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CONTENTS.

Two Shillings and Sixpence Net

Notes on the Theory and Calculation of Audio Frequency Valve Magnifiers.*

By J. K. CATTERSON-SMITH, M.I.E.E.

SYNOPSIS.

The article deals with troubles which arise through the self-capacity of the windings of transformers used in valve magnifiers. The theory of the valve and transformer coupling is developed and formulæ derived for use in calculating the windings and the size of the iron core. A first approximation for the capacity between layers is given.

The presence of capacity in the windings of the transformers used for coupling the valves in magnifiers is frequently a cause of difficulty in operation ; this is especially the case when the magnifier is intended to be aperiodic.

There appears to be a scarcity at present of data for guidance in respect to the predetermination of this capacity and in consequence the decision as to the suitability or otherwise of a given transformer is usually made on empirical grounds. It is hoped that in the near future experimental data will be forthcoming so that more exact ,design may be carried out than is possible at present, the writer's experience being that the formula which is quoted below results in discrepancies between the calculated and the observed " self-capacity " of the windings.

A rough outline of the problem is set out below and some indication is given of the magnitude of the quantities ; before proceeding to consider this it is advisable to review the conditions governing the design of the windings themselves for operation with a given type of valve.

The usual arrangement of the " intervalve " transformer is indicated in Fig. I for one stage of a magnifier. The magnification being obtained partly by the amplification at the valve and partly by the " step-up " of the transformer, the combination giving the voltage " step-up " per stage.

The number of turns in the windings for a given iron core depends upon

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the valves with which the transformer is to be used, and it is most fortunate that the conditions are not so complicated as they appear.

The writer has made use of the now well-known valve characteristics to formulate the expressions given below for the design of the windings for the transformers suitable for the "hard" valves in common use.

It is well not to lose sight of the fact that the ever-present danger of oscillations due to "self-capacity" makes it most important not to over-estimate the closeness with which the design may be carried out.

The symbols employed for the valve characteristics are :—

k_1 = slope of "anode current—grid voltage" curve,

k_2 = slope of "anode current—anode voltage" curve,

k_3 = slope of "grid current—grid voltage" curve,

k_4 = slope of "grid current—anode voltage" curve,

and $m = k_1/k_2$.

Referring to Fig. 1 it will be seen that the load on the secondary of the
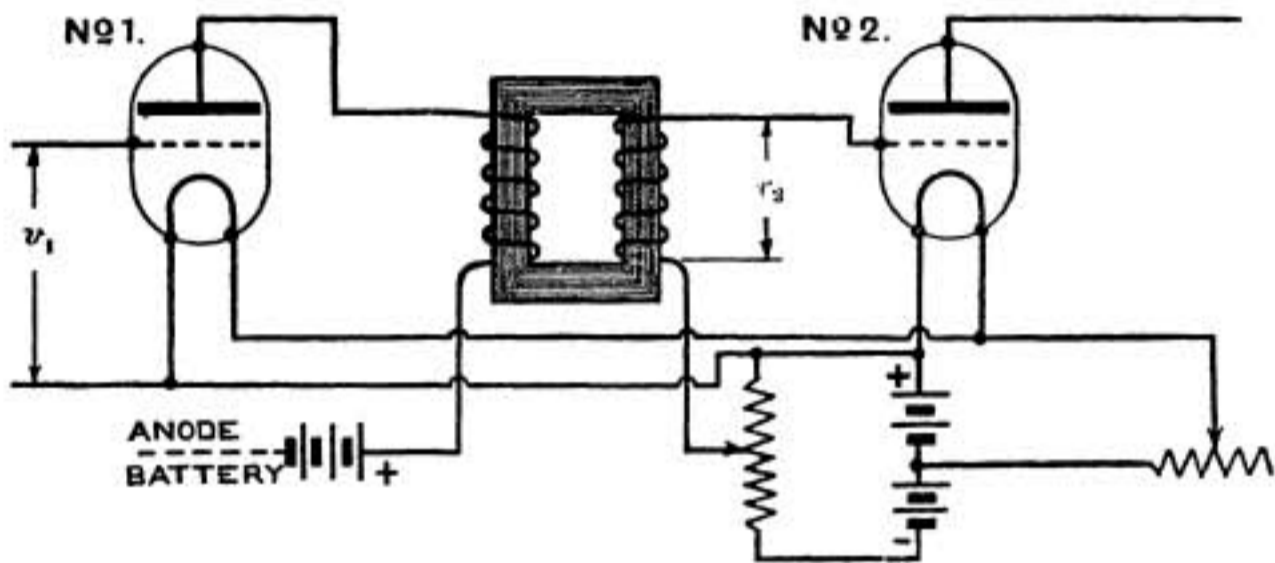

FIG. 1.

transformer is the alternating grid-current, taken by the second valve, at the alternating grid-voltage v_2 and this depends upon the slope k_3 of "the grid current—grid voltage" characteristic. The load is determined, therefore, by the resistance $R_g = 1/k_3$ if any small effects due to "k_4" are ignored.

The resistance of the load R_g appears in the primary side of the transformer as $R_g \cdot \dfrac{1}{r^2}$ where r is the transformation ratio or (secondary turns)/(primary turns) for an iron-cored transformer.

The total primary current is made up of two components at $\frac{1}{4}$-period phase difference, viz., i_μ the magnetising current lagging 90° to the primary voltage and i_w the load component which is in phase with the primary voltage. The primary voltage is the alternating anode voltage V.

Thus the anode current is :—

$$I = \sqrt{i_w^2 + i_\mu^2} = \frac{V}{Z} \text{ lagging by the angle } \phi$$

where $\cos \phi = \dfrac{Z \cdot r^2}{R_g}$ and Z is the equivalent impedance of the loaded trans-
former, or

$$Z = 1 \div \sqrt{\left(\frac{r^2}{R_g}\right)^2 + \left(\frac{1}{\omega L}\right)^2}$$

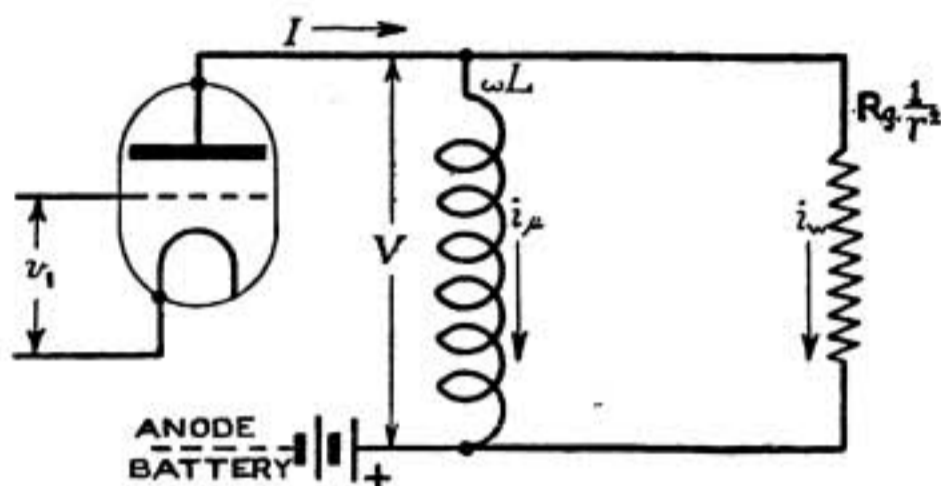The above conditions are represented by the "equivalent circuit" diagram

Fig. 2.

of Fig. 2 and the phase relations are as shown in Fig. 3.   It is clear that the anode current lags by ϕ to the anode alternating voltage and a little consideration of the problem will show that the anode current lags by a different
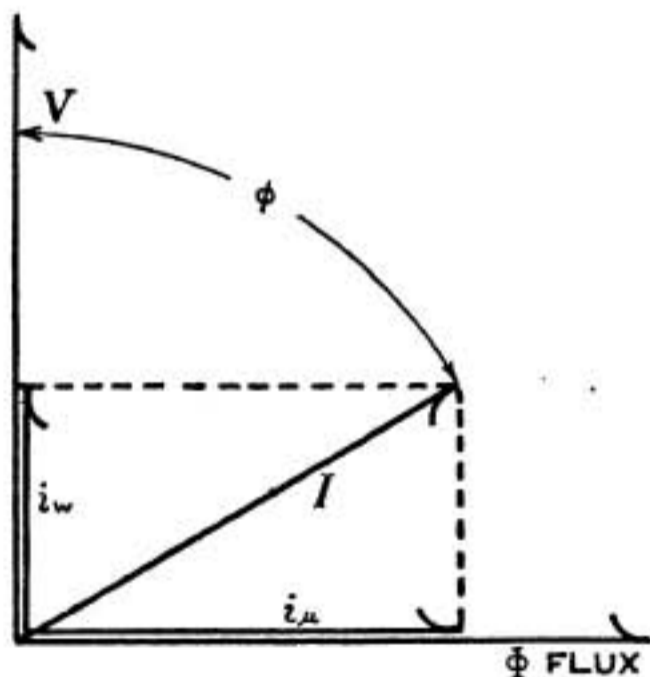
Fig. 3.

angle, viz., ψ to the alternating grid-voltage; this relationship is indicated in Fig. 4.*   The instantaneous values in terms of k_1 and k_2 for the valve are therefore expressed by:—

$$I_{inst} = k_1 v_{inst} - k_2 V_{inst} \quad \cdots \quad \cdots \quad \cdots \quad (1)$$
$$\text{in which}\quad I_{inst} = I_{max} \cdot \sin \theta$$
$$v_{inst} = v_{max} \cdot \sin(\theta + \psi)$$

*The vector v representing the "grid-voltage" is really at 180° to the position shown in Fig. 4.

$$V_{inst} = V_{max} \cdot \sin(\theta + \phi)$$
$$\text{and } V_{max} = I_{max} \cdot Z.$$

The foregoing relations may be substituted in equation (1) to find at what value of θ the grid voltage attains its crest value and it is found that the grid voltage is a minimum when

$$\theta = \tan^{-1}\left\{\frac{1}{k_2 Z} + \cos\phi\right\} \div \sin\phi \quad \ldots \ldots \quad (2)$$

Calling this value θ_1 gives $\psi = (90 - \theta_1)$.
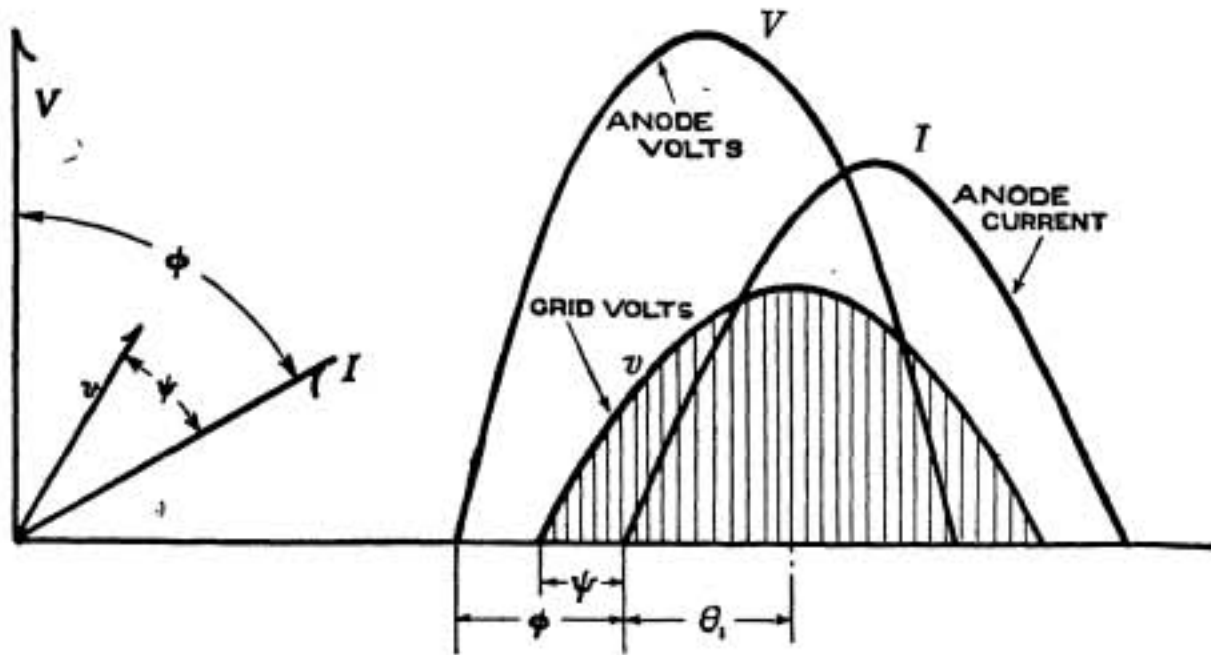
FIG. 4.

The amplification at the valve is the ratio of the alternating anode voltage to the alternating grid voltage or $\dfrac{V}{v}$ and the voltage at the grid of the succeeding valve is r times greater, thus the voltage " step-up per stage " is $r \cdot \dfrac{V}{v}$ which is denoted by the symbol Y. Putting m for k_1/k_2 it is a simple matter to derive from equation (1) the voltage step-up per stage

$$Y = m \cdot r \cdot \left[\frac{Z \cdot \cos\psi}{\frac{1}{k_2} + Z \cos\phi}\right]$$

and then substituting for ψ and ϕ the step-up is

$$Y = \frac{m \cdot r}{\sqrt{1 + \frac{1}{(k_2 Z)^2} + \frac{2r^2}{k_2 R_g}}} \quad \ldots \ldots \ldots \quad (3)$$

The graphs of this equation for various values of reactance ωL show that the step-up Y reaches a maximum for a definite ratio r.

Two cases are of interest :—

Case I.—When ωL is infinite the step-up attains its crest value when $r = \sqrt{k_2 R_g}$ or $\sqrt{k_2/k_3}$ and then

$$Y_{crest} = \tfrac{1}{2} m \cdot r \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

With ordinary valves this may be a good deal greater than the amplification obtained with a plain resistance coupling which approaches m as its limiting value.

The magnetising current is zero and both $\cos \phi$ and $\cos \psi$ are unity ; the transformer behaving as an " ideal " transformer giving the theoretical upper limit of the magnification per stage for an aperiodic magnifier.

Equation (4) will be found of use for gauging the possibilities of a given valve for use as a magnifier and for general work as an approximation avoiding the more cumbersome equations of the following case.

Case II.—The practical value of the reactance ωL is of the order of 50,000 or 100,000 ohms and then the step-up must be calculated by means of equation (3) for which the correct value of the transformation ratio, by putting $\dfrac{dY}{dr} = 0$, is found to be

$$r = \sqrt[4]{(k_2 R_g)^2 + \left(\frac{R_g}{\omega L}\right)^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

The graphs for low values of ωL, given by equation (3), are flattened and consequently the magnification is not nearly so sensitive to r, nevertheless r is always lower than might be expected and in practice appears limited to about 5 or 10 as an outside figure.

