425, June, 1920.

923. QUANTITATIVE STUDY OF TRIODE GENERATORS WITH THE AID OF OSCILLATION CHARACTERISTICS. H. G. Möller. (*Science Abstracts*, 23B, pp. 110—111, Abstract No. 208, February, 1920—Abstract.)

See RADIO REVIEW Abstract No. 293, April, 1920.

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* See also RADIO REVIEW Abstract No. 914.

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924. Triode Nomenclature and Symbols. L. B. Turner; E. V. Appleton; C. L. Fortescue; A. Press. (*Radio Review*, 1, pp. 314—316, March, 1920; p. 368, April, 1920; pp. 417—418, May, 1920; p. 472, June, 1920.)

925. On the Input Impedance of the Thermionic Amplifier. S. Ballantine. (*Physical Review*, 15, pp. 409—420, May, 1920.)

At low frequencies the input impedance of the three-electrode vacuum tube behaves as a pure capacity. At radio frequencies due to the internal capacity between the grid and plate electrodes, the input impedance resembles the combination of a condenser shunted by a conductance. The effective capacity and conductance of the input circuit are then functions of the load in the plate circuit. An inductive load may give rise to a negative input impedance and consequent feed-back or regenerative effects. These effects may be of especial importance in the design of cascade amplifiers.

For the purpose of the mathematical development the input impedance is defined as the ratio of the impressed E.M.F. to the current in the grid circuit, this current arising partly through the direct effect of the applied E.M.F. and partly through the feed-back effect of the grid-plate capacity of the valve. The input impedance Z_0 may be expressed as $g + j\omega C$ where g and C represent the effective conductance and capacity respectively. Equations are developed for the general case in which the load in the plate circuit consists of an inductance L in series with resistance R. In this case if the inductance is large its self-capacity becomes additive to the plate-filament capacity of the tube if the external resistance in series with it

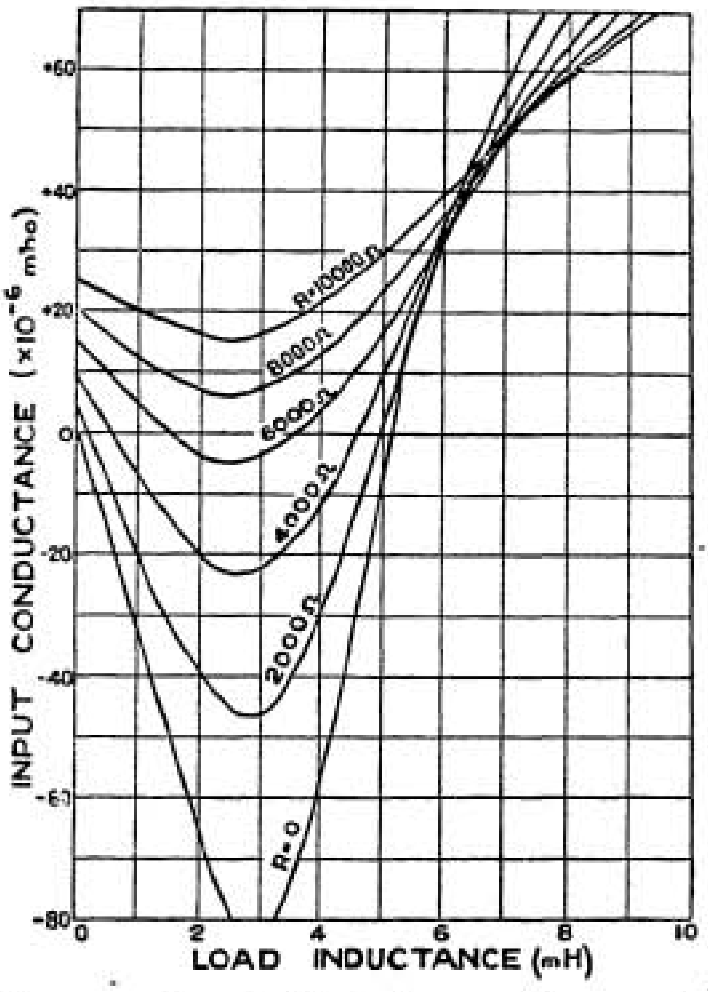

Fig. 3.—Input Conductance Curves for Composite Load, $Z = R + j\omega L$.
$\omega = 3 \times 10^6$; $\lambda = 627$ m.
Values of R are marked on the curves.

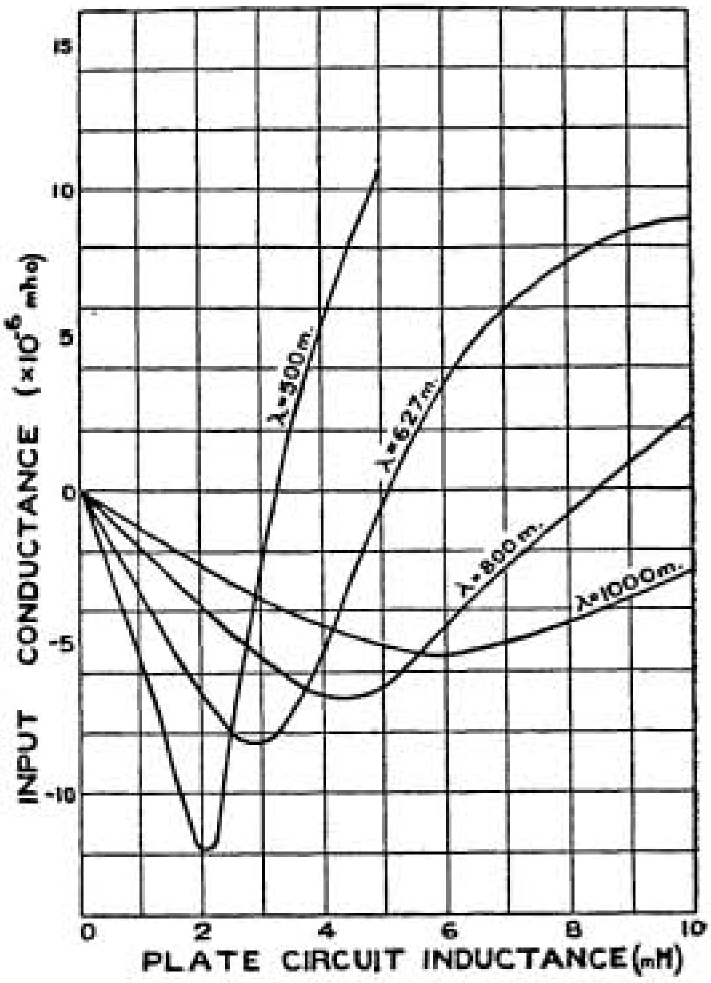

Fig. 4.—Effect of Frequency with Pure Inductance Load.
$R = 0$.

$R_0 = 20{,}000$ ohms; $\mu_0 = 6$; $C_1 = C_2 = C_m = 10\mu\mu$F.

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is negligible, as is generally the case. The effective input conductance and capacity are then shown to be as follows :—

$$g = \frac{\omega^2 C_m R_0[(\omega^2 L^2 + R^2)\left\{C_m + \mu_0(C_2 + C_m)\right\} + RR_0C_m - L\mu_0]}{[R + R_0\left\{1 - \omega^2 L(C_2 + C_m)\right\}]^2 + \omega^2[L + RR_0(C_2 + C_m)]^2}$$

$$\text{and } C = \frac{\begin{array}{l}\Big[\left\{R + R_0)^2 + \omega^2 L^2\right\}\left\{C_1 + C_m(1 + \mu_0)\right\} - R_0(R + R_0)C_m\mu_0 + \\ \quad + \omega^2 R_0^2(C_2 + C_m)\left\{(\omega^2 L^2 + R^2)C_0 - L\left(\frac{C_0}{C_2 + C_m} + C_1 + C_m\right)\right\}\Big]\end{array}}{[R + R_0\left\{1 - \omega^2 L(C_2 + C_m)\right\}]^2 + \omega^2[L + RR_0(C_2 + C_m)]^2}$$

where $C_0 = C_1C_m + C_2C_m + C_1C_2$; C_1 = grid-filament capacity; C_m = grid-plate capacity; C_2 = plate-filament capacity; R_0 = the internal plate-filament resistance of the tube, and μ_0 = magnification factor of the tube $(= e_p/e_g)$.

The occurrence of the term $\omega^2 C_m$ in the numerator of the expression for g indicates the importance of the regenerative action at high frequencies or short wavelengths. Curves are given in the original showing the values of g and C for various load inductances and resistances. Two typical curves are given in Figs. 3 and 4 and from these the range of regeneration, when the input conductance is negative, can be seen. An important practical deduction is that for any given frequency it is possible to load the plate circuit with such an impedance for the purpose of linking two valves in cascade that the input circuit exhibits no effect other than that of an increase in capacity, and hence a cascade amplifier constructed on these lines would then be perfectly stable.