In the foregoing treatment the effect of resistance drop and drop due to magnetic leakage has been left out of consideration for the sake of simplicity and because it seems that with the smallest gauges of copper wire the resistance can be made negligible. The same applies to the leakage drop at the exceedingly low values of the field strength in the magnetic circuit. The presence of drop in the transformer from either of these causes is of course detrimental to the performance of an aperiodic magnifier from the point of view of magnification.

The step-up Y_{max} obtained from equations (3) and (5) will be a reasonable percentage of Y_{crest} only if ωL is made sufficiently large. With constants for the valves such as $k_1 = 300 \times 10^{-6}$, $k_2 = 30 \times 10^{-6}$ and $k_3 = 1 \times 10^{-6}$ amp./volt, or $Y_{crest} = 27$, it is essential that ωL should not be less than 50,000 ohms which for $\omega = 5,000$, or 800 cycles per second, means an inductance of 10 henries in the primary winding. This large inductance can be obtained with very small transformers by the use of some thousands of turns. The following expression is useful in this connection :—

the inductance $L = \Phi \times \text{turns} \div i_\mu \cdot 10^{-8}$ henries and as

the density $\quad B = \mu \times \dfrac{4\pi}{10} \cdot i_\mu \cdot \dfrac{\text{turns in winding}}{\text{length of iron path}}$ this reduces to

$$L = \frac{4\pi}{10} \cdot \mu \cdot \frac{\text{iron section}}{\text{iron length}} \cdot (\text{turns})^2 \cdot 10^{-8} \text{ henries} \quad . \quad . \quad . \quad (6)$$

With ordinary alloyed transformer steel μ is of the order of 200 to 300 at these low magnetisations. It may be remarked that with ωL as small as 0.05×10^6 ohms the magnetising current is only 20 micro-amperes per volt and the value of the magnetising force (H) less than a thousandth of unity.

The best form of core to satisfy equation (6) is one having a high ratio of section to length of iron path ; such a condition is best met by the ordinary
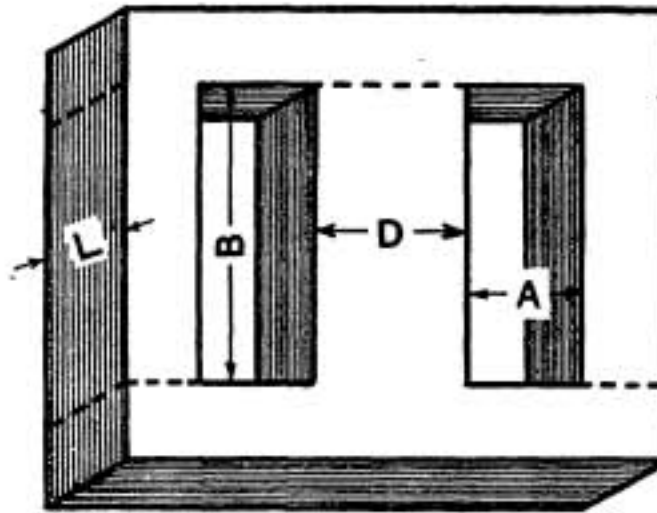

FIG. 5.

" shell type," Fig. 5, with a square window, *i.e.* $A = B = D = L$. With very small gauge wire the circular form of coil is imperative and this together with considerations of convenience in shape leads to the proportions $A = 0.5$ to $0.75D$, $B = 2$ to $3D$, and $L = D$ with a chamfer if desired. Thus $ABDL = 1$ to $2\frac{1}{4} \times D^4$ which gives the leading dimensions from :—

$$A.B.D.L = \frac{0.45 \times mV \times mA}{f \times f_i \times f_c \times \Delta \times B_{max}} \quad . \quad . \quad . \quad . \quad (7)$$

where the dimensions are in centimetres,

and $\quad mV =$ alternating milli-volts (r.m.s.) on primary.

$\quad mA =$ total primary current in milli-amps.

$\quad f =$ cycles per second.

$\quad f_i =$ iron space-factor, 70 per cent. to 90 per cent.

$\quad f_c =$ copper space-factor, 20 per cent. approx.

$\quad \Delta =$ primary current density amps./sq. mm.

$\quad B_{max} =$ flux density per sq. cm.

From the above it is clear that the number of primary turns will be of the order of 5,000 or 10,000 which produces sufficient capacity to cause resonance at moderate frequencies, sometimes dangerously near to the audio frequency at which the coil is working.

The winding may be regarded as consisting of an inductance L, a resistance R and a capacity C_s in series, see Fig. 6, and the problem is to determine the capacity C_s. This is made up of the capacity between layers and between turns. The former appears to be the chief source of the capacity C_s which gives trouble at audio frequencies and it only is considered in the following.

Treating each layer as though it consisted of square section conductor in place of circular wire with a distance t cm. between the layers and n layers
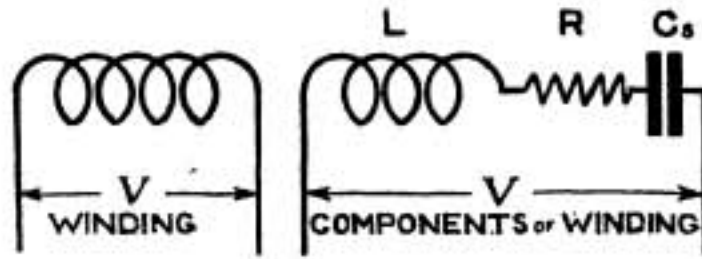

FIG. 6.

of dielectric, Fig. 7 represents a section of two of the layers in a coil of axial length B.   The voltage per layer of dielectric is V/n and the voltage at any elementary section distant x cms. from the junction of the layers
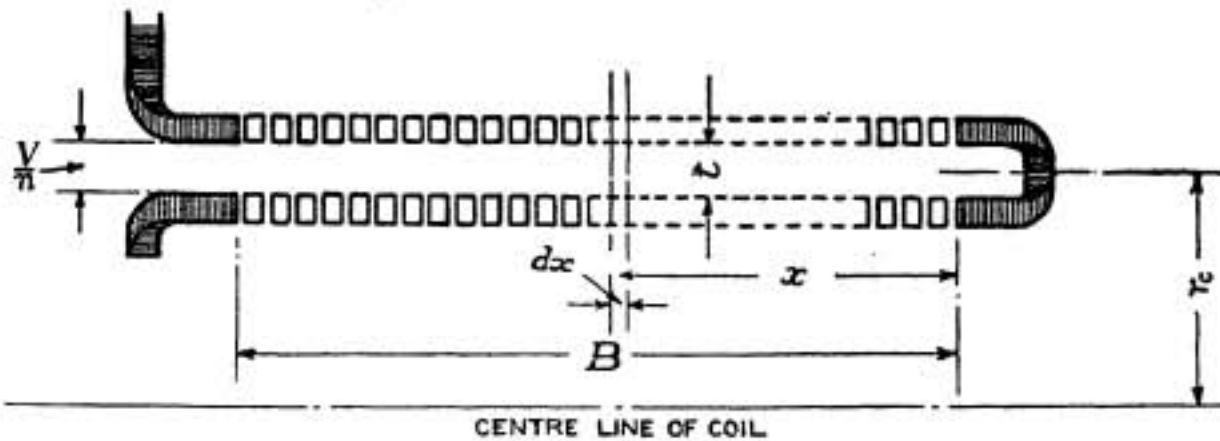

FIG. 7.

is $\dfrac{V}{n} \times \dfrac{x}{B}$. If the mean radius of the whole coil is r_c the capacity of the

elementary section is $\dfrac{2\pi \cdot r_c \cdot dx}{4\pi t} = \dfrac{r_c}{2t} \cdot dx$, and the charging current for the

whole layer $= \omega \cdot V = \cdot C_s = \displaystyle\int_{x=0}^{x=B} \omega \cdot \dfrac{V}{n} \cdot \dfrac{x}{B} \cdot \dfrac{r_c}{2t} \cdot dx = \omega \cdot V \cdot \dfrac{r_c \cdot B}{4n \cdot t}$

thus the self-capacity with a dielectric constant other than $1 \cdot 0$ is :—

$$C_s = k \cdot \frac{r_c \cdot B}{4n \cdot t} \times 1 \cdot 1 \times 10^{-6} \text{ mfd} . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

This of course depends upon the validity of some rather broad assumptions of which the most serious is that the charging current does not alter the distribution of the potential along the layers.   The writer has no experience of the use of a more exact expression and as has been mentioned previously the capacity given by equation (8) does not invariably tally with that observed by means of such a test as is indicated in Fig. 8.   The method is to set the supply frequency at any desired value by adjustment of C_1 and then alter C_2 until maximum noise is given by the telephone in series with the

transformer under test. Plotting the relation between C_1 and C_2 gives a straight line cutting the base ; and if this is extended to intersect the vertical axis the intercept is the value of the capacity C_s.   This is shown in Fig. 9.
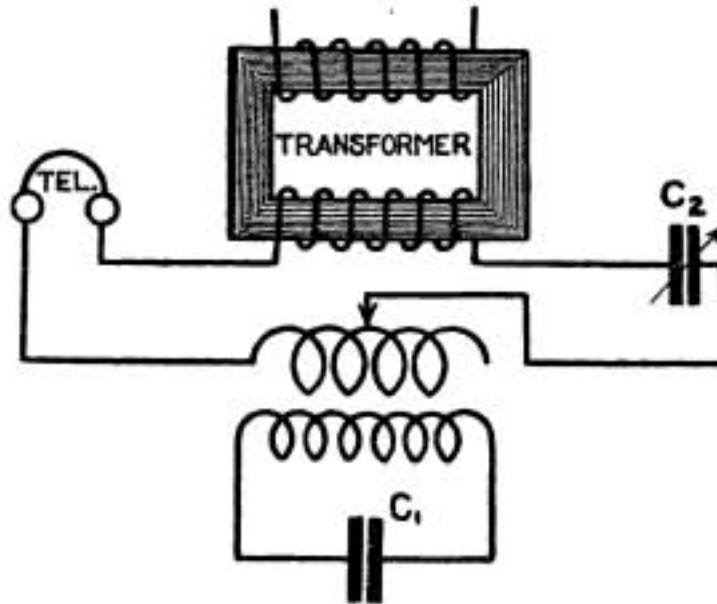
FIG. 8.

As an example of the magnitude of this capacity consider a coil of mean radius 2·0 cms. having 12 layers 5 cms. in length and $t = 0·0030$ cm. for a very light cotton spacing between layers.   If the coil is impregnated with
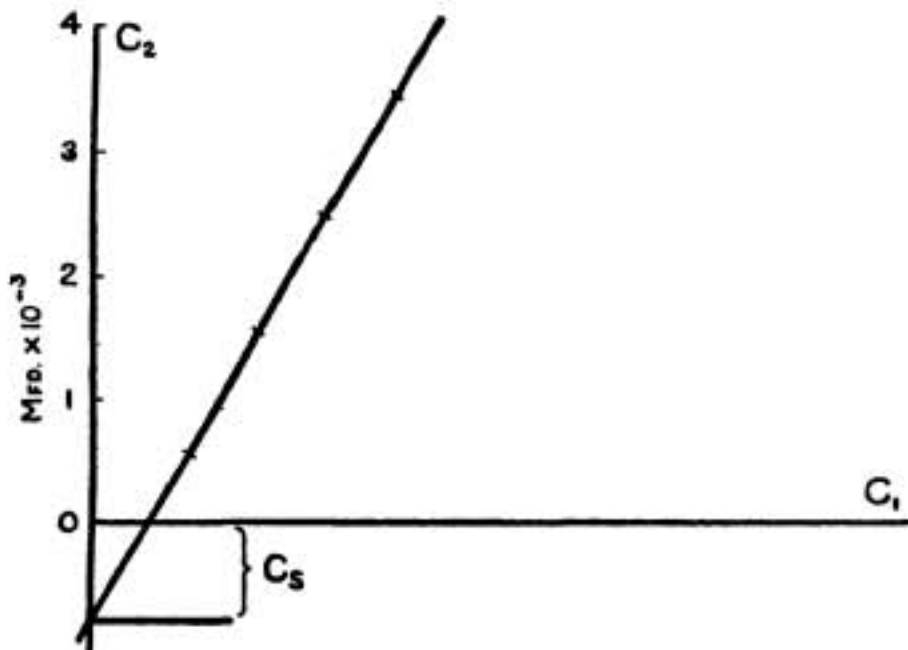
FIG. 9.

paraffin wax the dielectric constant is approximately 2·0, then equation (8) gives the self-capacity as :—

$C_s = 305 \times 10^{-6}$ mfd. or 0·30 milli-mfd. to which must be added the parallel self-capacity of the secondary making a total of approximately 0·6 milli-mfd.   It is scarcely necessary to add that the turns should be kept down and impregnation of the coils avoided, whilst enamel-covered wire does not appear to possess any great advantage over silk-covered wire. Consistent results are hardly to be expected unless the coils are machine wound.

On the Effect of Changes in Filament Temperature, Grid Potential and Anode Potential on the Frequency of the Oscillations Generated by a Thermionic Valve.*

By W. A. LEYSHON, B.Sc.

INTRODUCTION.