Two special cases are also considered in the paper in which the load in the plate circuit consists of either pure inductance or pure resistance. This leads to a simplification of the general equations given above. The conditions for maximum regeneration are also investigated and the following equation derived for the value of L required to give the maximum regeneration :—

$$L' = R\,\frac{\omega R_0 C' \pm \sqrt{\omega^2 R_0^2 C_m^2 + \mu_0^2}}{\omega[R_0^2\omega^2(C_2 + C_m)(C' + C_m) - \mu_0]}$$

where $C' = C_m + \mu_0(C_2 + C_m)$.

It is also shown from the equations and curves that if the inductance in the plate circuit is large—such as may arise from a pair of telephones—and has considerable distributed capacity a very considerable loss may be involved owing to the increase in the effective input conductance caused thereby.

926. AMPLIFIERS. M. Latour. (*Science Abstracts*, 23B, p. 67, Abstract No. 137, January, 1920—Abstract. *Electrical World*, 75, p. 1015, May 1st, 1920—Abstract.)
See RADIO REVIEW Abstract No. 291, April, 1920.

927. AMPLITUDE OF THE OSCILLATING CURRENT SET UP BY AUDION GENERATORS. A. Blondel. (*Science Abstracts*, 23B, p. 110, Abstract No. 207, February, 1920—Abstract.)
See RADIO REVIEW Abstract No. 418, June, 1920.

928. THE AUDION AS A CIRCUIT ELEMENT. H. W. Nichols. (*Physical Review*, 13, pp. 404—414, June, 1919.)

The functional equations for the three element valve or audion are used to deduce the actions taking place in any circuit containing the valve. It is assumed that the variations in the plate and grid currents and voltages are small. The equivalent circuits are developed which would replace the valve, and thus avoid the necessity of utilising the complete set of equations for all problems. The importance of the grid-filament and the grid-plate capacities is emphasised by two examples dealing respectively with the input impedance of the audion amplifier and with amplification at high frequencies.

929. COUPLING OF MULTI-STAGE AMPLIFIERS. G. W. O. Howe. (*Science Abstracts*, 23B, p. 223, Abstract No. 435, April, 1920—Abstract.)
See RADIO REVIEW, 1, pp. 279—280, March, 1920, for original paper.

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930. "THE THERMIONIC VALVE AND ITS DEVELOPMENTS IN RADIOTELEGRAPHY AND TELEPHONY" BY J. A. FLEMING. B. S. Gossling. (*Radio Review*, 1, pp. 156—159, December, 1919. *Annales des Postes, Télégraphes et Téléphones*, 9, pp. 148—149, March, 1920—Abstract.)

Review of book with the above title.

931. TECHNICAL DEVELOPMENT OF THERMIONIC TRANSMITTERS. L. Kühn. (*Science Abstracts*, 23B, p. 110, Abstract No. 205, February, 1920—Abstract.)

See RADIO REVIEW Abstract No. 295, April, 1920.

932. EARLY DEVELOPMENTS OF THE THREE-ELECTRODE TUBE. H. J. van der Bijl; M. Latour. (*Radio Review*, 1, pp. 467—469, June, 1920.)

933. THE VERSATILE AUDION. H. W. Secor. (*Electrical Experimenter*, 7, pp. 1000—1001 and 1080—1083, February, 1920.)

A popular *resumé* of some of the many radio and other uses to which the three-electrode valve may be put.

934. ON THE DETECTING EFFICIENCY OF THE THERMIONIC DETECTOR. H. J. van der Bijl. (*Revue Générale de l'Électricité*, 6, pp. 501—502, October 18th, 1919—Abstract.)

See RADIO REVIEW Abstract No. 296, April, 1920, for the original paper.

935. DETECTING EFFICIENCY OF THE THERMIONIC DETECTOR. H. J. van der Bijl. (*Science Abstracts*, 23B, p. 111, Abstract No. 212, February, 1920—Abstract.)

See RADIO REVIEW Abstract No. 296, April, 1920.

936. OSCILLATIONS OBTAINED BY COUPLING A SECONDARY CIRCUIT WITH A CONTINUOUS WAVE VALVE OSCILLATOR. J. S. Townsend. (*Radio Review*, 1, pp. 369—374, May, 1920. *Technical Review*, 6, p. 506, June 8th, 1920—Abstract. *Science Abstracts*, 23B, p. 326, Abstract No. 642, June 30th, 1920—Abstract.)

937. DETERMINATION OF CHARACTERISTIC CURVES OF TRIODES. R. Jaeger. (*Science Abstracts*, 23B, p. 111, Abstract No. 210, February, 1920—Abstract.)

See RADIO REVIEW Abstract No. 297, April, 1920.

938. VACUUM TUBE RECTIFIERS. J. Nienhold. (*British Patent* 142870, May 8th, 1920. Convention date, May 15th, 1917. Patent not yet accepted but open to inspection.)

Relates to a vacuum tube rectifier in which the cathode is made of electro-positive material such as potassium or potassium alloy and is of large surface while the anode or anodes have a small surface and are made of electro-negative materials such as copper or constantan. Argon, helium or neon at a pressure of from 0·1 mm. to 20 mm. may be used in the tubes.

939. RADIO COMPASS. P. H. Boucheron. (*Electrical Experimenter*, 7, pp. 906—907 and 949—951, January, 1920.)

Some of the early experimental work of direction finding is referred to together with the subsequent development of the apparatus by the U.S. Navy. In the apparatus described a loop aerial is employed consisting of twelve turns of wire on a frame 6 feet square.* A map is also given of the location of the various D.F. stations in the neighbourhood of New York Harbour†. In conclusion the theory of the apparatus is briefly touched upon.

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* See RADIO REVIEW Abstract No. 360, May, 1920, for further description.

† See also RADIO REVIEW Abstract No. 203, February, 1920, and No. 710, August, 1920.

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940. THE FESSENDEN PELORUS (WIRELESS COMPASS): A CAUTION AS TO ITS USE. R. A. Fessenden. (*Science Abstracts*, 23B, pp. 164—165, Abstract No. 332, March, 1920—Abstract. *Elektrotechnische Zeitschrift*, 41, p. 420, May 27th, 1920—Abstract.)

See RADIO REVIEW Abstract No. 431, March, 1920.

941. RADIO GUIDES SHIP THROUGH FOG. (*Electrical Experimenter*, 7, p. 781, December, 1919.)

A short note relative to the work of the radio compass stations at New York.

942. WIRELESS DIRECTION FINDING. J. Erskine-Murray and J. Robinson. (*British Patent* 141190, April 10th, 1919. Patent accepted April 15th, 1920. *Engineer*, 129, p. 544, May 21st, 1920—Abstract.)

This relates to an arrangement for receiving signals from a special transmitting station of the "radiophare" type in which signals are successively sent out in various directions of the compass. In the receiving apparatus described the detector is coupled to the aerial circuit through one or other of two variable couplings which may be adjusted until the strength of signals received from two successive transmissions may be made equal. The position of the variable coupling coil then enables a more accurate bearing to be obtained by giving the ratio of the signal strengths for two adjacent compass positions. It is also suggested that the programme of the transmitting station may be varied so that series of pairs of signals are sent out at adjacent compass positions thus enabling a better adjustment of the receiver to be obtained. The comparison of the signal strengths at the receiver may be arranged to be effected automatically in synchronism with the signals from the transmitting station.

943. WIRELESS DIRECTION FINDING. N. P. Hinton. (*La T.S.F. Moderne*, 1, pp. 26—27, April, 1920—Abstract.)

See RADIO REVIEW Abstract No. 359, May, 1920.

944. HOW TO MAKE A DIRECTION FINDER. (*Wireless World*, 8, pp. 244—246, June 26th, 1920; pp. 287—289, July 10th, 1920.)

Constructional details are given of a radiogoniometer for use with a Bellini-Tosi type of aerial.

945. DIRECTIVE WIRELESS SIGNALLING. C. K. Chandler. (*British Patent* 141587, July 25th, 1919. Patent accepted April 22nd, 1920.)

The arrangement described provides for the correction of errors in direction finding on aircraft arising from the currents induced in stay wires or other metal parts of the aeroplane. To effect the correction a fixed coil is mounted in the machine near the rotating D.F. aerials and is connected up through a rotating switch which is mechanically coupled to the rotating aerials so that the circuit of the correcting coil is closed through appropriate condensers to effect the desired correction for all positions of the D.F. aerial.

946. AERIAL ARRANGEMENTS FOR WIRELESS SIGNALLING. F. A. Kolster. (*British Patent* 138318, December 24th, 1919. Convention date, January 30th, 1919. Patent not yet accepted but open to inspection.)

For directional reception a frame aerial A, Fig. 5, is used in series with a tuning condenser C. In order to obtain an asymmetric reception curve one or other terminal of the tuning condenser is connected to earth through a tuning inductance L. The switch S_1 enables this earth connection to be changed over from one terminal to the other so as to reverse the direction of maximum reception. The frame aerial A should be formed with its turns well separated so that it has a large capacity to earth but very small distributed turn-to-turn capacity. The mid-point of the frame coil may be connected to a wire gauze grid B to increase the capacity to earth, or alternatively it may be connected to a separate elevated aerial. The switch S_2 in the diagram serves to connect the detecting valve V either across the coil L for standby reception, or across the tuning condenser C for directional working.

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Alternatively the single frame coil A may be replaced by two coils at right angles to each other or by a toroidal coil with movable connections to the tuning condenser. In this last case the direction of reception when the movable connections have been adjusted to give maximum signal strength is given by the direction at right angles to the line bisecting the angle between the two movable connections.

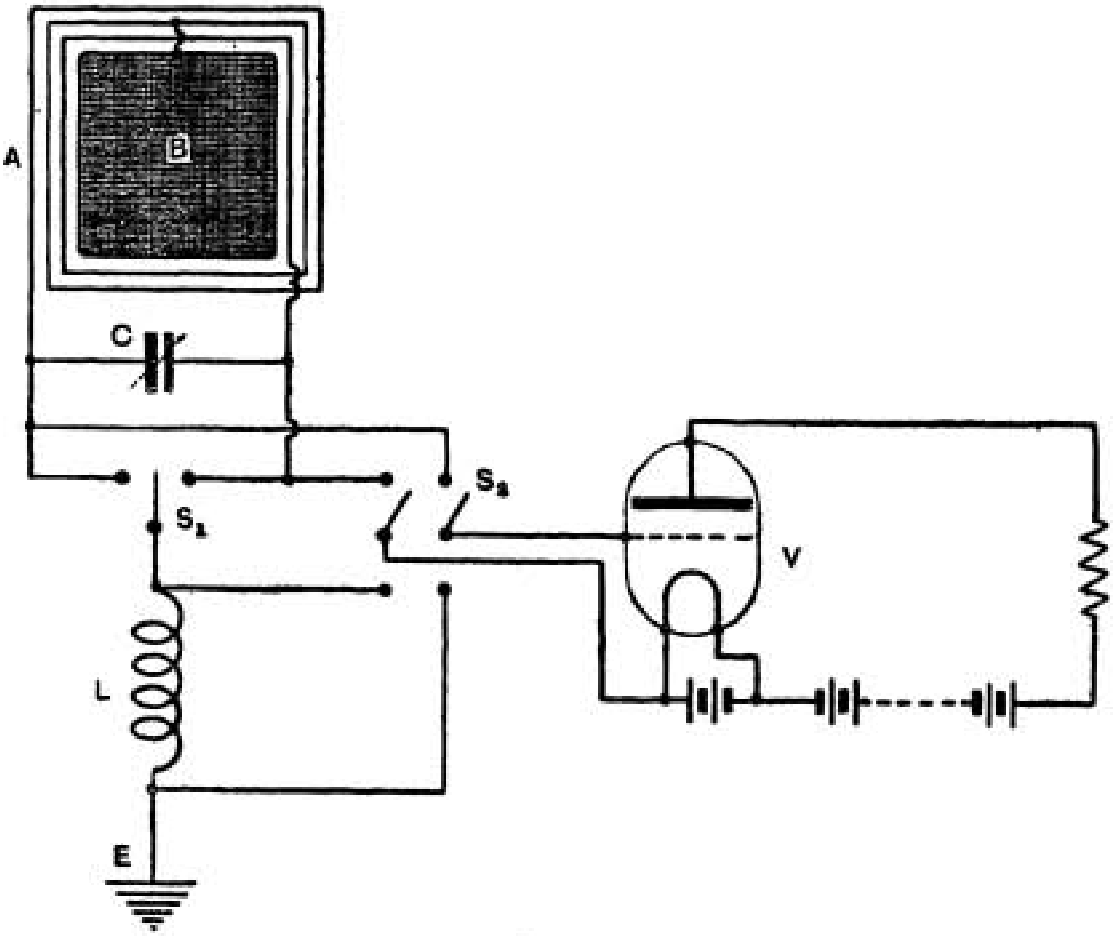

FIG. 5.

947. ON THE GONIOMETRIC FUNCTIONS APPLICABLE TO DIRECTIVE AERIALS. A. E. Blondel. (*Science Abstracts*, 23B, pp. 64—65, Abstract No. 131, January, 1920—Abstract.)

See RADIO REVIEW, 1, pp. 1—10, 58—60, 110—123, October, November, and December, 1919. Also RADIO REVIEW Abstract No. 362, May, 1920.

948. WIRELESS DIRECTION FINDING. F. E. Smith. (*Radio Review*, 1, pp. 415—417, May, 1920. *Technical Review*, 6, p. 506, June 8th, 1920—Abstract.)

949. THE HEIGHT OF THE AURORA BOREALIS AS DETERMINED AT THE HALDDE OBSERVATORY, NORWAY. L. Vegard and O. Krognes. (*Journal of the Franklin Institute*, 189, p. 674, May, 1920.)

A large number of measurements are summarised. These all indicate an average height of 108·2 kilometres for the lower boundary of auroræ. The observations centre particularly round two heights of 100 and 106 kilometres respectively.

950. PROPAGATION OF ELECTROMAGNETIC WAVES OVER A PLANE CONDUCTING SURFACE. H. Weyl. (*Elektrotechnische Zeitschrift*, 41, p. 400, May 20th, 1920—Abstract.)

See RADIO REVIEW Abstract No. 433, June, 1920.

951. THE TRANSMISSION OF ELECTROMAGNETIC WAVES ABOUT THE EARTH. J. Erskine-Murray. (*Wireless World*, 7, pp. 651—664, February, 1920. *Technical Review*, 6, p. 263, March 16th, 1920—Abstract. *Telegraphen- und Fernsprech-Technik*, 9, p. 65, July, 1920—Abstract.)

See RADIO REVIEW, 1, pp. 237—239, February, 1920, for abstract.

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952. On the Propagation of Electromagnetic Waves around the Earth. B. van der Pol. (*L'Elettrotecnica*, 7, pp. 269—270, May 25th, 1920—Abstract.)
See Radio Review Abstracts No. 48, November, 1919, and No. 513, July, 1920.

953. Detector for Wireless Telegraphy. J. Nienhold. (*German Patent* 304373, August 4th, 1917. Patent granted October 17th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, pp. 509—510 June, 1920—Abstract.)

A detecting circuit (see Fig. 6) in which the valve tube which contains a rare gas or a mixture of rare gases is provided with three electrodes. The cathode K is coated with an alkali metal and a constant glow discharge is maintained between it and the sieve-like anode m. Rectification is obtained by utilising the asymmetrical electrical properties of the space between m and a.

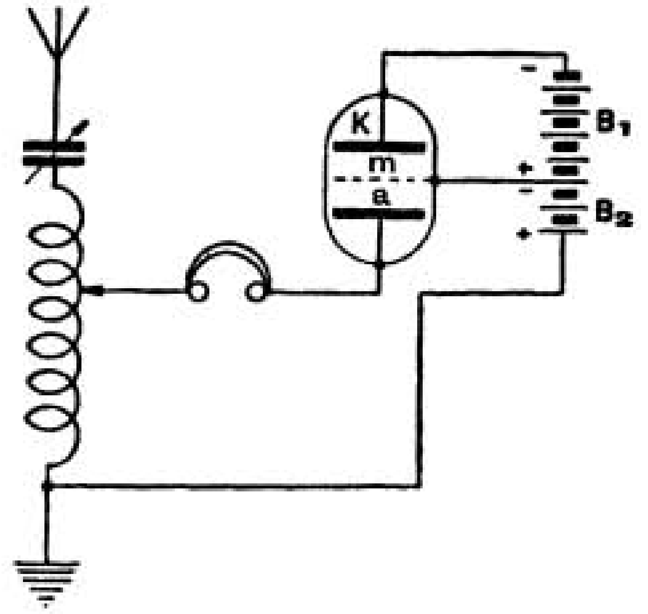

Fig. 6.

954. Possible Ether Structure. O. J. Lodge. (*Philosophical Magazine*, 39, pp. 170—174, February, 1920. *Science Abstracts* 23a, p. 194, Abstract No. 505, April, 1920—Abstract.)

955. The Stokes-Planck Ether. L. Silberstein. (*Philosophical Magazine*, 39, pp. 161—170, February, 1920. *Science Abstracts*, 23a, pp. 194—195, Abstract No. 506, April, 1920—Abstract.)