The experiments to be described† were undertaken in order to find out whether (1) a change in the circuit conditions of an oscillating valve produced any change in the frequency of the oscillations generated—the oscillating circuit maintained by the valve being otherwise left unchanged, and (2) when it had already been established that such changes occurred, to discover to what extent they occurred and in what ways the various causes were related to the effects produced.
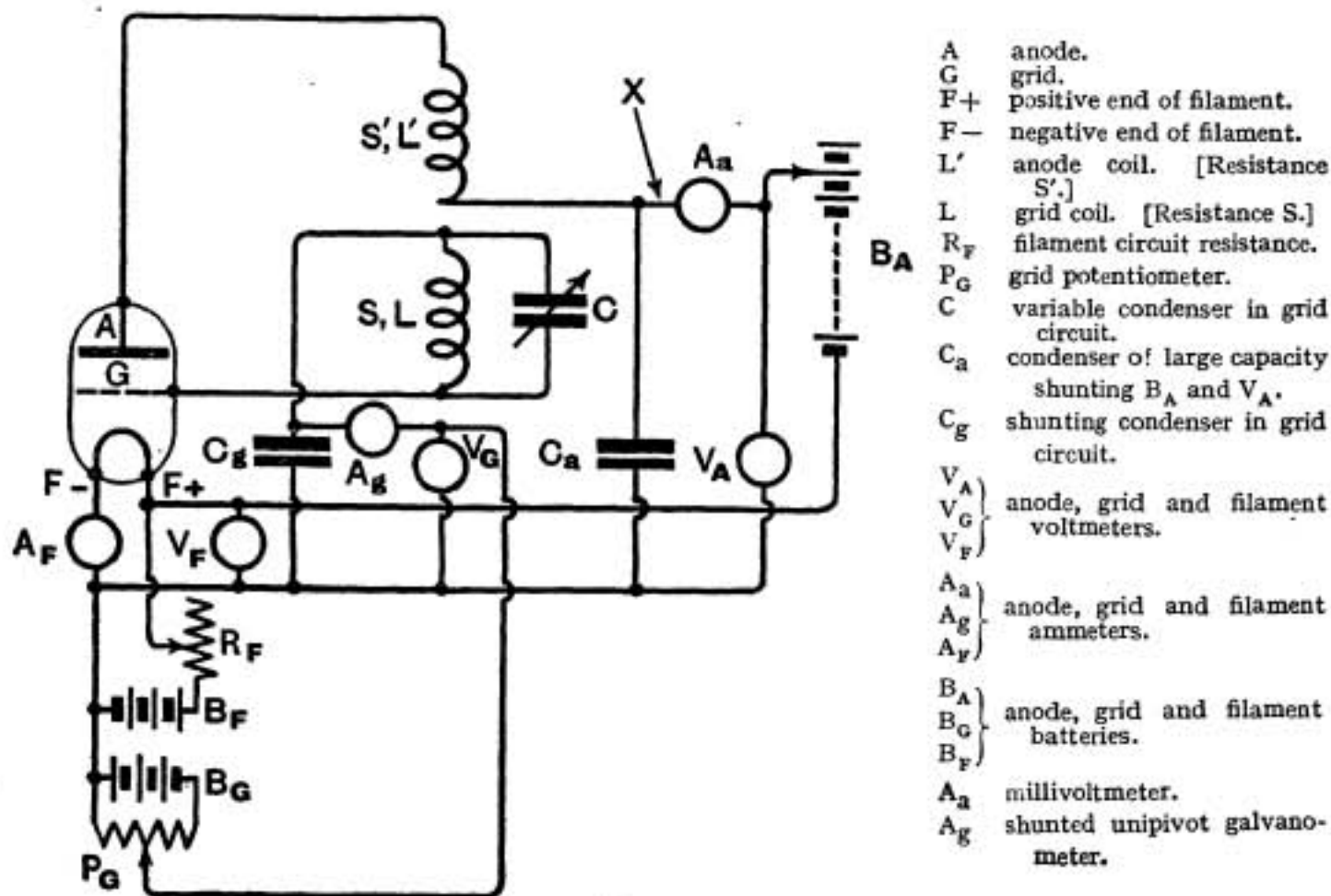

A	anode.
G	grid.
F+	positive end of filament.
F−	negative end of filament.
L′	anode coil. [Resistance S′.]
L	grid coil. [Resistance S.]
R_F	filament circuit resistance.
P_G	grid potentiometer.
C	variable condenser in grid circuit.
C_a	condenser of large capacity shunting B_A and V_A.
C_g	shunting condenser in grid circuit.
$\left.\begin{array}{l}V_A\\V_G\\V_F\end{array}\right\}$	anode, grid and filament voltmeters.
$\left.\begin{array}{l}A_a\\A_g\\A_F\end{array}\right\}$	anode, grid and filament ammeters.
$\left.\begin{array}{l}B_A\\B_G\\B_F\end{array}\right\}$	anode, grid and filament batteries.
A_a	millivoltmeter.
A_g	shunted unipivot galvanometer.

FIG. 1.

† These experiments were in progress before the publication of the paper by Dr. W. H. Eccles and Dr. J. H. Vincent, entitled, "On the Variations of Wavelength of the Oscillations generated by Three-Electrode Thermionic Tubes due to Changes in Filament Current, Plate Voltage, Grid Voltage or Coupling" (*Proceedings of the Royal Society*, 96A, pp. 455—465, February 3rd, 1920).

The circuits used were different and the frequency of the oscillations was very much greater (of the order of 10^7 per second) in this case.

It was expected that such changes would be small, and a sensitive method of detecting them was therefore required.

DESCRIPTION OF APPARATUS.

The apparatus used consisted of two high frequency oscillating sets A and B, which could be made to heterodyne. A diagram is given (Fig. 1) showing the circuit arrangements in B. A differed from B in that a pair of high resistance telephones was inserted at X. It was in some cases found desirable to insert the telephones in a corresponding point in B.

In the actual experiments the condenser C was of very small capacity. In order to calibrate this a variable condenser C_1 of larger capacity was placed in parallel with it in circuit A and sufficient capacity introduced into circuit B to make it possible to obtain a heterodyne note with A. The condenser C_1, which had previously been calibrated by a bridge method using a vibration galvanometer, was then set at successive known values and C adjusted until the circuits were in tune. The calibration of C was thus carried out by a substitution method.

The coupling between the oscillation coils of A and B was adjusted to be so small that on bringing B into tune with A the resonance point was very definite, and an exceedingly small range of capacity (about $\frac{1}{100} \mu\mu$ F) was sufficient to cover the " silence space."

METHOD OF USING THE APPARATUS.

The condenser C having been calibrated C_1 was removed and the circuits again made to heterodyne.

It was found that on increasing the filament temperature of valve B the heterodyne note entirely disappeared and a new adjustment of C in the direction of diminished capacity was necessary in order to bring the circuit into resonance with A.

The changes in effective capacity of the valve resulting from changes in filament temperature could thus readily be measured. (The term " effective capacity " may perhaps be regarded as legitimate, in that the changes of frequency produced by altering valve conditions may be counteracted by a change of capacity of the tuning condenser.)
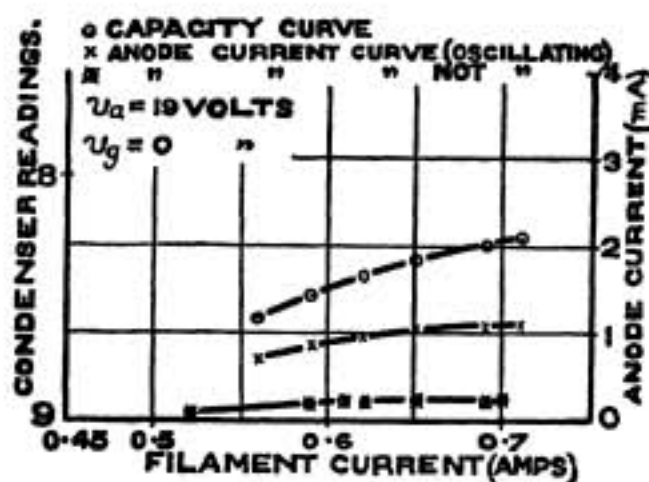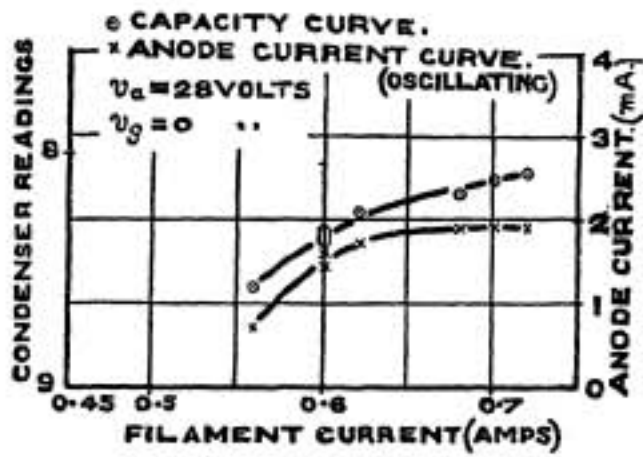

FIG. 2.

FIG. 3.
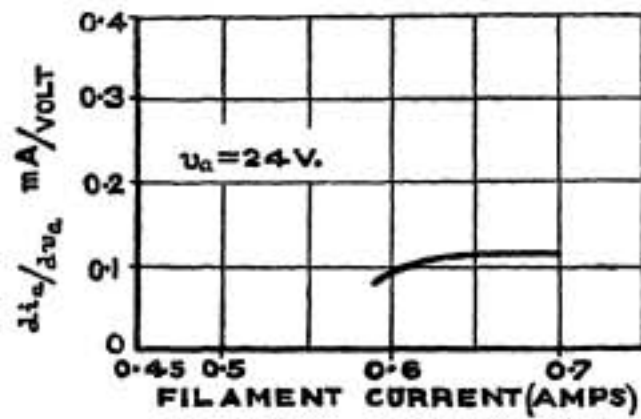
FIG. 4.
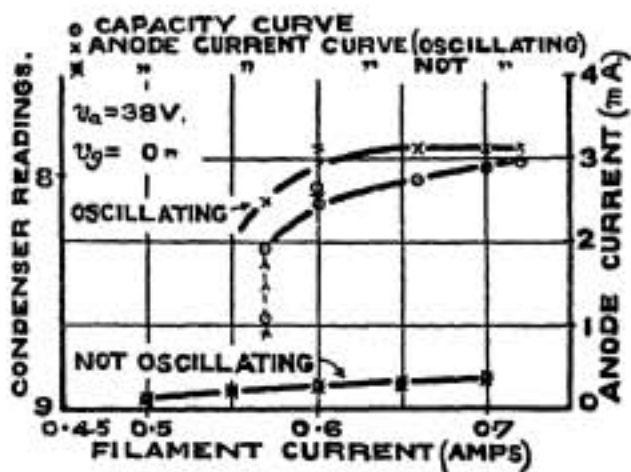
FIG. 5.
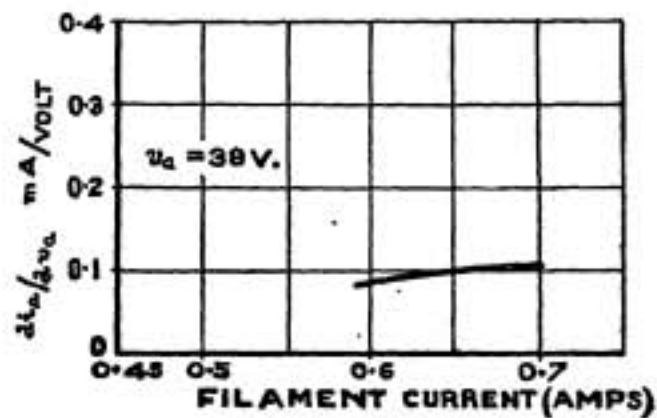
FIG. 6.
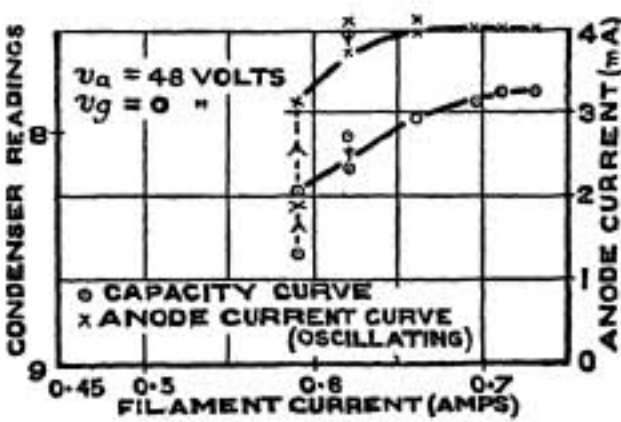
FIG. 7.
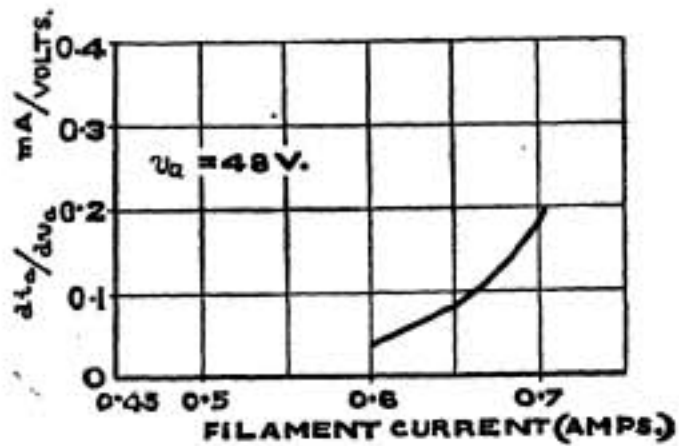
FIG. 8.

For given values of the anode and grid voltages, curves were obtained for valve B showing the variations in the value of the capacity of the balancing condenser C with increasing filament current—the frequency of the oscillations generated being kept constant.

RESULTS.

Several valves were tested and although the actual shape of the curve between capacity and filament temperature for a given anode and grid potential depended on the valve used, similar changes in the shape of the curves always resulted on altering these potentials.
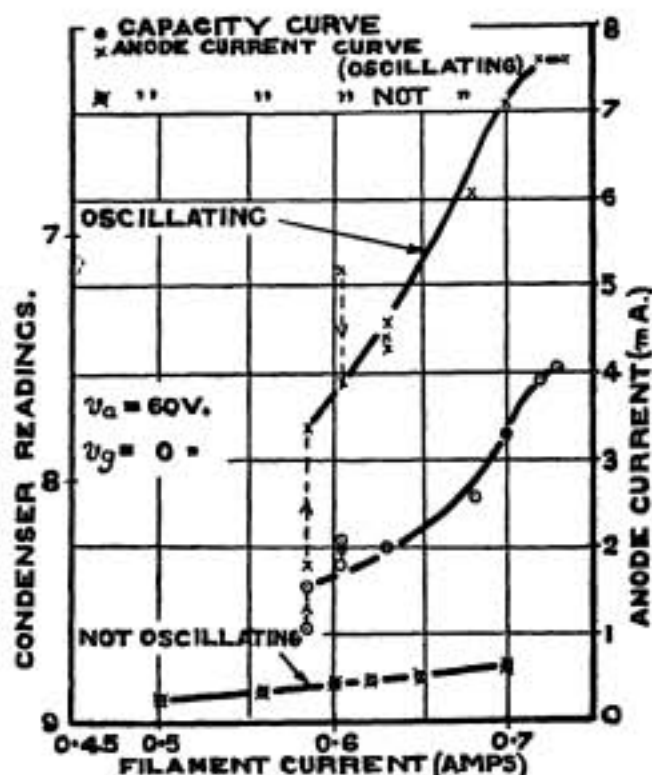
FIG. 9.
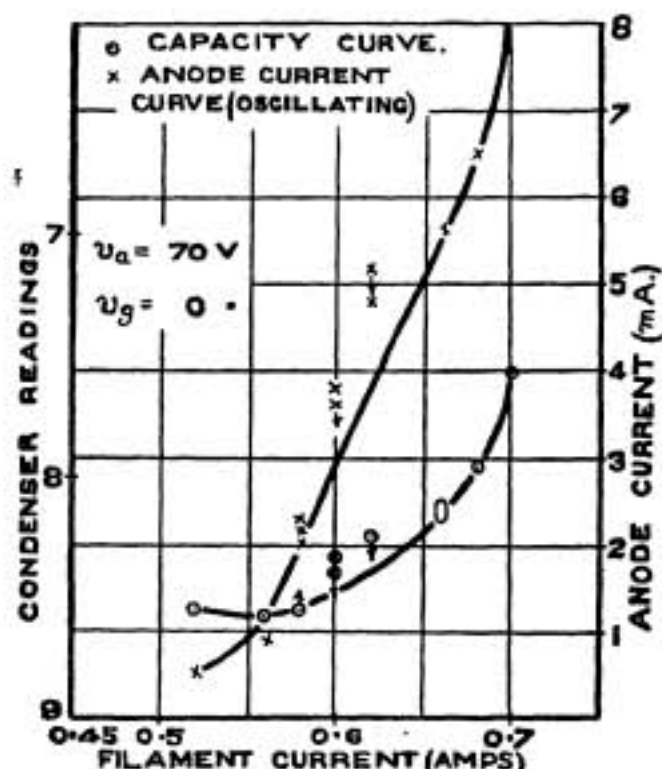
FIG. 10.

A set of curves is given in Figs. 2—10 for a valve of the Osram B type, showing variations in capacity, and in anode current, with filament temperatures. For comparison, corresponding values of anode current obtained with the reaction coil cut out—*i.e.* with the valve not oscillating, are also shown.

The curves showing variation in grid current with increasing filament temperature are shown in Fig. 11. The grid current with the non-oscillating valve was negligible compared with that taken when the valve was oscillating.
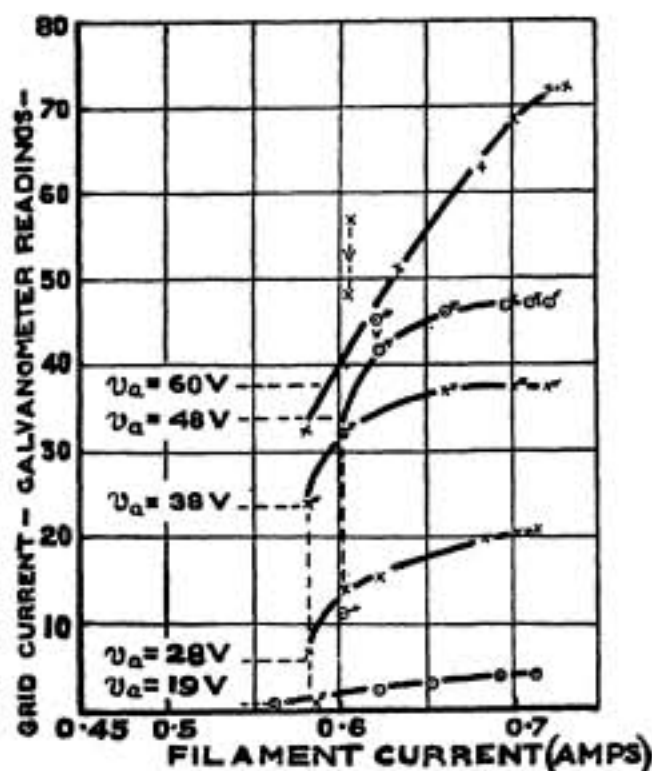
FIG. 11.

It will be seen that the scale for condenser readings is inverted so that a point higher up on the graph corresponds to a lower reading of the condenser—the curves were drawn in this way to facilitate comparison with the anode current curves and with the curves shown in Figs. 4, 6, and 8. These latter show the variation of the (oscillating) anode current with anode voltage for different filament temperatures and were obtained from the other curves.

Curves obtained for the same valve after reducing the reaction coil—no alteration being made in the coupling—are shown in Figs. 12—14. It will be noticed, referring to Figs. 2—11, that :—

(1) The slope of the capacity—filament-current curve is, for low anode

voltages, greatest at low filament temperatures. (In the curves obtained for another valve, the capacity of the condenser C definitely approached a lower limit at high filament temperatures.)
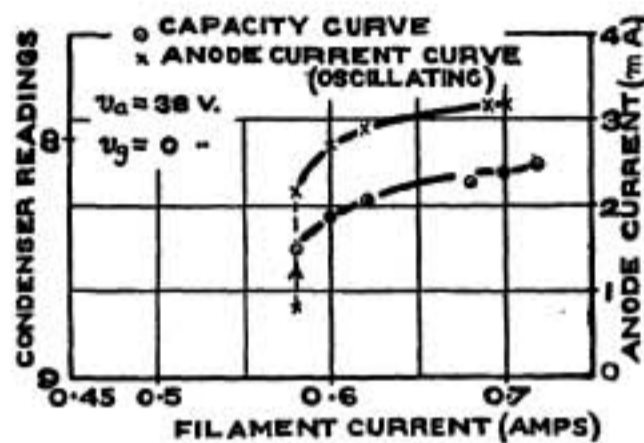
FIG. 12.

On the other hand, with higher anode voltages the slope of the capacity curve is least at low filament temperatures.

Similar changes in the shape of the capacity—filament-current curve have been observed in the case of every other valve tested under the same circuit conditions.
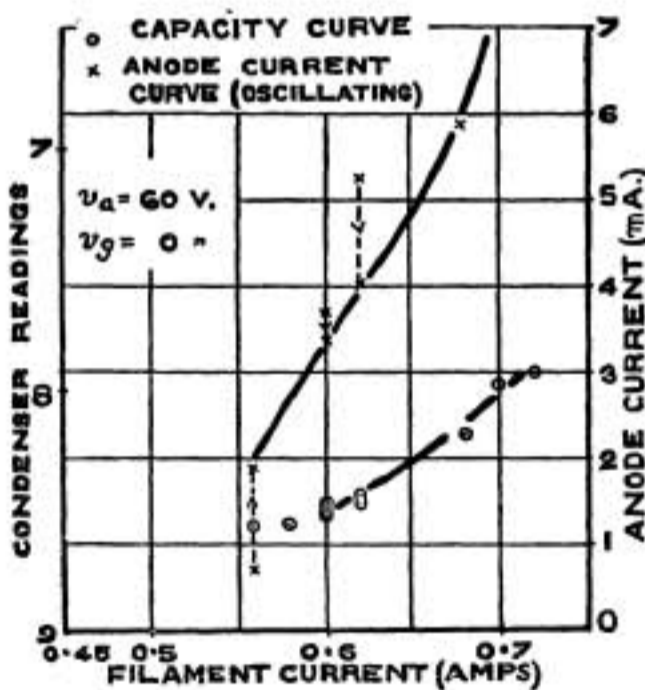
FIG. 13.
Curves with Reaction Coil reduced.
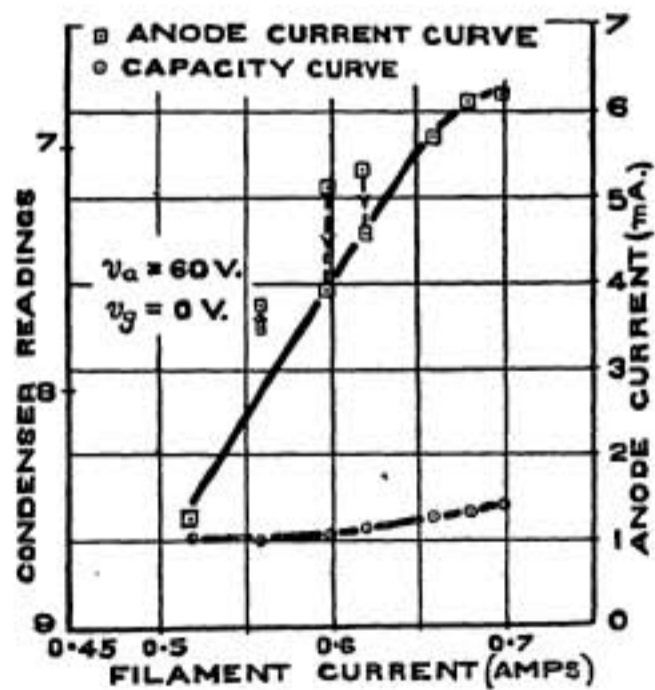
FIG. 14.
Curves with Reaction Coil still further reduced (no alteration in coupling between anode and grid coils).

(2) For this particular valve there is a certain amount of instability at a temperature corresponding to a filament current of about 0·58 ampere; some time elapses before the frequency of the oscillation for a particular condenser setting is constant. A corresponding effect is noticed in the anode and grid current curves. It occurs at points where a small change of filament temperature produces a large change in the anode and grid currents.

(3) The steepness of the anode and grid current curves as compared with that of the corresponding curves obtained for the non-oscillating valve is very marked. (See Fig. 9.)

(4) The anode and grid current curves for the oscillating valve follow each other very closely.

Referring to Figs. 12—15, it is seen that :—

(1) The effect of reducing the reaction coil is to reduce greatly the slope of the capacity—filament-current curve. (See Figs. 13 and 14.)

(2) The grid currents are less than those for corresponding voltages with a larger reaction coil. (See Figs. 11 and 15.)

(3) The anode current is not reduced to the same extent as the grid current on reducing the reaction coil and leaving the other conditions unchanged.

Other curves are given (see Figs. 16 and 17) showing the effect on the capacity curve of raising the grid voltage.

FIG. 15.
Grid Current Curves.
Curve I. corresponds with Fig. 12.
„ II. „ „ Fig. 13.
„ III. „ „ Fig. 14.

It is evident that the shape of the curves showing the relation between grid voltage and capacity will be different for different anode voltages and filament temperatures.

Similarly a series of curves anode-voltage—capacity would have to be drawn for different grid voltages and filament temperatures in order to express completely the relation between these quantities for a given valve and associated circuit.

FIG. 16.

FIG. 17.

Curves for V. 24 Valve showing effect of raising the Grid Voltage.

DISCUSSION OF RESULTS.

The observed changes of frequency due to altering the circuit conditions of the valve may be due to :—

(1) An alteration in the values of the various "conductances" of the valve, *i.e.* of the quantities $\frac{\partial i_a}{\partial v_g}$, $\frac{\partial i_a}{\partial v_a}$, $\frac{\partial i_g}{\partial v_g}$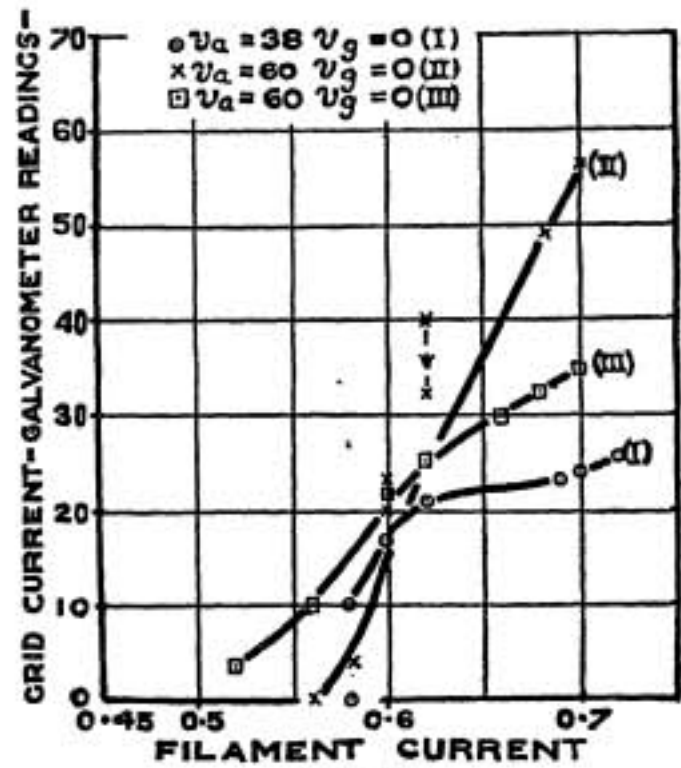 and $\frac{\partial i_g}{\partial v_a}$, where v_a, v_g represent anode and grid voltages and i_a, i_g anode and grid currents respectively.

(2) An actual change of capacitance between the valve electrodes. (It is possible that the inductivity of an electron atmosphere, such as that which exists in a very hard valve, is not the same as that of a vacuum; in a soft valve all gas molecules will tend to collect in the space charge region at high filament temperatures where they would tend to increase the inductivity of the grid-filament space. This effect, however, would probably be far too small to need consideration.)

It was suggested that the expansion of the filament wire might cause it to move appreciably nearer to the grid, and thus alter slightly the effective capacity; by throwing an enlarged image of the filament on a screen it was found that the movement amounted to about 0·3 mm. when the filament voltage was altered from 1·4 to 4 volts; this movement is not sufficient to account for any large part of the changes in effective capacity that have been observed.

To show how the value of $\frac{di_a}{dv_a}$ affects the frequency of the oscillations generated :—

Let L = Grid circuit inductance (of the order of $20\mu H$).
S = Grid circuit resistance (of the order of $1·5$ ohm).
C = Grid circuit capacity (of the order of $20\mu\mu F$).
L' = Anode circuit inductance (of the order of $20\mu H$).
S' = Anode circuit resistance (of the order of 2 ohms).
i = Variable part of current in grid oscillatory circuit.
v_g = Variable part of voltage on grid.
i_a = Variable part of current in anode circuit.
v_a = Variable part of voltage on anode,

and let the variable part of the current to the grid in the valve be neglected.

Then

$$v_g = \frac{1}{C}\int i.dt \quad \ldots \ldots \ldots \ldots \quad (1)$$

$$L.\frac{di}{dt} + Si + \frac{1}{C}\int i.dt - M.\frac{di_a}{dt} = 0 \ldots \ldots \ldots \ldots \quad (2)$$

$$L'\frac{di_a}{dt} + S'i_a + v_a - M.\frac{di}{dt} = 0 \quad \ldots \ldots \ldots \ldots \quad (3)$$

also $i_a = av_a + gv_g$ whence $v_a = \dfrac{i_a - \dfrac{g}{C}\displaystyle\int i.dt}{a} \quad \ldots \ldots \ldots \quad (4)$

where, $a = \dfrac{di_a}{dv_a}$ and $g = \dfrac{di_a}{dv_g}$.

On solving these equations we obtain

$$\omega^2 (M^2 - LL') + \frac{L'}{C} + SS' + \frac{S}{a} - \frac{Mg}{Ca} = 0 \quad \cdots \cdots \cdots \quad (5)$$

$$\omega^2 \left(SL' + S'L + \frac{L}{a}\right) \qquad\qquad = \frac{S'}{C} + \frac{1}{aC} \cdot \cdots \cdot \quad (6)$$

For tight coupling $M^2 - LL' =$ (approximately) 0.

$$\therefore \frac{L'}{C} + SS' + \frac{S}{a} - \frac{Mg}{Ca} = 0 \quad \cdots \cdots \cdots \cdots \cdots \quad (7)$$

gives the condition for oscillation.

$$\text{From (6)} \quad \frac{1}{\omega^2} = LC + \frac{SL'C}{S' + \dfrac{1}{a}}$$

$$i.e. \quad \frac{1}{\omega^2} = LC + \frac{aSL'C}{1 + aS}$$

$$= LC + aSL'C \text{ approximately, since } aS \text{ is}$$

$$\text{of the order } 10^{-3} \quad \cdot \quad (8)$$

Hence if L, C, M, S' are constant, an increase in a will lower the frequency. In the experiments described ω was kept constant.