956. Variation in Direction of Propagation of Long Electromagnetic Waves. A. H. Taylor. (*Science Abstracts*, 23b, p. 163, Abstract No. 331, March, 1920—Abstract. *Electrical World*, 76, p. 137, July 17th, 1920—Abstract.)
See Radio Review Abstract No. 430, June, 1920.

957. Radiotelegraphy in the Alps. (*Engineering*, 109, p. 753, June 4th, 1920.)

A brief note referring to a series of experiments conducted in Switzerland last year between forty radio stations distributed over the country to determine the influences of topographical features on the range of signalling. The wavelengths used varied between 600 and 2,100 metres. Extensive plains, valleys, lakes and water courses were found to increase the range, while high mountain chains and expanses of firm grainy snow diminished the range. Best signals were obtained with a wavelength between 900 and 1,800 metres.

958. Measurement of the Strength of the Electromagnetic Field of Transocean Wireless Signals. G. Vallauri. (*L'Elettrotecnica*, 7, pp. 298—300, June 15th, 1920.)
See editorial article, pp. 652—655 of this issue, where the paper is discussed.

959. On the Quantitative Determination of Electromagnetic Radiation Field Strength in Wireless Telegraphy. H. R. von Traubenberg. (*Science Abstracts*, 23b, p. 163, Abstract No. 330, March, 1920—Abstract. *Electrical World*, 75, p. 1437, July 19th, 1920—Abstract.)
See Radio Review Abstract No. 303, April, 1920.

960. Refraction of Electric Waves. T. L. Eckersley. (*Radio Review*, 1, pp. 421—428, June, 1920.)

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961. HARMONICS IN C.W. TRANSMISSION. L. A. T. Broadwood. (*Wireless World*, 8, pp. 82—91, May 1st, 1920; pp. 125—131, May 15th, 1920. *Technical Review*, 6, p. 548, June 22nd, and p. 590, July 6th, 1920—Abstract. *Science Abstracts*, 23B, p. 323, Abstract No. 637, June 30th, 1920—Abstract.)

Paper read before the Wireless Society of London. For abstract see RADIO REVIEW, 1, p. 385, May, 1920. The full paper and discussion are given in the *Wireless World*, above reference.

962. RECEIVING APPARATUS FOR WIRELESS TELEGRAPHY AND TELEPHONY. C. Bardeloni. (*British Patent* 141185, April 3rd, 1919. Convention date, October 3rd, 1916. Patent accepted April 15th, 1920.)

This specification provides for the combination of a crystal detector such as carborundum with a thermionic valve. Various modifications are described in which the crystal may be connected in shunt to the tuned secondary circuit of the receiver and with the grid filament circuit of the valve, or it may be connected in series with the grid circuit between the tuned secondary circuit of the receiver and the filament of the valve. Other modifications show the addition of a variable voltage from a potentiometer between the crystal and the grid of the valve.

963. NOTES ON THE DESIGN AND CONSTRUCTION OF VACUUM TUBE AMPLIFIERS. J. Scott-Taggart. (*Wireless World*, 7, pp. 440—444; pp. 505—508; pp. 671—673; pp. 701—704; November, December, February and March, 1920. *Technical Review*, 6, p. 86, January 20th; p. 301, March 30th, 1920—Abstract. *Telegraphen- und Fernsprech-Technik*, 9, pp. 34—35, May, 1920—Abstract.)

This article is divided into three parts dealing respectively with low frequency amplifiers, detector amplifiers and resistance amplifiers. In the first constructional details are given of a suitable inter-valve transformer and a set of diagrams of the arrangements for various stages of amplification. In the second part the arrangement of the amplifier when one of the valves is provided with a grid condenser and leak for detection purposes is set out in detail, together with particulars of the Marconi type 55 seven-valve amplifiers, and the use of a multi-stage amplifier with the circuits of each coupling transformer tuned to the oscillating frequency to increase the selectivity. In the third section resistance capacity coupling is described and its modification using a choke coil to replace the resistance.

964. AN AMPLIFIER EMPLOYING THERMIONIC INTER-VALVE RESISTANCE COUPLINGS. J. Scott-Taggart. (*Electrical Review*, 86, pp. 549—550, April 30th, 1920. *Science Abstracts*, 23B, p. 325, Abstract No. 640, June 30th, 1920—Abstract.)

The article describes a multi-stage amplifier of the resistance—capacity coupled type in which the usual anode resistances are replaced by two-electrode valves. This arrangement provides a convenient means for adjusting the value of the anode resistances by varying the filament heating currents of the two-electrode valves. It is also stated that a certain degree of limiter action may be obtained by choosing suitable values for the filament currents for the two-electrode valves.

965. THERMIONIC VALVE AMPLIFIERS. L. B. Turner. (*British Patent* 139867, February 17th, 1919. Patent accepted March 18th, 1920.)

This specification deals with the coupling of two valves by resistances in the manner described in the RADIO REVIEW by the same author.*

966. THE KALLIROTRON, AN APERIODIC NEGATIVE-RESISTANCE TRIODE COMBINATION. L. B. Turner. (*Radio Review*, 1, pp. 317—329, April, 1920. *Technical Review*, 6, p. 424, May 11th, 1920—Abstract. *Science Abstracts*, 23B, p. 277, Abstract No. 545, May 31st, 1920—Abstract.)

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* "The Kallirotron," L. B. Turner (RADIO REVIEW, 1, pp. 317—329, April, 1920).

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967. THE KALLIROTRON, AN APERIODIC NEGATIVE-RESISTANCE TRIODE COMBINATION. G. B. Ehrenborg; L. B. Turner; M. Latour. (*Radio Review*, 1, pp. 469—472, June, 1920, also pp. 523—524, July, 1920.)

Correspondence relative to the paper by L. B. Turner with the above title.*

968. ON BLONDEL'S AND TOULY'S NEW ARRANGEMENTS OF POTENTIOMETRIC AMPLIFIERS. A. Blondel and M. Touly. (*Science Abstracts*, 23B, p. 88, Abstract No. 166, February, 1920—Abstract.)

See RADIO REVIEW Abstracts Nos. 236 and 237, March, 1920.

969. A NON-RADIATING WIRELESS RECEIVING CIRCUIT FOR THE RECEPTION OF DAMPED AND UNDAMPED WAVES. J. Scott-Taggart. (*Science Abstracts*, 23B, pp. 168—170, Abstract No. 340, March, 1920—Abstract. *Revue Générale de l'Électricité*, 7, p. 133D, April 24th, 1920—Abstract.)

See RADIO REVIEW Abstract No. 170, January, 1920.

970. HETERODYNE RECEPTION. H. Salinger. (*Science Abstracts*, 23B, pp. 109—110, Abstract No. 204, February, 1920—Abstract.)

See RADIO REVIEW Abstract No. 370, May, 1920.

971. RECEIVERS FOR WIRELESS TELEGRAPHY. C. S. Franklin. (*Science Abstracts*, 23B, pp. 166—167, Abstract No. 336, March, 1920—Abstract.)

See RADIO REVIEW Abstract No. 375, May, 1920.

972. ON THE MEASUREMENT OF THE FREQUENCY OF ACOUSTIC AND ELECTRIC OSCILLATIONS BY A BEAT METHOD. R. Weller. (*Science Abstracts*, 23A, p. 234, Abstract No. 596, April, 1920—Abstract.)

See RADIO REVIEW Abstract No. 308, April, 1920.

973. THE REPRODUCTION OF SPEECH BY GALENA WITH UNDAMPED WAVES. Mlle. P. Collet. (*Comptes Rendus*, 170, pp. 1378—1380, June 7th, 1920.)

Some experiments on the acoustic effects of galena crystals are dealt with in this note. For the purposes of these experiments a platinum point attached to the membrane of a phonographic reproducer was mounted so as to rest on the galena crystal. The valve transmitter generating undamped waves was coupled to a circuit containing the galena contact, which latter circuit also included either an interrupter or a microphone transmitter. It was found that the interruptions of the circuit from the speech impressed on it by the microphone transmitter were faithfully reproduced by the diaphragm attached to the galena. Heterodyne phenomena were also evidenced when the galena was coupled to two transmitters operating at different frequencies. The phenomena appear to have a thermal origin.

974. ON TWO TYPES OF CURRENT RECTIFICATION BY GALENA. Mlle. P. Collet. (*Comptes Rendus*, 170, pp. 1489—1491, June 21st, 1920.)