On differentiating (8) with respect to filament temperature we obtain

$$L.dC + aSL'.dC + SL'C.da = 0.$$

The second term is negligible in comparison with $L.dC$.

Hence to a first approximation

$$- L.dC = SL'C.da.$$

In the experiments described

L	was of the order of	$20\mu H$	$= 20 \times 10^3$ e.m. units.
dC	,,	,,	$\frac{1}{4}\mu\mu F = \frac{1}{4} \times 10^{-9} \times 10^{-12}$ e.m. units.
C	,,	,,	$20\mu\mu F = 20 \times 10^{-21}$ e.m. units.
S	,,	,,	$1 \cdot 5$ ohm $= 1 \cdot 5 \times 10^9$ e.m. units.
L'	,,	,,	$20\mu H = 20 \times 10^3$ e.m. units.
da	,,	,,	$0 \cdot 16 \times 10^{-12}$ e.m. units.

then the left-hand side of the equation $= 20 \times 10^3 \times \frac{1}{4} \times 10^{-21}$;

$$= 5 \times 10^{-18}$$

and the right-hand side $= 1 \cdot 5 \times 10^9 \times 20 \times 10^3 \times 20 \times 10^{-21} \times 0 \cdot 16 \times 10^{-12}$

$$= 1 \times 10^{-19}.$$

Thus it is seen that the change in effective capacity is greater than that which would be expected from a change in the value of a.

The curves show that decreasing the reaction coil L' reduces the change in effective capacity produced by altering the filament temperature—the other circuit conditions remaining unaltered. This would be expected from the relation $L.dC = L'SC.da$.

When oscillations of large amplitude are taking place the grid conductance becomes appreciable and this grid conductance, in addition to the anode

conductance, exercises a damping effect on the grid oscillatory circuit.   The effect of the grid conductance has been considered in the case of a valve used as an amplifier or rectifier by E. V. Appleton,* who showed that minimum damping could be obtained by choosing a condenser of suitable capacity for the circuit.

The effect of the increasing grid current is to make the potential oscillation greater on the negative than on the positive side ; the mean grid potential is therefore more negative as the filament temperature is raised, making it possible for the " space charge " to be formed at lower temperatures than for the non-oscillating valve with zero grid potential.   This is shown in the curves given by the anode and grid currents approaching an upper limit (for lower voltages) as the filament temperature is raised.

The anode circuit itself may be considered as an oscillatory circuit, since there is a certain amount of capacitance between the anode and the filament of the valve.   The actual frequency of the oscillations generated will therefore depend on the natural frequencies of the two oscillatory circuits and on the coupling between them.

Since the actual changes of anode current produced by altering the filament temperature are always much greater than those of the grid current, it would be expected that the natural frequency of the anode oscillatory circuit would undergo larger changes than that of the grid circuit.   It would therefore appear that smaller changes in the frequency of the oscillations generated are likely to occur if the oscillatory circuit is connected to the grid of the valve than if it is connected to the anode—provided that the reaction coil is sufficiently small.

SUMMARY OF RESULTS.

(1) When an oscillatory circuit is maintained by a thermionic valve—the circuit being connected to the grid of the valve—changes in the effective capacity of the valve are observed on altering the filament temperature.

(2) On increasing either the steady voltage applied to the anode or that applied to the grid of the valve, these changes in effective capacity are increased.

(3) A reduction of the inductance of the reaction coil without altering the coupling between it and the oscillatory circuit causes a very appreciable diminution in the changes of effective capacity observed.

(4) The changes—which, in the arrangement employed, correspond to changes in effective capacity of the order of $0.5\mu\mu F$—apparently are not wholly accounted for by changes in the values of the " conductances " of the valve.

The experiments described have been carried out in the Laboratories of Applied Electricity, University of Liverpool.   My thanks are due to Professor E. W. Marchant, D.Sc., for his help and advice during their progress.

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The Generation of Large Powers at Radio Frequencies.

By THE EDITOR.

There was a stage in the development of the low-frequency alternate current generator when the outstanding feature was diversity of design. Armatures were sometimes inside and sometimes outside the field system ; the outside member was generally fixed, but in some cases, as at Niagara, the inside member was fixed and the outside member rotated around it. There was the Lauffen type with claw-poles, the Mordey Victoria with a stationary disc armature, the Ferranti with a rotating disc armature and various types of inductor alternators. With time came a gradual elimination and standardisation, modified only to suit the changing conditions due to the introduction of the steam turbine and the gradual growth in the size of the units. The early types are now only found in museums and technical colleges, and new machines, whether built in this country, in America, in France or in Germany, are very similar in the general design, however they may differ in detail.

If at the present time it is decided to build a transmitting station for radio-telegraphy over several thousand miles, it is necessary to erect an aerial with a height say of 500 feet, and a capacity of 0·01 to 0·05 microfarad, and to supply this aerial with from 100 to 300 kilowatts at a frequency of 15,000 to 25,000 cycles per second with the provision of a suitable arrangement for signalling. There are several different methods in use at the present time for meeting these requirements, but it is obvious that they cannot all be of equal merit and it is a matter of some importance to determine as soon as possible which is the best method. If all the wireless telegraph companies in the world were to pool their experience and resources and be uninfluenced by considerations of patent rights and national prejudices, which system would be employed ? Although the synchronous spark and the quenched spark appear to have been superseded for such large powers, the timed-spark system of the Marconi Company has recently been installed at the Norwegian transatlantic station at Stavanger. Arc generators have been carrying a large part of the transatlantic traffic between the United States and France and Italy and the new station at Bordeaux is being fitted with a 1,000 kilowatt arc supplied by the Federal Poulsen Company of America. An Alexanderson disc-inductor alternator generating directly the requisite frequency has been working at the New Brunswick station for some time, and no one can listen to the constant pitch of the note as received by the beat method without admiring the extremely accurate speed regulation. At Lyons the Société Française Radio-électrique have recently installed an inductor alternator of a different type, connected directly to the aerial and delivering thereto over 200 kilowatts. We understand that two 500 kilowatt machines of the same type are to be installed at Bordeaux. If this be so, arcs and high-frequency machines will be working side by side both at Lyons and Bordeaux. At Eilvese, near Hanover, the Goldschmidt internal cascade machine has worked throughout

the war and is still in continuous operation. At Nauen the Telefunken Company has recently installed a new high-power plant consisting of an alternator giving 6,000 cycles per second, connected to the aerial through two frequency doubling transformers in cascade, thus giving 24,000 cycles per second.

In addition to these half-dozen alternative systems all in actual operation, there is always the three-electrode valve, awaiting the successful design of a high-power type, but remaining for the present a matter of pious hopes and less pious rumours.

It will be seen that there is far greater diversity at the present day in the methods of generating high frequency currents than there ever was in the methods of generating low frequency currents, and there is little doubt that the future will see the elimination of some of these methods and the gradual improvement and standardisation of others.

It is probable that the power supplied to the aerial has now reached the highest value which will be required and that, with a higher efficiency of radiation of the transmitting aerial, and with greatly improved methods of eliminating atmospheric disturbances, and thus being enabled to use increased amplification, smaller transmitting powers will be found sufficient. For the present, however, the power required is several hundred kilowatts and the time seems ripe for a careful non-partisan comparison of the relative advantages and disadvantages of the various methods at present employed to produce this power.

High Frequency Alternators.*

By MARIUS LATOUR.

The author pointed out that the various types of high frequency alternator may be classified as follows :—(1) machines in cascade, (2) internally-cascaded machines, (3) homopolar disc machines (4) variable reluctance alternators, and (5) alternators using only a part of the armature periphery. Of these the paper dealt in particular with the last two classes, the general treatment following the lines of a previous paper by the same author.†

At the conclusion of the lecture the author briefly considered the conditions of maximum efficiency for machines of this type. The various methods of speed regulation were briefly touched upon, including the use of a second machine mounted upon the same shaft and so arranged that it is loaded to the same extent that load is removed from the H.F. alternator when signalling, but the author was of the opinion that the most satisfactory solution was to be obtained with some form of vibrating contact speed regulator controlling the speed of the driving motor. Finally the conditions under which H.F. alternators may be run in parallel were developed by the aid of vector diagrams, and the best condition was proved to be when the reactance of the machine was equal to its resistance. This condition may be most easily secured when a condenser is inserted in series with each machine.

In the discussion Professor Field gave some interesting particulars of machines for 600 cycles, which was, of course, quite outside the range of frequencies contemplated in the paper. Other speakers discussed the question of the relative merits of valve and alternator transmitters from various points of view. It was also suggested that the question of alternator development was wrapped up in that of the receiver development. If receiving circuits can be devised which have a very minute decrement a much more exact speed regulation of the H.F. alternator will become necessary.

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* Abstract of paper read before the Wireless Section of the Institution of Electrical Engineers on June 9th, 1920.

† *Bulletin de la Société Française des Électriciens*, 9, pp. 97—114, February, 1919. (Abstracted in *Wireless World*, 7, pp. 187—190, July, 1919, and pp. 247—248, August, 1919.)

Some of the Problems of Atmospheric Elimination in Wireless Reception.*

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

The object of this paper was to indicate some of the solutions which have been put forward on various occasions with a view to eliminating or reducing the effects of atmospheric disturbances in wireless receivers. After a brief introduction dealing with the nomenclature and classification of atmospherics, the fundamental electrical differences between atmospherics and C.W. or spark signals were indicated by means of a series of oscillograms, while the different effects produced in a tuned secondary circuit were also shown by means of a radio receiving apparatus subjected to the influence of signals from a " tonic-train " valve transmitter, together with irregular " X " impulses manufactured artificially by discharges from a condenser of large capacity. These differences are the basis of all the various methods that have been devised for eliminating atmospheric impulses. The effect of coupling and the advantages of a so-called " aperiodic " aerial receiver were then pointed out, and the various methods of atmospheric elimination classified as follows :—(1) Intensity limiters ; (2) Directional reception methods ; (3) Filtering circuits and (4) Methods dependent upon the aerial form.

One of the earliest intensity limiters was Austin's silicon-arsenic contact. This has been succeeded by the dimmed valve limiters in modern receivers. A recent addition to this class of limiter is L. B. Turner's Kallirotron limiter.†

As regards directional reception its chief advantages lie in somewhat limiting the areas from which atmospherics are received. The balanced aerial receivers both with radio frequency or with audio frequency balance may be classed with this group. The fundamental difficulty of these methods is that two currents of unequal frequency can never cancel out each other, whereas two currents of the same frequency and magnitude and of opposite phase can so cancel out. This effect was demonstrated at the meeting by means of two oscillating valves which could be coupled to a third circuit containing a valve amplifier and loud speaking telephone. A promising improvement of these balanced aerial methods has recently been described ‡ in which a frequency changing coupling is used between the two aerial circuits so that the opposing currents may be given the same frequency. No test results of this arrangement are yet available. Weagant's spaced aerial receivers may also be included in this class.§

In the simplest of filtering circuits a negative resistance may be used to increase selectivity. This may be derived either from a valve with reaction coupling, or by the use of a special valve of the Pliodynatron type, or from a combination of valves as in Turner's Kallirotron.‖ The early patterns of Marconi X-stopper may be regarded as some of the earliest examples of true filtering circuits. More recently we have the Western Electric Co.'s filter circuits ¶ and Lévy's filter ** which is based upon the principle of the double heterodyne.

The properties of any given arrangement of receiving aerial are largely a question of its effective resistance to the incoming signals. Some arrangements of aerials give a larger ratio of signal strength to atmospheric strength than do others, and by combining two aerial systems having different values for this ratio it is possible to effect at least a partial elimination of the atmospherics. Typical examples described in the paper were Priess's and Pickard's circuits †† while finally A. H. Taylor's experiments on horizontal aerials were also detailed.‡‡

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* Abstract of paper read before the Wireless Society of London on May 21st, 1920.
† See RADIO REVIEW, 1, pp. 317—329, April, 1920, for description.
‡ RADIO REVIEW Abstract No. 524.   § RADIO REVIEW Abstract No. 18, October, 1919.
‖ RADIO REVIEW, 1, pp. 317—329, April, 1920.   ¶ RADIO REVIEW Abstract No. 523.
** RADIO REVIEW Abstract No. 196, February, 1920.
†† RADIO REVIEW Abstract No. 75, December, 1919, also Abstract No. 525.
‡‡ RADIO REVIEW Abstract No. 149, January, 1920, and No. 313, April, 1920.

Review of Radio Literature.

1. Articles and Patents.

462. ON THE PERIOD AND DECREMENT OF AN OSCILLATORY ELECTRICAL CIRCUIT PROVIDED WITH A SHORT-CIRCUITED SECONDARY. I. Jones. (*Philosophical Magazine*, 39, pp. 553—565, May, 1920.)

The question of the influence of a short-circuited secondary is investigated mathematically commencing with the fundamental equations of the system. The complete formulæ for the frequency and decrement are not developed, but the results of particular solutions are given in the form of tables and curves. It appears from these that the expression

$$n = \frac{1}{2\pi} \sqrt{\frac{1}{C_1 L_1} - k_1{}^2}$$

(where k_1 represents the decrement), which is strictly applicable to a single oscillatory circuit possessing resistance, cannot generally be used when the damping arises from the resistance of a closed secondary circuit. When the ratio R_2/L_2 of secondary resistance to secondary inductance is large the results found in the paper approximate to those given by the above formula. If secondary capacity is present the arrangement may possess two frequencies.

463. SPONTANEOUS ELECTRIC OSCILLATIONS IN VARIOUS CONDUCTORS. W. Schottky. (*Annalen der Physik*, 57, p. 541. *Elektrotechnische Zeitschrift*, 40, p. 526, October 16th, 1919. *Revue Générale de l'Électricité*, 7, pp. 84D—85D, March 13th, 1920, Abstract.)

Starting from the kT law (k = gas constant and T = absolute temperature) the author arrives at the conclusion that in a receiving circuit having a natural frequency within the audible limits the disturbance of electrons under the influence of heat should give rise to a continuous sound in a telephone connected to the end of the conductor, quite apart from any external influence, provided that the currents thus set up are sufficiently amplified. Similar oscillations due to the impact of an electrified particle on to the electrode of an amplifier are also referred to.

464. AN ARRANGEMENT FOR SETTING UP OSCILLATIONS OF A SINGLE FREQUENCY ONLY, E. Bellini. (*Revue Générale de l'Électricité*, 7, p. 117D—118D, April 10th, 1920. Abstract.)

See RADIO REVIEW Abstract No. 99.

465. INDUCTANCE, CAPACITY AND RESISTANCE OF COILS AT RADIO FREQUENCY. L. E. Whittemore and J. Breit. (*Revue Générale de l'Électricité*, 7, p. 83D—84D, March 13th, 1920, Abstract.)

See RADIO REVIEW Abstract No. 93 for the original paper.

466. CALCULATION OF ANTENNA CAPACITY. L. W. Austin. (*Proceedings of the Institute of Radio Engineers*, 8, pp. 164—168, April, 1920. *Technical Review*, 6, p. 506, June 8th, 1920, Abstract.)

See RADIO REVIEW Abstract No. 88, January, 1920, where a paper has already been dealt with covering the same subject-matter.

467. ELECTRICAL MEASUREMENTS AT HIGH FREQUENCY. L. Brillouin. (*Bulletin de la Société Française des Électriciens*, 9, pp. 555—572, November, 1919. *Revue Générale de l'Électricité*, 7, p. 156, January 31st, 1920, Abstract. *Science Abstracts*, 23B, pp. 108—109, Abstract No. 203, February, 1920, Abstract.)

An account of methods developed mainly by Armagnat during the war. The resistance

of frame aerials of various sizes, numbers of turns, spacings, etc., at various frequencies were measured by the added resistance method and also by the heating produced. The results agreed. A number of curves are given very similar to those given by Blatterman,* and the same expression is used as a measure of the efficiency of the coil as a receiver. Reference is made to the error in direction finding due to the direct aerial effect and unbalanced capacities. The calibration of wave meters by heterodyne methods is described and also various absolute methods, viz., by standardised coils and condensers, by high-frequency alternators and by the multivibrator of Abraham and Bloch. The various methods of tuning exactly to the harmonics of the latter are discussed.

468. ELECTRICAL MEASUREMENT. (*N. P. L. Review*, 1, pp. 29—30, January, 1920.)

A brief summary is given of the radio research work in hand at the National Physical Laboratory, this includes standardisation of high frequencies, investigation into the construction of loss-free mutual inductances and exploration of the characteristics of triode valves under different conditions of treatment and use.

469. THE MEASUREMENT OF VERY SMALL ALTERATIONS OF CAPACITY BY MEANS OF UNDAMPED OSCILLATIONS. J. Herweg. (*Verhandlungen der Deutschen Physikalischen Gesellschaft*, 21, pp. 572—577, September, 1919. *Science Abstracts*, 23A, p. 243, Abstract No. 619, April, 1920, Abstract.)

A heterodyne method in which the beat note from two generating triodes produces beats with the note from a standard fork. The alteration of the capacity of the oscillatory circuit of one generator is measured by the alteration in beat frequency. The whole of the apparatus with the exception of the telephone ear-piece and the tuning fork is enclosed in an earthed case. The method admits of the detection of a change of capacity of one part in a million.

470. MEASUREMENT OF RECEIVED RADIO CURRENTS WITH THE ELECTRO-METER. E. O. Hulbert and G. Breit. (*Physical Review*, 15, pp. 405—408, May, 1920.)

In the method described a Dolezalek quadrant electrometer is connected across a resistance inserted in the plate circuit of a three-electrode valve which may be used alone as a detector, or as the detecting valve of a multi-stage amplifier. The vane of the electrometer is charged to 400 volts from a secondary battery. A sensitivity is obtained of 2,500 millimetres deflection per volt applied to the quadrant. The resistance in the plate circuit of the valve was from 20,000—60,000 ohms and a pair of telephone receivers was also included. To calibrate the arrangement a condenser potentiometer was arranged consisting of two variable condensers in series, across one of which the amplifier was joined. The electrometer deflection was found approximately proportional to the square of the mean value of the high frequency voltage impressed upon the amplifier.

471. SOME LABORATORY USES FOR THE CONTACT RECTIFIER. J. C. Jensen. (*Physical Review*, 15, pp. 224—225, March, 1920.)

In the experiments described a rectifier consisting of a piece of polished silicon pressed against polished carbon was found to give greater rectification and less resistance than a point contact. A pressure of about 5 grammes per square centimetre was used.

472. AN UNDAMPED WAVE METHOD OF DETERMINING DIELECTRIC CONSTANTS OF LIQUIDS. W. H. Hyslop and A. P. Carman. (*Physical Review*, 15, pp. 243—244, March, 1920.)

The measurements were made with two oscillating valve circuits using the beat method to indicate the frequency difference. The dielectric under test was introduced between the plates of a condenser forming part of one oscillation circuit, and the beat note restored to its original frequency by alteration of a standard condenser in parallel with the test condenser. Con-

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* RADIO REVIEW Abstract No. 144.

stancy of the beat note was obtained by comparison with a standard tuning fork For a wavelength of about 5,000 metres the following results were obtained at a temperature of 21° C. :—Kerosene 2·12, toluol 2·39, ether 4·32, olive oil 3·11, petrol-ether 1·86.   Accuracy = 1 per cent.

473. CONDUCTIVITY AND DIELECTRIC COEFFICIENT OF DIELECTRICS AT HIGH FREQUENCIES. G. E. Bairsto. (*Proceedings of the Royal Society*, 96A, pp. 363—382, January 2nd, 1920. *Science Abstracts*, 23A, pp. 163—164, Abstract No. 433, March, 1920.)

Measurements of the A.C. conductivity, dielectric coefficient, and power factor of dry blotting paper, crown glass, vulcanised rubber, gutta-percha, marble and slate have been made at frequencies from 1,000 cycles to 3,000,000 cycles per second using an arc generator in compressed air to give oscillations of sinoidal wave-form.   The hysteresis loss per cycle was found constant at low frequencies, while at very high frequencies it tended to vanish. The loss due to viscosity was found proportional to the square of the frequency at low frequencies.   The maximum A.C. conductivity is very much greater than the D.C. conductivity. The dielectric coefficient increases rapidly at audio-frequencies but at a slower rate beyond the audio limit.

474. ELECTRO-PLATED IRON IN HIGH-FREQUENCY FIELDS. G. Preuner and L. Pungs. (*Verhandlungen der Deutschen Physikalischen Gesellschaft*, 21, pp. 594—602, September, 1919. *Science Abstracts*, 23A, p. 244, Abstract No. 622, April, 1920, Abstract.)

Experiments are described on the effect of giving iron fittings used in wireless installations an electrolytic deposit of copper or zinc.   A deposit of from 0·03 to 0·04 mm. thickness was found sufficient to shield the iron so that the losses were nearly the same as if the fitting were of solid copper.   The thickness of zinc should be of the order of 0·1 mm. for the same effect.

475. A POCKET SIZE WAVEMETER. E. Nesper. (*Jahrbuch der Drahtlosen Telegraphie*, 14, pp. 624—629, November, 1919. *Science Abstracts*, 23B, p. 172, Abstract No. 347, March, 1920, Abstract.)

The wavemeter described is contained in two boxes 20 × 10 × 7 cm.   It comprises a circuit with a variable condenser of maximum capacity 1,200 cm., a hot wire instrument, and a set of five coils giving the following wavelength ranges : 45—220 m., 110—430 m., 270— 1,150 m., 720—2,500 m., and 1,200—4,300 m.   Photographs of the apparatus are given.

476. PRODUCTION OF UNDAMPED WAVES BY RHYTHMIC SPARKS. (*Génie Civil*, 76, p. 83, January 17th, 1920. *Revue Générale de l'Électricité*, 7, p. 103D, March 27th, 1920, Abstract.)

An illustrated description of the Marconi timed disc continuous wave oscillation generator— extracted from article in *Wireless World*, 7, pp. 310—316, September, 1919.

477. TRANSMITTERS. A. Taylor. (*French Patent* 498602, April 24th, 1919. Published January 16th, 1920.)

The invention relates to radiotelegraphic transmission systems and particularly to means for producing signals.   The object is to provide a key capable of dealing with large currents. For further particulars, see British Patent No. 131561.*

478. RADIOTELEGRAPHY. L. F. Fuller. (*U.S. Patent* 1330254, filed April 23rd, 1917. Patent granted, February 10th, 1920.)

This patent covers the same subject-matter as British Patent 133901.†

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* RADIO REVIEW Abstract No. 189.
† RADIO REVIEW Abstract No. 218 (March, 1920).

479. APPARATUS FOR GENERATING UNDAMPED OSCILLATIONS. J. Nienhold. (*German Patent* 301241, April, 1917. Patent granted, October 9th, 1919. *Jahrbuch der Drahtlosen Telegraphie*, 15, p. 166, February, 1920, Abstract.)

A simple type of arc circuit with a cathode of an alkalic metal and a metallic anode (*e.g.* iron) both enclosed in an atmosphere of one of the inert gases.

480. FILTER CIRCUITS FOR HIGH FREQUENCY OSCILLATIONS. Western Electric Company, U.S.A. (*British Patent* 136712, February 19th, 1919. Patent accepted, December 24th, 1919.)

The object of the arrangement described is to provide a means for suppressing harmonics and allowing current of the desired frequency only to pass into the output circuit. The arrangement is indicated in Fig. 1 : V_1 is the
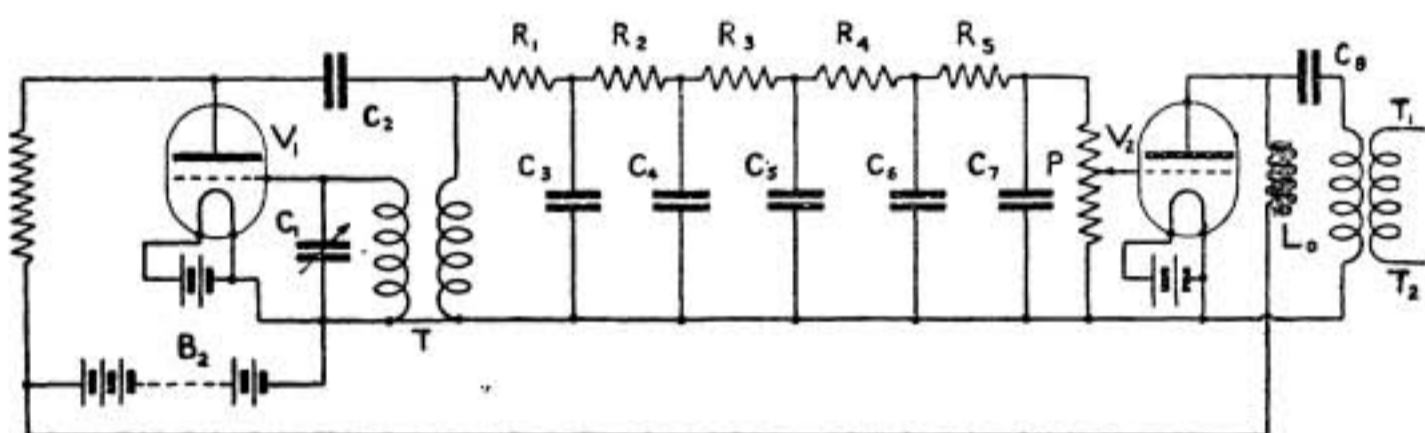
FIG. 1.

valve oscillation generator and V_2 is the valve amplifier. The output circuit is joined to T_1T_2. The resistances $R_1 \ldots R_5$ are inserted between the condensers to prevent them from affecting the tuning of the circuits of the generating valve V_1. The capacity of these condensers $C_3—C_7$ are adjusted so as to offer a high impedance to the currents of the desired output frequency, but to allow the undesired harmonics to pass through them. The amplifier V_2 is fed from the potentiometer P as indicated. The condenser C_1 may alternatively be connected between the grid and anode of the oscillating valve, instead of in the position shown.

481. GENERATION OF OSCILLATIONS BY CATHODE-RAY VACUUM TUBES. E. F. Huth and S. Loewe. (*German Patent* 302465, July, 1917. Patent granted, October 4th, 1919. *Jahrbuch der Drahtlosen Telegraphie*, 15, p. 77, January, 1920, Abstract.)

A triode oscillator (see Fig. 2) with a single coil and variable condenser and filament tappings.
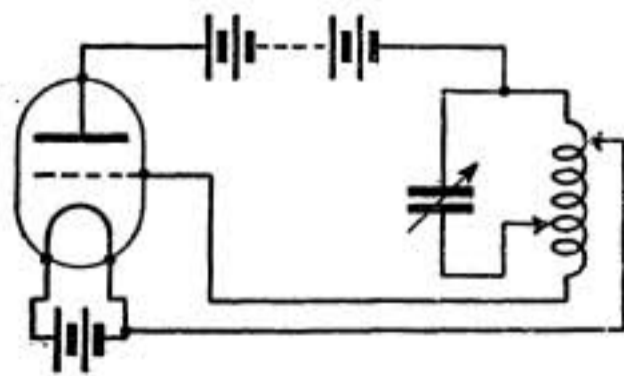
FIG. 2.

482. METHODS OF USING TRIODES AS OSCILLATION GENERATORS. G. Vallauri. (*L'Elettrotecnica*, 7, pp. 60—62, February 5th, 1920.)

A non-mathematical discussion of several well-known methods. Suitable numerical values of L and C are given. A method is described in which the alternating current in the anode circuit of one valve acts on the grid of a second valve, thus amplifying the output. The use of an oscillating triode as a wavemeter, using the double click phenomenon, is also described.

483. SHAFT BEARINGS. E. F. W. Alexanderson. (*British Patent* 135824, October 17th, 1919. Convention date November 26th, 1918. Patent accepted, December 31st, 1919.)

Arrangements are described for equalising the thrust on two bearings placed at opposite ends of the shaft of an inductor alternator, by a special form of link mechanism connecting the two bearings.

484. HIGH FREQUENCY INDUCTOR ALTERNATORS. E. F. W. Alexanderson. (*British Patent* 135825, October 24th, 1919. Convention date, November 26th, 1918. Patent not yet accepted but open to inspection.)

This relates to the cooling of H.F. machines by pipes located in slots in the core rings and by appropriate shaping of the winding terminals, etc.

485. HIGH FREQUENCY INDUCTOR ALTERNATORS. E. F. W. Alexanderson. (*British Patent* 136147, October 27th, 1919. Convention date, December 6th, 1918. Patent not yet accepted but open to inspection.)

In the construction of the field magnet windings for high-frequency inductor alternators a number of independent exciting windings may be arranged so that each of them is capable of furnishing the full load field excitation. In the normal operation of the machine all the windings may be excited but in the event of the breakdown of one of the windings the remainder can be supplied with a larger current.

486. CHARACTERISTIC CURVES OF FREQUENCY DOUBLERS APPLIED TO RADIOTELEGRAPHIC TRANSMISSION. T. Minohara. (*Revue Générale de l'Électricité*, 7, pp. 283—291, February 28th, 1920. *Technical Review*, 6, p. 424, May 11th, 1920, Abstract. *Science Abstracts*, 23B, p. 202, Abstract No. 403, April 30th, 1920, Abstract.)