As a result of experiments on rectification of alternating currents and oscillations by galena contacts, the author distinguishes two types of rectification; (1) brought into play when the applied energy is small and (2) when the input power is large. The first case corresponds to that of ordinary wireless reception and the phenomena shown agree with those customarily associated with this detector when used in wireless receivers. It was found that the rectified current was always in one direction for the sensitive points and flowed from the crystal to the metallic point. The output of continuous (rectified) current was found to bear no very definite relation to the input energy, but in the case of the second type of rectification where the input was larger it was found that all points, whether "sensitive" or not in the usual meaning of the term, gave a rectified current in the reverse direction to that given by the ordinary sensitive points working with feeble oscillations. This second type of rectification was in the opposite direction to the first and the sensitive spots on the crystal showed rectification first in one direction, subsequently falling to zero and then in the other direction as the input energy was steadily increased. This phenomenon explains the observation that such crystals

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* RADIO REVIEW, 1, pp. 317—329, April, 1920.

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working at their most sensitive points are not such good rectifiers for strong signals as for weaker ones.

975. THE RECTIFYING ACTION OF CRYSTAL DETECTORS. M. J. Huizinga. (*Physikalische Zeitschrift*, 21, pp. 91—96, February 15th, 1920. *Elektrotechnische Zeitschrift*, 41, p. 573, July 22nd, 1920—Abstract.)

A description of experiments to support the view that the rectification is due to electrolysis. On passing 1 milliampere between a platinum point and molybdenum sulphide a drop of liquid forms at the point; with the point negative the liquid is blue and an analysis gives MoO_2, 4 MoO_3, 6 H_2O, with the point positive the resistance is much higher, the liquid is brown and gives MoS_2 and MoS_3. Pyrites and many other minerals gave somewhat similar results, although in some cases no liquid is apparent, due to its evaporation as soon as it is produced. The rectification takes place without any apparent decomposition, however, in a vacuum, in hydrogen or under paraffin. The author gives a number of characteristic curves and comes to the conclusion that the rectification is in all cases due to electrolytic action and to the different polarisation potentials in the two directions. The electrolytic action takes place in an adhering gas or moisture film. The actual resistance of such detectors is much less than is usually assumed and is usually less than 100 ohms.

976. THERMIONIC VALVES—A WIRELESS BELL CALL. (*Times Engineering Supplement*, No. 548, p. 207, June, 1920.)

A description is given of the Fleming five-electrode valve which is designed particularly for use as a relay for calling up a wireless receiving station.*

977. THERMIONIC VALVE RELAYS. R. Whiddington. (*British Patent* 141900, April 15th, 1919. Patent accepted April 29th, 1920.)

In the use of a triode valve as a trigger relay in which the received impulse triggers off the valve oscillations, it has previously been customary to restore the circuits to their normal state by mechanically interrupting one of the oscillatory circuits.† It is now proposed to overcome this complication by inserting in one of the oscillatory circuits a resistance, such as an incandescent lamp having a positive resistance-temperature coefficient. The rise in the resistance of the lamp when oscillations start is then sufficient to quench them out again as soon as the received impulse ceases.

978. A NEW AMPLIFIER. F. Marin. (*L'Électricien*, 49, pp. 132—134, September 30th, 1919. *Science Abstracts*, 23B, pp. 67—68, Abstract No. 138, January, 1920—Abstract.)

An electromagnetically operated microphonic relay amplifier is described for use in radio reception. The apparatus includes an electromagnet which is joined in circuit in place of the usual telephones, with a reed fixed near the coil of the magnet. The reed carries a small carbon block which forms the microphonic contact with a small point of carbon.

See also RADIO REVIEW Abstract No. 169, January, 1920.

979. WIRELESS EMERGENCY CALLING DEVICE FOR SHIPS. (*Elektrotechnische Zeitschrift*, 41, p. 456, June 10th, 1920.)

In view of the newspaper reports of the Marconi automatic calling device ‡ it is pointed out that the Telefunken Company have been developing such a device since 1916. It consists of an automatic sender and an accurately tuned relay receiving device which operates an alarm.

980. RECORDING OSCILLOGRAPHS AND AMPLIFIERS OF EXTREMELY LOW FREQUENCY: THEIR APPLICATION TO THE RECORDING OF RADIOTELEGRAPHIC SIGNALS. H. Abraham and E. Bloch. (*Technical Review*, 6, p. 341, April 13th, 1920—Abstract. *Science Abstracts*, 23B, p. 277, Abstract No. 546, May 31st, 1920—Abstract. *Electrical World*, 75, p. 1325, June 5th, 1920.)

See RADIO REVIEW Abstract No. 439, June, 1920.

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* See RADIO REVIEW Abstract No. 805, September, 1920.

† See RADIO REVIEW Abstract No. 196, February, 1920, and No. 688, August, 1920.

‡ See RADIO REVIEW Abstract No. 551, July, 1920.

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981. WIRELESS RECEIVING SYSTEMS. E. F. W. Alexanderson. (*British Patent* 142074, December 1st, 1919. Convention date, April 18th, 1919. Patent not yet accepted but open to inspection.)

This specification deals with the use of a loop aerial receiver in which the loop functions both as a closed circuit aerial and as an open elevated aerial by reason of its capacity to earth.* In order to secure effective balancing of the currents set up in these two circuits, phase adjusting arrangements of the type previously described by the same author † are included in each circuit. The movable coils of the phase adjuster are joined in series and then finally coupled to the detecting valve or other receiver.

982. WIRELESS RECEIVING APPARATUS. C. P. Ryan. (*British Patent* 141269, August 28th, 1919. Patent accepted April 15th, 1920.)

In order to increase the selectivity of a receiver and to eliminate the effects of atmospherics and undesired transmissions the receiving telephone is placed opposite the end of a resonating tube to which is attached a microphone transmitter coupled to a vibrating relay. This last is connected to a second relay for operating a Morse inker or other recording apparatus. The resonant tube may be tuned to the acoustic frequency of the signals by opening or closing perforations along its length.

983. THE RECEPTION OF WAVES OF VERY HIGH FREQUENCIES. E. H. Armstrong. (*British Patent* 137271, July 9th, 1919. Convention date, December 30th, 1918. Patent not yet accepted but open to inspection.)

In a receiver for waves of very high frequencies the incoming oscillations are first heterodyned to a supersonic frequency, which may be of the order of a million per second. These supersonic beat currents are then amplified and subsequently detected in any known manner as for example by a second heterodyne to give beats of audible frequency. Alternatively the second heterodyne may produce beats of a lower supersonic frequency which may again be amplified before the final detection. The method is said to reduce interference from atmospherics.

984. LONG WAVE RECEPTION AND THE ELIMINATION OF STRAYS ON GROUND WIRES. A. H. Taylor. (*Science Abstracts*, 23B, pp. 167—168, Abstract No. 338, March, 1920—Abstract.)

See RADIO REVIEW Abstract No. 313, April, 1920.

985. LONG WAVES AND STRAYS ON ROGERS ANTENNÆ. A. H. Taylor. (*Electrical Experimenter*, 8, pp. 58—59 and 100—101, May, 1920.)

Paper read before the Institute of Radio Engineers. See RADIO REVIEW Abstract No. 313, April, 1920, for abstract.

986. LOCATING SUBMARINES BY AUDION SIPHONING. E. T. Jones. (*Electrical Experimenter*, 7, p. 782, December, 1919.)

By the term "siphoning" the author apparently refers to re-radiation from the receiving aerial arising from the heterodyning oscillations. The possibility of locating submerged submarines by detecting such radiation from their receiving apparatus by means of a suitable D.F. apparatus is referred to. Experiments are quoted in which a receiving set was enabled to hear a distant station, which it was normally unable to do, when a large antenna in the neighbourhood was picking up those signals with a heterodyne receiver, the radiation from the heterodyne apparently also conveying the received signal with it to the second receiving station. It is stated that experiments have also shown that at the second receiver a large proportion of the atmospheric interference heard in the main receiver was eliminated, and the author therefore suggests that useful results might be obtained by including a small frame

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* Compare RADIO REVIEW Abstract No. 75, Fig. 6, December, 1919, and Abstract No. 525, July, 1920.

† See RADIO REVIEW Abstract No. 75, Fig. 4, December, 1919.

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aerial in series with the secondary tuned circuits of the main receiver so that the radiation from those circuits, and from the heterodyne receiver coupled thereto, might be picked up on a second receiver using a frame aerial. Some considerable distance may separate the two receivers.

987. THERMIONIC AMPLIFIERS. H. D. Arnold. (*British Patent* 141040, March 29th, 1920. Convention date, January 5th, 1919. Patent not yet accepted but open to inspection.)

The arrangement described is a filter circuit for the elimination of disturbing impulses, atmospherics, etc. It depends upon the fact that a shock impulse acting upon a resonant circuit which has considerable damping sets up in it oscillations of a different frequency from the sustained waves to which the circuit is resonant. One arrangement is indicated in Fig. 7.