This paper investigates theoretically and experimentally the conditions of operation of frequency doublers (Joly-Vallauri type) in which two similar transformers are provided with both A.C. and D.C. magnetisation. Two conditions of operation are distinguished, (1) in which the secondary E.M.F. of double frequency is sinoidal with small power output, and (2) in which the secondary E.M.F. is rich in higher harmonics and has considerable power, while the second harmonic is filtered out by a resonant circuit. To obtain the first condition the A.C. ampere-turns must be 1·66 times the D.C. ampere-turns, and for the second case the two ampere-turns must be equal, while the D.C. excitation must bring the iron to the knee of the magnetisation curve. Maximum power is obtained when the secondary current is slightly leading. A number of oscillograms are included in the paper which support the theory.

487. RADIOPHONE MODULATOR. (*Wireless Age*, 7, p. 23, December, 1919.)

A number of microphones are arranged in series so that each one shunts only one or two turns of the aerial inductance. The microphones are all influenced by one mouthpiece.*

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* See also RADIO REVIEW Abstract No. 131.

488. Is Radiotelephony suitable for Intercommunication in Large Electric Power Systems? J. Nübel. (*Elektrotechnische Zeitschrift*, 41, pp. 125—128, February 12th, 1920. *Technical Review*, 6, p. 341, April 13th, 1920, Abstract.)

A very thorough discussion of the relative merits of line and radio telephony in a large power distributing system, especially with overhead transmission. The author decides against radio telephony.

489. Telephone Transmitter. A. P. Pinkler. (*U.S. Patent* 1330391, filed March 2nd, 1917. Patent granted, February 10th, 1920.)

Relates to a special construction of microphone having a V-shaped insulating projection inside the granule chamber to restrict the current flow to the centre of the granular mass.

490. Telephone Receiver. R. Nordenswan and R. C. Winckel. (*U.S. Patent* 1330214, filed January 4th, 1918. Patent granted, February 10th, 1920.)

Relates to a special construction of the magnet system for telephone receivers.

491. Combined Transmitter and Receiver for Wireless Telephony. W. E. Barber. (*British Patent* 136654, December 20th, 1918. Patent accepted, December 22nd, 1919.)

The special feature described consists in the use of an electromagnetic relay for dimming the filaments of either the transmitting or receiving valves, the relay being controlled by speech currents from the transmitting microphone. The circuit arrangement is indicated in Fig. 3. The windings of the relay Y are inductively coupled through T_1 to the circuit of the transmitting micro-
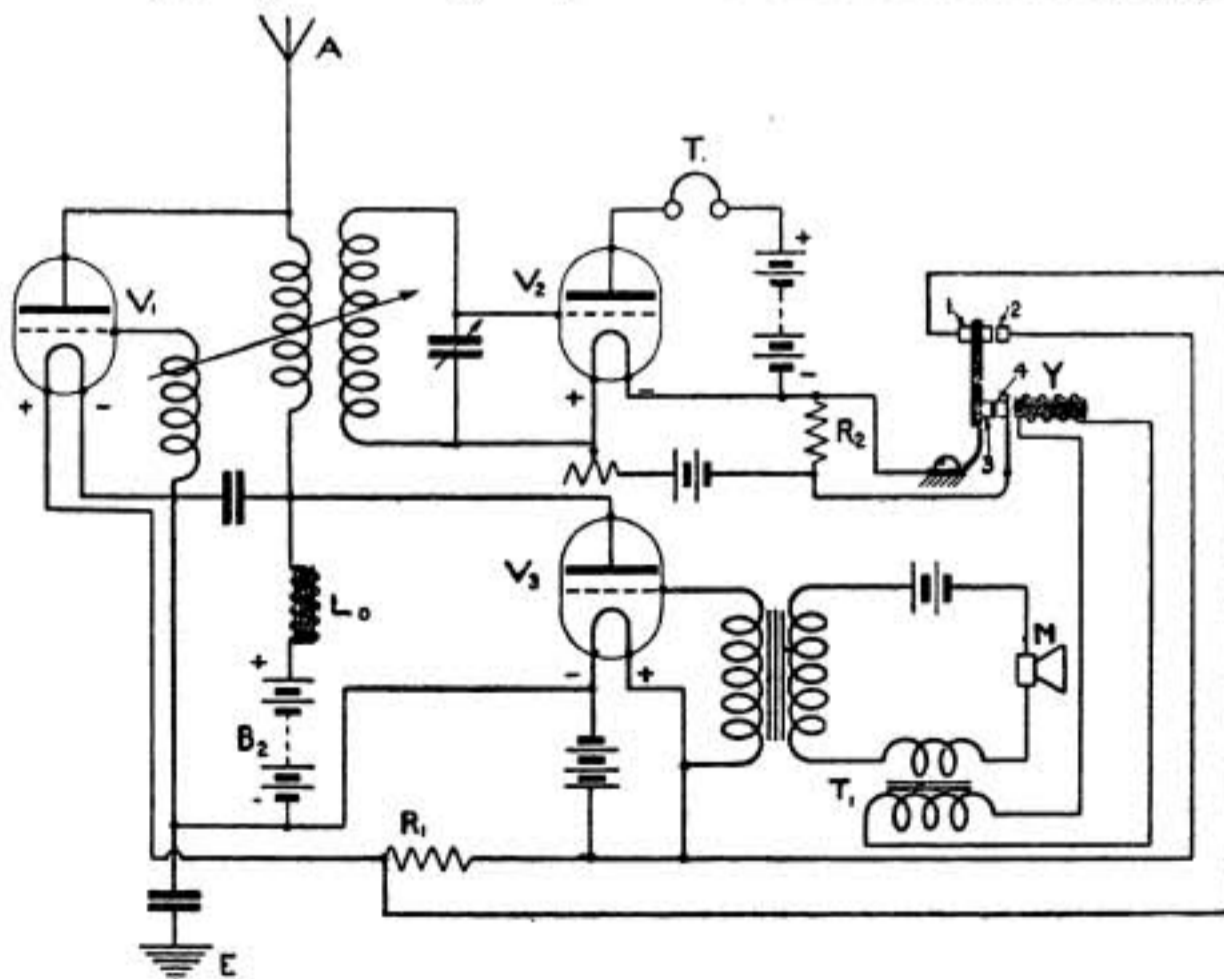

Fig. 3.

phone M as indicated. Resistances R_1 and R_2 are joined in the filament circuits of the transmitting and receiving valves respectively. These resistances are short-circuited by the contacts 1, 2, and 3, 4 respectively, so that when current flows through the magnet windings of Y the resistance R_1 is short circuited while R_2 is not, and *vice-versâ*. The general arrangement of the transmitting circuit is the same as described in Major Prince's I.E.E. paper—see RADIO REVIEW, pp. 281—283, March, 1920.

492. DUPLEX WIRELESS SIGNALLING. P. P. Eckersley. (*British Patent* 135895, May 5th, 1919. Patent accepted December 11th, 1919.)

The proposed arrangement is indicated in Fig. 4. The transmitter G is included in the aerial circuit together with an inductance L_1 and a condenser C_1 which are made equal to the inductance and capacity of the aerial itself. A potential node is thus formed at the point P, and this point is earthed through the inductance L_2 and the condenser C_2 which are adjusted to tune the complete aerial circuit $AL_2C_2E_2$ to the frequency of the waves to be received. The inductance L_2 is coupled to the receiver through L_5. If the wavelengths of the transmitted and received waves differ less than 25 per cent., rejector circuits C_3L_3 and C_4L_4 tuned to the received and transmitted waves respectively may be inserted in the transmitting and receiving earth connections as indicated.
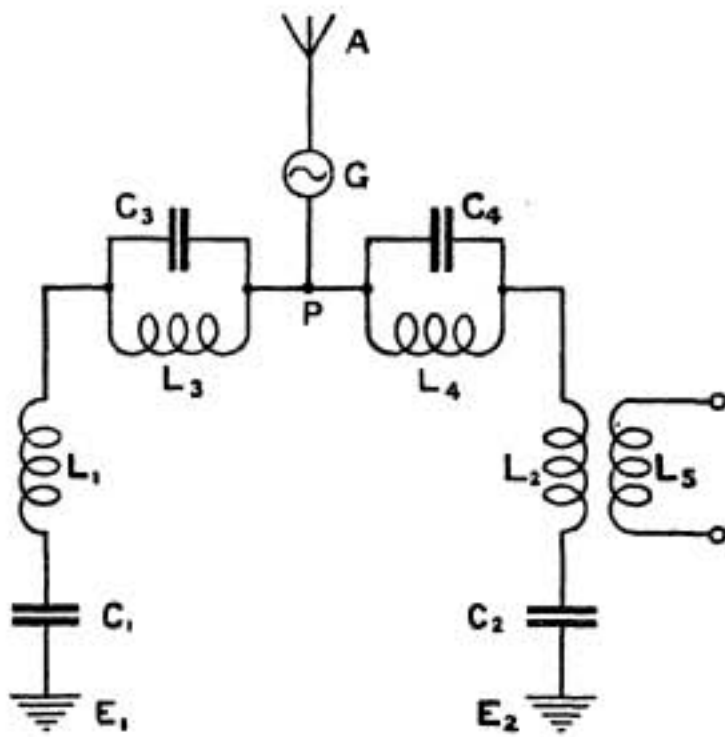
FIG. 4.

493. DUPLEX WIRELESS SIGNALLING. H. J. J. M. de R. de Bellescize. (*British Patent* 136524, July 5th, 1919. Convention date, December 7th, 1918. Patent not yet accepted but open to inspection.)

For duplex working using an ordinary open aerial for the transmitter, and a frame aerial for receiving, the transmitting aerial is arranged as symmetrically as possible about a plane passing through the transmitting aerial and at right angles to the plane of the receiving frame aerial. When the shape of the transmitting aerial cannot be modified to comply with this requirement the plane of the receiving frame aerial may be inclined to the vertical so as to reduce the interference to a minimum. In addition one or more small auxiliary frame aerials may be arranged near the receiving aerial and connected to it so as to still further reduce the disturbance from the transmitter. Various other compensating arrangements are also described in the original.

494. TELEPHONE EARPIECES. E. Hausdorf. (*British Patent* 136511, September 9th, 1919. Patent accepted, December 18th, 1919.)

A telephone receiver for military and similar uses is provided with a double cover, the inner one being arranged to enter the ear and the outer one to embrace the ear. The arrangement is designed to exclude external noises.

495. WIRELESS SIGNALLING. Compagnie Française pour l'Exploitation des Procédés Thomson-Houston. (*French Patent* 499381, January 19th, 1918. Published February 10th, 1920.)

The invention described in this specification relates to wireless telegraphy systems, and more particularly a duplex system with provision for sending and receiving at a single station.
For further particulars, see British Patent No. 130090.*

496. TRANSATLANTIC RADIO COMMUNICATION. E. F. W. Alexanderson. (*Revue Générale de l'Électricité*, 7, p. 117D, April 10th, 1920, Abstract.)
See RADIO REVIEW Abstract No. 216.

497. VALVE CONSTRUCTION. V. J. F. Bouchardon and M. A. Lesage (*French Patent* 498736, April 29th, 1919. Published January 21st, 1920.)

The invention described in this specification relates to vacuum tubes having incandescent cathodes, such as valves. The object is to provide incandescent electrodes which will not readily break. For this purpose, the incandescent electrode comprises a round filament or a ribbon of tungsten, molybdenum or other difficultly fusible metal wound in a helix on a cylinder of refractory non-conducting material such as silica or porcelain.

498. PROTECTION DEVICE FOR VALVE FILAMENT. E. F. Huth. (*German Patent* 307682, March 3rd, 1918. Patent granted, October 1st, 1919. *Jahrbuch der Drahtlosen Telegraphie*, 15, p. 80, January, 1920, Abstract.)

A cathode consisting of two metal filaments of different resistances in parallel. Excessive heating of the filament which is used as the emitter makes its resistance greater than that of the other.

499. THE THEORY OF THE OSCILLATING AUDION. D. Coster. (*Physikalische Zeitschrift*, 20, pp. 579—584, December 15th, 1919. *Science Abstracts*, 23B, p. 224, Abstract No. 439, April, 1920, Abstract.)

The audion is treated as an A.C. generator with an internal resistance $\partial v_a/\partial i_a$ and an E.M.F. λv_g, where λ is the voltage ratio and v_g the alternating P.D. on the grid. To sustain undamped oscillations the conditions must satisfy an equation of the type $Ri + Ldi/dt +$

$\frac{1}{C}\int i dt = E \cos pt$, where E, which depends on v_g, is some function of I determined by

the coupling between the anode and grid circuits. The equations are developed and solutions obtained for several methods of coupling.

500. THE ALGEBRA OF IONIC VALVES. W. H. Eccles. (*Technical Review*, 6, p. 226, March 2nd, 1920, Abstract.)
See RADIO REVIEW Abstract No. 421, June, 1920.

501. THERMIONIC VALVES. F. Bacon. (*Electrical Review*, 86, p. 661, May 21st, 1920, Abstract.)

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* RADIO REVIEW Abstract No. 202 (February, 1920).

Paper read before the Institution of Electrical Engineers (Western Section).

A general distinction was drawn between two and three electrode valves, and the chief features of each described in a general way.

502. The Self-oscillations of a Thermionic Valve. R. Whiddington. (*Proceedings of the Cambridge Philosophical Society*, 19, p. 346, February, 1920.)

Abstract of paper describing the phenomena dealt with by the same author in the RADIO REVIEW, I, pp. 53—58, November, 1919. The formula for the frequency of the oscillations is given as $n^2 = (2e/md^2)V$, where n = frequency, e/m = ratio of charge to mass of the ion, d = radial distance from filament to grid, and V = the positive potential on the grid.

503. On the Variations of Wavelength of the Oscillations Generated by Three-Electrode Thermionic Tubes due to Changes in Filament Current. W. H. Eccles and J. H. Vincent. (*Proceedings of the Royal Society*, 96A, pp. 455—465, February 3rd, 1920. *Nature*, 104, p. 617, February 5th, 1920, Abstract. *Science Abstracts*, 23B, pp. 223—224, Abstract No. 437, April, 1920, Abstract.)

The object of the investigations was to study experimentally the effects of altering the chief variables (filament current, plate and grid voltages, etc.) with a view to finding the most favourable conditions for the production of oscillations of constant frequency. Observations were made by means of the beat note produced between two circuits oscillating at nearly the same frequency, variations of this note being measured acoustically. At small filament currents the oscillation frequency decreased with increase of filament current, while at higher values it increased with the current. At a certain value of filament current the frequency was stationary for small variations of the current. Using this fact the frequency can be kept constant to 1 part in 100,000. Increasing the anode voltage increased the wavelength, as did also an increase of grid voltage.

504. A New Low-power Lamp Rectifier of Alternating Currents. J. Scott-Taggart. (*Electrician*, 84, p. 451, April 23rd, 1920. *l'Électricité*, 2, p. 12, June 1st, 1920, Abstract. *Science Abstracts*, 23B, p. 274, Abstract No. 540, May 31st, 1920, Abstract.)