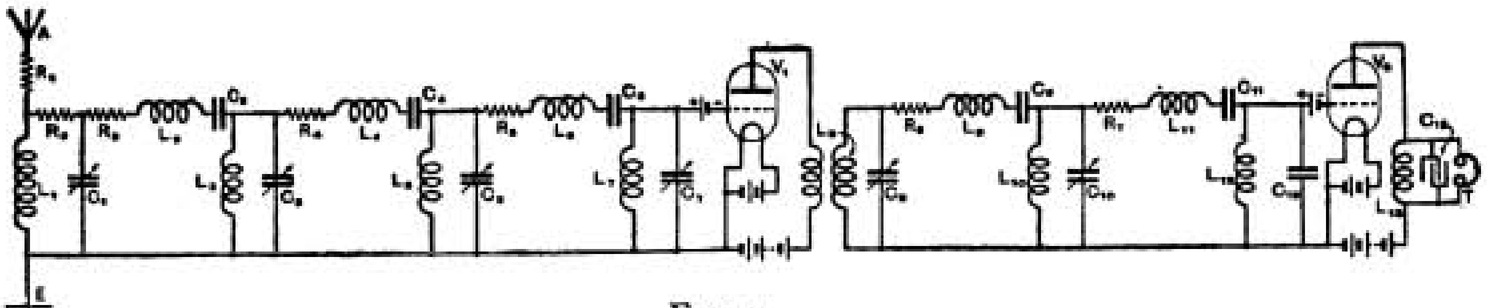

FIG. 7.

In this diagram damping resistances R_1 R_2 R_3 are shown inserted in series with various resonant circuits which are tuned to the incoming wave, the circuits R_3 L_2 C_2; R_4 L_4 C_4; R_5 L_6 C_6, etc., being tuned to this signal frequency so that the undesired impulses are filtered out before reaching the amplifying valve V_1. The amplified currents are then passed through L_8 C_8 and a second series of filtering circuits R_6 L_9 C_9; L_{10} C_{10}; R_7 L_{11} C_{11}, etc., to the detecting valve V_2 and the receiving telephones T. Alternatively if desired an amplifying valve may be placed between each unit of the filtering circuits, that is to say such a valve may replace L_3 C_3; L_5 C_5, etc., so that there is a single resonant filtering circuit only between each valve.

988. THE UNI-CONTROL RECEIVER. R. E. Thompson. (*Science Abstracts*, 23B, p. 70, Abstract No. 141, January, 1920—Abstract.)
See RADIO REVIEW Abstract No. 442, June, 1920.

989. RECEIVING CIRCUITS. H. J. J. M. de Bellescize. (*La T.S.F. Moderne*, 1, pp. 24—25, April, 1920—Abstract.)
See RADIO REVIEW Abstract No. 244, March, 1920.

990. ELECTRIC RELAYS. M. Latour. (*British Patent* 138383, October 19th, 1918. Convention date, October 4th, 1917. Patent accepted February 12th, 1920.)

Provision is made for indicating the failure of the filament of a vacuum tube amplifier by means of a relay having a winding in series with the filament and a shunt winding connected in parallel with it.

991. RECEIVING APPARATUS. Marconi's Wireless Telegraph Company, Limited. (*French Patent* 501493, July 8th, 1919. Published April 15th, 1920.)

The specification describes improvements in receivers for wireless telegraphy which are specially adapted for short wavelengths. For further particulars, see British Patent 134246.*

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* RADIO REVIEW Abstract No. 375, May, 1920.

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992. RECEIVING APPARATUS. E. H. Armstrong. (*French Patent* 501511, December 30th, 1918. Published April 16th, 1920.)

The specification describes a method of receiving very high-frequency oscillations. For particulars, see British Patent 137271.*

993. IMPROVEMENTS IN APPARATUS FOR RECEIVING RADIO SIGNALS. R. A. Weagant. (*British Patent* 138586, May 22nd, 1919. Convention date, February 7th, 1919. Patent not yet accepted but open to inspection.)

The subject matter of this patent was described in the article referred to in RADIO REVIEW Abstract No. 18 of October, 1919. See also RADIO REVIEW Abstracts Nos. 62, November, 1919, 312, April, 1920, and 440, June, 1920, where further references are given to descriptions of similar apparatus.

994. POSSIBILITIES OF CONCEALED RECEIVING SYSTEMS. A. H. Taylor. (*L'Elettrotecnica*, 7, pp. 229—230, May 5th, 1920—Abstract.)

See RADIO REVIEW Abstract No. 41, November, 1919.

995. AERIALS, THEIR FORMS AND USES. P. R. Coursey. (*Wireless World*, 8, pp. 109—112, May 15th, 1920. *Technical Review*, 6, p. 589, July 6th, 1920—Abstract.)

A *resumé* of the various types and forms of aerials including some of the advantages of frame aerials for reception purposes.

996. FRAME AERIALS FOR RECEPTION. E. Blake. (*Wireless World*, 8, pp. 152—155, May 29th; pp. 184—188, June 12th, 1920.)

The article reviews the mode of operation of the frame aerial for reception purposes and the leading features in its design for any particular conditions. The latter section follows in a general outline the method developed by A. S. Blatterman.† In conclusion the article deals with some constructional details of a frame aerial suitable for experimental work.

997. AERIAL ARRANGEMENTS FOR WIRELESS RECEPTION. R. A. Weagant. (*British Patent* 138588, August 6th, 1919. Convention date, February 7th, 1919. Patent not yet accepted but open to inspection.)

Further arrangements are described in this specification for minimising the effects of atmospheric interference in wireless reception (see RADIO REVIEW Abstract No. 993). The particular arrangement specified comprises the combination of a vertical non-directive aerial with one or more frame or horizontal directive aerials to that the currents induced by the atmospherics may be cancelled out while the signal current remains. The coupling between the non-directive and directive aerials may be in one direction or the other as most effective for eliminating the atmospherics, or alternatively one of the directive aerials may be rotated to give the best results. In a modification the directive aerials (crossed frames, or crossed horizontal aerials) may be connected to earth through a tuning inductance so that they act both as directive aerials and as elevated non-directive aerials. Compare also RADIO REVIEW Abstract No. 946 in this issue.

998. THE RELATIVE ADVANTAGES OF ELEVATED ANTENNÆ, LOOP AERIALS AND UNDERGROUND WIRES FOR THE RECEPTION OF RADIO-SIGNALS. G. W. O. Howe. (*Radio Review*, 1, pp. 175—178, January, 1920.)

999. RADIOTELEPHONY AND THE AEROPLANE. W. O. Mundt. (*Electrical Experimenter*, 7, pp. 1030 and 1088—1089, February, 1920.)

The author deals with various patterns of aerial that have been employed on aeroplanes. The directional effects of the different arrangements are also considered.

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* RADIO REVIEW Abstract No. 983 in this issue.

† See RADIO REVIEW Abstract No. 144, January, 1920.

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1000. SUBMARINE'S UNDERWATER RADIO. (*Electrical Experimenter*, 7, pp. 661 and 707, November, 1919.)

Reference is made to some tests between an aeroplane and a submerged submarine carried out by the United States Navy, and particulars are given as to the loop aerial arrangement used on the submarine. A three-stage valve amplifier is used for receiving and a 1 kW. quenched spark for transmission from the submarine. A 0·0005 microfarad condenser is joined in series with the loop.

See also RADIO REVIEW Abstract No. 452, June, 1920.

1001. TALKING THROUGH THE TREES. G. O. Squier. (*Technical Review*, 6, p. 263, March 16th, 1920—Abstract.)

See RADIO REVIEW Abstract No. 317, April, 1920.

1002. STATIONARY WAVES ON WIRES. P. R. Coursey. (*Wireless World*, 8, pp. 127—129, June 26th, 1920.)

The arrangements for setting up stationary waves on a long helix are described together with some of their applications.

1003. THE CALCULATION OF LOADS IN GUY ROPES FOR MASTS OR TOWERS. C. T. G. Hooper. (*Science Abstracts*, 23B, p. 112, Abstract No. 213, February, 1920—Abstract.)

See RADIO REVIEW, 1, pp. 161—173, January, 1920, for the original article.

1004. SOME WIRELESS WONDERS. A. A. Campbell Swinton. (*Wireless World*, 8, pp. 47—57, April 17th, 1920. *Technical Review*, 6, p. 459, June 22nd, 1920—Abstract.)

Presidential address delivered to the Wireless Society of London on February 27th, 1920.

With a few introductory remarks the author briefly reviewed the method of operation of a triode valve and valve amplifying arrangements used with frame aerials for the reception of wireless telegraph and telephone messages. Six oscillograms of the wave form of speech sounds are included, together with a description of the arrangement used at the meeting for the reception and recording of messages from the Eiffel Tower and other large wireless stations. Valve amplifiers were used throughout with a special low frequency amplifier for the final stage which operated a siphon recorder.

1005. WIRELESS AND THE PRESS—THE *DAILY MAIL'S* WIRELESS STATION. (*Wireless World*, 8, pp. 222—224, June 26th, 1920.)

A brief illustrated description of the installation at the *Daily Mail* office. A 48-turn frame aerial is employed in conjunction with a seven-valve receiving amplifier.

1006. WIRELESS RAILWAY SIGNALLING. H. Gewecke. (*Telefunken Zeitung*, 4, No. 20, pp. 56—60, May, 1920.)

A brief description of a system for automatically operating on a locomotive apparatus controlled by wireless signals.

1007. RECENT PROGRESS IN WIRELESS TELEGRAPHY. J. O. G. Cann. (*Journal of the Engineering Institute of Canada*, 3, pp. 239—243, May, 1920.)

This paper gives a very brief *resumé* of wireless development under the following heads :—

Historical, giving the leading points in the development from 1867 onwards ; spark system ; arc system, including illustrations of 125 kW. arc installation at Newcastle (Canada) ; the dynamic method (H.F. Alternator) ; the thermionic valve method ; direction finding ; static elimination, including a brief reference to Weagant's receiving aerials ; high speed transmission.

1008. THE WIRELESS TELEGRAPH APPARATUS OF THE GERMAN ARMY. A. Salomon. (*Science Abstracts*, 23B, p. 171, Abstract No. 344, March, 1920—Abstract.)

See RADIO REVIEW Abstract No. 447, June, 1920.

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1009. MODERN AMERICAN RADIO APPARATUS. (*Electrical Experimenter*, 7, pp. 779 and 828—829, December, 1919.)

A short general illustrated article briefly describing some of the wartime developments made by the General Electric Company, U.S.A.*

1010. NAUEN RADIO OPENED AGAIN. (*Electrical Experimenter*, 7, p. 662, November, 1919.)

Refers to some of the changes made in the Nauen station during the war. Illustrations of the aerial system and of some of the radio plant are included.

1011. A TWO-STAGE AMPLIFIER. (*Everyday Engineering Magazine*, 9, p. 153, May, 1920.)

An illustrated description of an instrument manufactured by the Wireless Improvement Company.

1012. A FORM OF INDUCTIONLESS HIGH RESISTANCE. N. W. McLachlan. (*Radio Review*, 1, pp. 429—431, June, 1920. *Technical Review*, 6, p. 659, August 3rd, 1920—Abstract.)

1013. THE IMPORTANCE OF THE NAUEN STATION DURING THE WAR. H. Schlee. (*Telefunken Zeitung*, 3, No. 17, pp. 61—64, August, 1919.)

A well-illustrated descriptive article.

1014. NEW MARCONI WIRELESS CALL SIGNAL DEVICE. (*Elektrotechnische Zeitschrift*, 41, p. 358, May 6th, 1920—Abstract. Also, *Electrical Experimenter*, 7, p. 1283, April, 1920—Abstract. *Scientific American*, 122, p. 697, June 26th, 1920—Abstract.)

See RADIO REVIEW, 1, p. 293, March, 1920, and also Abstract No. 551, July, 1920.

1015. WIRELESS SOCIETY OF LONDON'S EXHIBITION OF APPARATUS. (*Wireless World*, 7, pp. 517—530, December, 1919.)

Illustrated descriptions are given amongst others of the following apparatus :—

R.A.F. Wireless Telephone Set ; R.A.F. Direction Finding Apparatus with Amplifier ; Scott-Taggart—Ediswan Small Power Full-Wave Rectifying Valve ; Scott Taggart's Continuous Wave Transmitting Valve ; Two- and Three-Valve Amplifiers and a Valve Relay constructed by H. Burberry ; Modern Marconi D.F. Apparatus ; Leslie Miller's Portable Quenched Spark Transmitter ; F. Read's Crystal and Valve Receivers ; and a Frame Aerial and Seven-Valve Amplifier used by Mr. Campbell Swinton.

1016. A SENSITIVE TELEGRAPH RECEIVER. W. E. Peirce. (*Telegraph and Telephone Age*, 38, p. 286, May 16th, 1920.)

A short note *re* a new receiver applicable for radio work, in which the diaphragm is arranged to operate an ordinary telegraph sounder or tape recorder.

1017. SELECTIVE WIRELESS CONTROL. E. L. Deeter. (*Electrical Experimenter*, 7, pp. 1284 and 1344, April, 1920.)

A receiving arrangement is described using either a coherer or a two-stage amplifier and relay to control the distant apparatus.

1018. THE WIRELESS HOUND. (*Scientific American*, 122, p. 601, May 29th, 1920. *English Mechanic*, 111, p. 244, June 18th, 1920. *Wireless World*, 8, p. 351, July 24th, 1920—Abstract.)

A short illustrated description of a small vehicle controlled by radio.

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* See also RADIO REVIEW Abstract No. 27, November, 1919.

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1019. INVISIBLE OPTIC TELEGRAPHY BY INFRA-RED RAYS. H. de Gallaix. (*Electrical Experimenter*, 7, pp. 1126—1127 and 1214—1215, March, 1920.)

The development of an apparatus used during the war for telegraphic signalling by infra-red rays is described in this article. At the transmitter a small searchlight was used which contained an electric incandescent or an arc lamp as the light source. The front of the searchlight was fitted with a special glass containing manganese salts which while allowing the infra-red rays to pass was practically opaque to ordinary visible light. At the receiver the beam was concentrated by means of an ordinary type of parabolic searchlight mirror on to an endless paper strip which was driven round by clockwork so that it passed through the focus of the mirror. The paper band was sensitised by a special material containing zinc-sulphate. The effect of the infra-red light caused the paper to turn black and the incoming signals were thus read directly from the moving tape. In its path the paper tape was passed through a second vessel in which it was subjected to blue light from a lamp. This had the effect of obliterating the black marks made by the infra-red rays and of rendering the paper ready for the receipt of fresh messages. Using searchlight mirrors one foot in diameter transmission has been achieved over about half-a-mile. Larger distances may be covered with a more powerful light source.

1020. SELENIUM AND SOME OF ITS USES. P. R. Coursey. (*Wireless World*, 8, pp. 145—149, May 29th, 1920.)

Some of the chemical properties of selenium are passed in review and its applications to photometry, light telegraphy and telephony, control of mechanism by light rays, the optiphone and for recording and reproducing sound waves are dealt with in turn.

1021. EARTH CURRENT TELEGRAPHY. N. Jouaust. (*Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, 131, pp. 408—415, November—December, 1919. *Revue Scientifique*, 58, p. 307, May 22nd, 1920—Abstract.)

The principle of the methods of earth current telegraphy (T.P.S.) developed by the French Military Radiotelegraphic Service are detailed, together with a brief historical *resumé* of the method, concluding with a description of apparatus employed. Three-electrode valve amplifiers were used for reception.

1022. AIRCRAFT WIRELESS APPARATUS: CRYSTAL RECEIVERS. J. J. Honan. (*Wireless World*, 7, pp. 605—608, January, 1920; pp. 665—667, February, 1920; pp. 729—731, March, 1920.)

An illustrated description of Mark III. and Mark IV. short wave receiving tuners used by the R.A.F.

1023. THE IMPERIAL WIRELESS COMMITTEE (1919—1920). (*Wireless World*, 8, p. 306, July 10th, 1920—Abstract. *Nature*, 105, p. 594, July 8th, 1920—Abstract. *Electrical World*, 76, p. 124, July 17th, 1920—Abstract. *Electrical Review*, 87, p. 16, July 2nd, 1920, and pp. 42—43, July 9th, 1920—Abstract. *Telegraph and Telephone Age*, 38, p. 413, August 1st, 1920—Abstract. *Electrician*, 85, pp. 1 and 42, July 2nd, 1920—Abstract.)

Report of the Committee published July, 1920—see RADIO REVIEW, 1, pp. 543—544, August, 1920, for Abstract.

1024. THE FIRST ANNUAL CONFERENCE OF AMATEUR WIRELESS SOCIETIES. (*Wireless World*, 8, pp. 16—20, April 3rd, 1920.)

A verbatim report of the proceedings at the conference held on February 27th under the chairmanship of Sir Charles Bright.

1025. A SWEDISH RADIOTELEGRAPHIC INVENTION. (*Revue Générale de l'Électricité*, 7, p. 35B, January 31st, 1920.)

A brief note relative to a new method of secret transmission, but giving no details.

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1026. WIRELESS TELEGRAPHY LAWS (JAPAN). (*Journal Télégraphique*, 44, pp. 42—45, March 25th, 1920; pp. 57—59, April 25th, 1920.)

1027. JAPANESE LAWS *re* PRIVATE WIRELESS INSTALLATIONS. (*Journal Télégraphique*, 44, pp. 91—96, June 25th, 1920.)

1028. THE USE OF WIRELESS FOR COMMERCIAL TRAFFIC. H. Thurn. (*Elektrotechnische Zeitschrift*, 40, pp. 545—546, October 30th, 1919. *Revue Générale de l'Électricité*, 7, p. 85D, March 13th, 1920, Abstract.)
See also RADIO REVIEW Abstract No. 539, July, 1920.

1029. TELEGRAPHY, TELEPHONY AND WIRELESS IN THE WAR: REPORT OF THE CHIEF SIGNAL OFFICER FOR THE YEAR ENDED JUNE 30TH, 1919. (*Science Abstracts*, 23B, pp. 214—215, Abstract No. 425, April, 1920—Abstract.)

1030. WIRELESS WONDERS AT WOOLWICH. (*English Mechanic*, 111, p. 256, June 25th, 1920.)

A brief *resumé* of some of the wartime work carried out at the Signals Experimental Establishment, Woolwich.

1031. WIRELESS TELEGRAPHY ON RAILWAYS. (*Telefunken Zeitung*, 3, No. 18, pp. 36—44, October, 1919.)

A popular description of the use of wireless telegraphy and telephony in railway work.

1032. DEVELOPMENT OF THE TELEFUNKEN COMPANY. (*Telefunken Zeitung*, 3, No. 18, pp. 29—35, October, 1919.)

Figures are given illustrating the growth of the company especially since 1914.

1033. WIRELESS STRAYS FROM THE UNKNOWN. G. Marconi. (*Electrician*, 84, p. 122, January 30th, 1919.)

A letter protesting against recent journalistic statements as to "mysterious messages from the unknown," and disclaiming assertions as to messages being received from Mars.

1034. THE DISCOVERY OF ELECTROMAGNETIC WAVES. P. R. Coursey. (*Wireless World*, 8, pp. 73—75, May 1st, 1920. *Technical Review*, 6, p. 549, June 22nd, 1920—Abstract.)

This article briefly recapitulates Hertz's work leading up to the discovery of electromagnetic waves, and the arrangement used for setting up stationary waves on a long horizontal wire.

1035. FRENCH RADIOTELEGRAPHIC SYSTEM. (*Electrician*, 84, p. 678, June 18th, 1920.)

A few particulars are given of the French Government scheme for supplementing the existing telegraph and cable systems of communication. It is divided into four sections; the first to provide communication with ships at sea; the second to maintain regular communication with the mountainous regions of the country; the third to provide communication between France and other parts of Europe and the fourth for linking up the French colonies, including Saigon, Noumea and Tahiti. Stations capable of transmitting 7,500 miles are to be erected at Paris, Saigon and Tahiti and less powerful stations at a number of other colonial points.

1036. A TRIP WITH A RADIO MAN ACROSS THE ATLANTIC. J. Dunsheath. (*Telegraph and Telephone Age*, 38, pp. 334—335, June 16th, 1920.)

This article includes many references to wireless stations picked up at various distances across the Atlantic and concludes with a plea for the publication of more exact information as to the transmission times of meteorological messages, time signals, ice warnings, press, etc.

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1037. REGULATIONS FOR SMALL WIRELESS RECEIVING STATIONS. (*L'Électricien*, 50, p. 115, March 15th, 1920.)

Gives particulars of the conditions under which the use of receiving stations is allowed in France for reception of time signals, etc.

1038. THE LANGMUIR CONDENSATION PUMP. L. A. Hawkins. (*Everyday Engineering Magazine*, 9, p. 130, May, 1920.)

A brief illustrated description.

1039. THE TIMES OF TRANSMISSION OF THE PRINCIPAL WIRELESS STATIONS. P. Corret. (*La T.S.F. Moderne*, 1, pp. 50—56, May, 1920.)

An extensive time table is given of transmissions from the most important European stations. The call letters, wavelength and type of wave are given, together with an indication of the nature of the messages sent (time signals, weather signals, press, etc.). The particulars given are corrected to the end of May, 1920.

1040. DIRECTION FINDING STATIONS. (*Admiralty Notice to Mariners*, Nos. 363 and 524, 1920. *Wireless World*, 8, p. 104, May 1st, 1920—Abstract.)

Information is furnished with regard to the working arrangements and regulations for Direction Finding Stations available for use by the Mercantile Marine in Great Britain, Canada, United States, France, Italy, and Germany.

1041. REPORT OF THE ACTIVITIES OF THE "TELEGRAPHEN-VERSUCHSAMT" IN 1919. K. W. Wagner. (*Telegraphen- und Fernsprech-Technik*, pp. 1—7, April, 1920; and pp. 21—28, May, 1920.)

A brief review of the researches carried out by the telegraph administration, covering the whole field of telegraphy and telephony including wireless. Fourteen researches are reported dealing with wireless telegraphy and telephony, including—Installation of high-speed Wheatstone wireless system Berlin—Weimar; The freedom from disturbance of different receiving systems; Measurement of small coupling; High-voltage Wehnelt rectifiers; Effect of sending by altering the wavelength; The constancy of frequency in different sending systems; Wireless telephony; Reception on the telegraphone; Tests on the Eilvese receiving system.

2. Books.

GRUNDRISS DER FUNKEN-TELEGRAPHIE IN GEMEINVERSTÄNDLICHER DARSTELLUNG. By Dr. Franz Fuchs. (Munich: *R. Oldenbourg*. Eleventh Edition, 1920. Pp. 73. Price 2.75 M.)

This is the eleventh edition of this little book which was written during the war for the instruction of the great number of untrained men who were drafted into the wireless signalling section of the army. It assumes no previous electrical knowledge and seeks by means of simple explanations and numerous diagrams to give a knowledge of the principles involved. Although dealing principally with the systems employed by the German Army in the field, a section has been added describing the uses of three electrode valves. The last two diagrams in the book are somewhat misleading, but on the whole it is an admirable book for the purpose in view. The descriptions are clear and to the point and the diagrams are excellent.

G. W. O. H.

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DE INVLOED VAN EEN GEIONISEERD GAS OP HET VOORTSCHRIJDEN VAN ELECTROMAGNETISCHE GOLVEN EN TOEPASSINGEN DAARVAN OP HET GEBIED DER DRAADLOOZE TELEGRAPHIE EN BIJ METINGEN AAN GLIMLICHTONTLADINGEN. [THE EFFECT OF IONISED GAS ON THE TRANSMISSION OF ELECTROMAGNETIC WAVES AND ITS APPLICATION TO RADIOTELEGRAPHY.] By Balth. van der Pol. (Haarlem, 1920. Pp. 87.) [In Dutch.]

This reprint of a thesis presented by the author for the degree of Doctor of Science of the University of Utrecht, contains a description of a number of experiments made with the object of determining the effect of ionisation on the conductivity and apparent dielectric constant of a gas. An introduction is devoted to a review of the work of Macdonald, Poincaré, Nicholson and Watson on the mathematical side and of Austin on the experimental side of long distance transmission. The theory of Eccles and Salpeter that the velocity of the waves in the upper atmosphere is increased owing to the effect of free ions in reducing the apparent dielectric constant is then explained and a number of experiments with the object of confirming this theory are then described. The wavelengths employed were only between 1 and 2 metres, and the method consisted in setting up waves on a pair of Lecher wires by means of a Blondlot oscillator, except that in a few tests a three-electrode valve was employed. Attempts to transmit waves through a cylinder enclosing the Lecher wires failed owing to the absorption which occurred when the gas was ionised to any considerable extent. The method was therefore modified and the properties of the ionised gas determined by connecting the open ends of the Lecher wires through a vacuum condenser, the dielectric of which could be ionised by means of separate electrodes supplied at a high voltage. The Lecher wires were made telescopic and the P.D. was explored by means of a Duddell thermo-galvanometer connected to two exploring wires which were not brought into actual contact with the Lecher wires. A glow discharge was maintained within the vacuum condenser and the gas pressure varied between 0·345 and 2·19 mm.; this altered the reflecting properties of the condenser and changed both the distance to the first potential node, and the amplitude of the oscillation set up. From the results obtained the author considers that under some conditions there is a reduction of the apparent dielectric constant of the ionised vacuous space.

The author investigates the transverse conductivity of a vacuum tube along which a glow discharge takes place. The tube is placed between two electrodes which partially embrace it; these two electrodes constitute a condenser, and by sliding the tube along between the electrodes the conductivity can be determined at any point without the use of exploring wires.

G. W. O. H.

ERRATA.

Page 593, *Fig.* 6, *the equation of the dotted curve should read:*

$$\tan \delta = -7{\cdot}5^\circ \sin 2\phi.$$

Page 625, *footnote, for* Abstract No. 8 *read* Abstract No. 830.

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