A simple construction for a low-power low-voltage rectifier is described consisting of a flat nickel plate placed between the two legs of a horseshoe filament of spiralised tungsten wire. External connections are taken from the mid-point of the filament and from the plate. Alternate half-waves of the alternating voltage are rectified by the two halves of the filament. In an improved arrangement the complete V filament is surrounded by a cylindrical anode.

505. Improvements in Electromagnetic Wave Navigational Arrangements. J. Erskine-Murray and J. Robinson. (*British Patent* 135896, November 4th, 1919. Patent accepted, December 4th, 1919.)

A special form of " radiophare " is described. The transmitting station is provided with means of sending out signals in pairs in directions a definite azimuthal angle apart, the directions of propagation being gradually rotated. When the pairs of signals are of equal strength in the receiver, the line joining the stations bisects the azimuthal angle, and by noting the time or the number of signals that have passed since a definite cardinal point signal was heard, the direction of the transmitting station may be ascertained.

In one of the arrangements described a pair of crossed aerial coils or loops, arranged preferably at right angles to one another, are rotated about a

central vertical axis. The exciting circuits are connected to the aerial in turn by a two-way switch so that a signal is sent out by each aerial in turn for every angular position of the pair.

Various other modifications are described using fixed aerial loops in conjunction with radiogoniometer coils.

506. APPARATUS FOR DETERMINING THE DIRECTION OF ARRIVING ELECTROMAGNETIC WAVES. J. Erskine-Murray and J. Robinson. (*British Patent* 136600, December 9th, 1918. Patent accepted December 9th, 1919.)

The arrangement described is apparently an attempt to obtain with one frame aerial the results obtainable with the well-known crossed coil R.A.F. arrangement. A pair of contacts are arranged on either side of the moving frame and a third contact on the frame itself may connect with either of the previously mentioned contacts. The circuit from the frame to the detector is made through either of these contacts so that a signal is heard when the frame is moved to touch either of the contacts, but is inaudible between them. The pair of contacts is mounted on two arms which may be rotated round the vertical axis of rotation of the receiving coil, and to determine the direction of an incoming wave the coil is oscillated from one contact to the other and the position of these contacts adjusted until the signal strengths obtained in the two positions are the same. The bisector of the angle between the contacts then indicates the direction of the incoming waves. A similar arrangement may be adapted to the moving coil of a radiogoniometer.

507. DIRECTION AND POSITION FINDING. H. J. Round. (*Journal of the Institution of Electrical Engineers*, 58, pp. 224—257, March, 1920. *Electrician*, 84, pp. 317—319, March 19th, 1920, Abstract. *Electrical Review*, 86, pp. 185—187, 220—221, February 6th and 13th, 1920, Abstract. *Engineering*, 109, pp. 108—112, January 23rd, and pp. 161—164, January 30th, 1920. *Science Abstracts*, 23B, pp. 218—220, Abstract No. 428, April, 1920.)

See RADIO REVIEW, 1, pp. 235—237 and 289—292, February and March, 1920, for abstract. Captain Round's reply is included in the *Journal of the Institution of Electrical Engineers*.

508. THE BEHAVIOUR OF HERTZIAN GRATINGS. R. Gans. (*Annalen der Physik*, 61, pp. 447—464, March 3rd, 1920, Abstract.)

A mathematical investigation of the action of a grating, consisting of a number of fine parallel wires, when placed in the path of an electromagnetic wave. The resistance of the wires is first neglected and then taken into account. Two cases are considered, viz., when the wires are in the plane of polarisation, and when they are at right-angles thereto. Previous work on the subject is criticised. The calculations are applied to experimental results obtained by Schaefer and Laugwitz, but the agreement is not good, one possible cause of the discrepancies being the use of damped oscillations in the experiments.

509. ON THE FUNDAMENTAL FORMULATIONS OF ELECTRODYNAMICS. G. H. Livens. (*Philosophical Transactions of the Royal Society*, 220A, pp. 207—245, March 17th, 1920. *Science Abstracts*, 23A, pp. 286—287, Abstract No. 738, May, 1920, Abstract.)

An attempt to formulate a complete statement of Maxwell's theory in a logically consistent form. This formulation is then compared with other statements of the theory. The fundamental equations are derived by using the principle of least action ; the connections between the original differential theory and subsequent dynamical theories are discussed. The concluding section (15) contains a summary of the results of the discussion.

510. THE SCATTERING OF PLANE ELECTRIC WAVES BY SPHERES.   T. J. I'a
Bromwich.   (*Philosophical Transactions of the Royal Society*, 220A,
pp. 175—206, February 2nd, 1920.   *Science Abstracts*, 23A, p. 235,
Abstract No. 601, April, 1920, Abstract.)

A mathematical paper giving results worked out some years ago.   The author compares his methods and results with those of Rayleigh, Love, Nicholson and Macdonald.

511. THE NORMAL PROPAGATION OF E.M. WAVES THROUGH A LAYER OF
VARIABLE DIELECTRIC CONSTANTS.   J. Wallot.   (*Annalen der Physik*,
60, pp. 734—762, December, 1919.   *Science Abstracts*, 23A, p. 162,
Abstract No. 430, March, 1920.)

A theoretical investigation of the partial reflection suffered by a plane wave when passing from one medium to another through a wall in which the dielectric constant changes gradually from that of the first to that of the second medium.   The partial reflection is not appreciable unless the thickness is so small as to be comparable with the wavelength, but it increases as the thickness is decreased, reaching finally the value given by Fresnel's formula.

512. RECEPTION INTENSITY OF WIRELESS WAVES.   A. Press.   (*Electrician*,
83, p. 629, December 5th, 1919.   *Revue Générale de l'Électricité*, 7,
p. 83D, March 13th, 1920, Abstract.   *Science Abstracts*, 23B, p. 167,
Abstract No. 337, March, 1920, Abstract.)

This paper is in the nature of a preliminary note to a contribution which is to appear in the *Proceedings of the Institute of Radio Engineers*.   The author distinguishes two sets of waves sent out from a vertical grounded antenna, (1) designated as " galvanic " radiation and set up by the magnetic linkings, and (2) designated as " voltaic " radiation, and set up by the electrostatic effect of the antenna.   Equations are deduced for each of these components and their form is found to correspond with that of an empirical formula given by W. H. Eccles in his " WIRELESS TELEGRAPHY AND TELEPHONY." *   One of the coefficients also suggests the type of correction factor put forward by Dr. Cohen.†

513. ON THE PROPAGATION OF ELECTROMAGNETIC WAVES AROUND THE EARTH.   B. van
der Pol.   *Revue Générale de l'Électricité*, 7, p. 98, March 27th, 1920, Abstract.)
See RADIO REVIEW Abstract No. 48, November, 1919.

514. RECORDING JAVA RADIO SIGNALS IN GERMANY.   (*Elektrotechnische
Zeitschrift*, 41, p. 141, February 12th, 1920.)

The signals received at Geltow (near Berlin) on a frame aerial 80 metres square from Malabar (arc) and Tjililin (alternator and frequency transformers) are recorded as dots and dashes on a tape.   The antenna power in each case is 80 kw.

515. REVERSIBLE OR RECIPROCAL AMPLIFIERS.   M. Latour.   (*Bulletin de
la Société Française des Électriciens*, 9, pp. 589—600, December, 1919.
Revue Générale de l'Électricité, 7, pp. 359—364, March 13th, 1920,
Abstract.   *Technical Review*, 6, p. 424, May 11th, 1920, Abstract.
Science Abstracts, 23B, p. 280, Abstract No. 552, May 31st, 1920,
Abstract.)

Transformer windings and connections whereby a three-electrode valve inserted in a telephone line acts as an amplifier to speech in either direction.

516. THE DESIGN OF MULTI-STAGE VACUUM-TUBE RECEIVING CIRCUITS.
J. Scott-Taggart.   (*Wireless Age*, 7, pp. 15—17, December, 1919.)

This article describes the arrangement of a three-valve amplifier with aperiodic inductance coupling and a four-stage amplifier with tuned inter-valve auto-transformer coupling.

* (London : *Benn Bros., Ltd.*   Second Edition, 1918, p. 153.)
† See *Electrician*, 86, pp. 743—744, February 25th, 1916.

517. VACUUM TUBE AMPLIFYING CIRCUIT. E. F. Huth and L. Kühn. (*German Patent* 307681, November 21st, 1917. Patent granted, October 6th, 1919. *Jahrbuch der Drahtlosen Telegraphie*, 15, p. 78, January, 1920, Abstract.)

A two-valve amplifying circuit (see Fig. 5) in which retroaction in one valve circuit is brought about by an intermediary valve V_2.
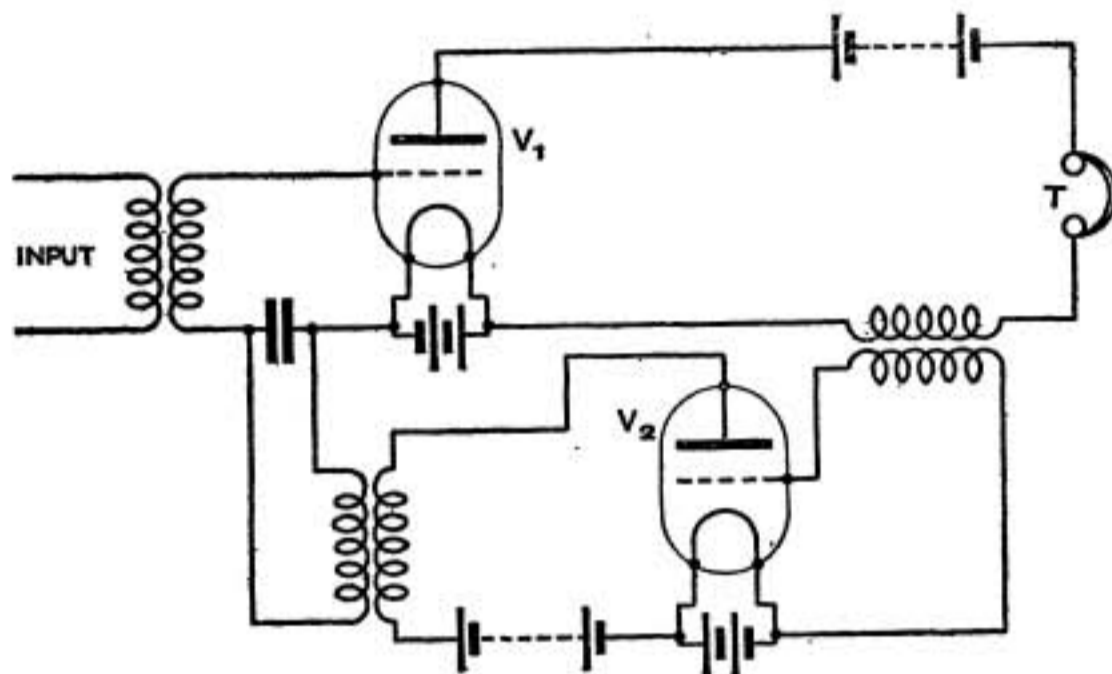

FIG. 5.

518. A MEDIUM-WAVE REGENERATIVE RECEIVER. E. G. Underwood. (*Wireless Age*, 7, pp. 25—26, December, 1919.)

The article includes constructional details and illustrations of the receiver.

519. AMPLIFIER DETECTOR FOR WIRELESS TELEPHONY. L. N. Brillouin and G. A. Beauvais. *Revue Générale de l'Électricité*, 7, p. 118D, April 10th, 1920, Abstract.)

See RADIO REVIEW Abstract No. 153.

520. NOTES ON BEAT RECEPTION. L. W. Austin and F. G. Grimes. (*Journal of the Washington Academy of Sciences*, 10, pp. 174—177, March 19th, 1920. *Science Abstracts*, 23B, p. 275, May, 1920, Abstract.)

The paper briefly summarises the results of experiments on the various factors influencing heterodyne and autodyne reception. For any given circuit, valve, and wavelength, best results were obtained with the same strength of heterodyne oscillations, independent of the signal strength. The linear response relation previously found for the autodyne was found to also hold for separate heterodyne with either triode or crystal detector. Large resistances may be inserted in the receiver secondary circuit without impairing signal strength, provided local oscillations are kept at the same strength. Hence with an oscillating tube directly in a loop circuit the received signal strength is independent of the loop resistance. The sensitiveness was found to be independent of the ratio L/C, provided local oscillations were kept at best value. The de-tuning of the receiver with autodyne reception was found not to reduce its sensitiveness as compared with heterodyne if a sensitising circuit was coupled to the secondary circuit so that the coupling wavelengths agree with the signal and heterodyne wavelengths, but the separate heterodyne was less liable to interference.

521. MUSICAL RECEPTION WITH CONTINUOUS WAVES WITHOUT LOCAL OSCILLATIONS. L. W. Austin. (*Journal of the Washington Academy of Sciences*, 10, pp. 223—226, April 19th, 1920.)

Some experiments on a "tone wheel" detector are described with a view to comparing its

sensitiveness with that of a heterodyne receiver. The chief results were as follows :—The sensitiveness of the tone wheel without amplification varies from one-sixth to one-third of that of the oscillating triode ; the law of response is linear. The tone wheel is somewhat superior to the heterodyne in keeping out strong interference ; it may be used either with radio or audio frequency amplifiers, the former being preferable. The brush action is improved by filling in the spaces between the teeth with insulating material.

522. AMPLIFICATION OF CURRENT IN A BUNSEN FLAME. C. W. Heaps. (*Physical Review*, 15, pp. 222—223, March, 1920.)

Experiments are described designed to ascertain whether a similar effect could be obtained with a third terminal or grid in a Bunsen flame as in a triode valve. The characteristic curves obtained were very similar to the usual valve curves. The best arrangement of electrodes in the flame consisted of (1) a clean horizontal platinum wire near the base of the flame to act as the " plate " ; (2) a horizontal wire with about a centimetre of the end bent upwards to serve as cathode ; and (3) a coil of three or four turns of wire serving as a " grid " and placed over the upturned end of the cathode. On the tip of the cathode a little sealing wax was burnt to leave a residue which when heated acted as an efficient source of electrons. The energy amplification was of the order of 450 to 500.

523. IMPROVED CIRCUIT ARRANGEMENTS FOR THE REDUCTION OF STATIC INTERFERENCE IN RADIO RECEIVING STATIONS. Western Electric Company, U.S.A. (*British Patent* 135635, December 6th, 1918. Patent accepted, December 4th, 1919.)

This patent describes a number of special filter circuits designed with the object of allowing certain frequencies to pass and cutting out others. In particular two types are mentioned : infra-filters which operate to suppress currents of a frequency below a certain limit, and ultra-filters for suppressing currents of a frequency above a certain limit. By a combination of the two types of filter only currents between the two frequency limits are transmitted. The simplest form of the filter arrangement is indicated in Fig. 6 (a) and
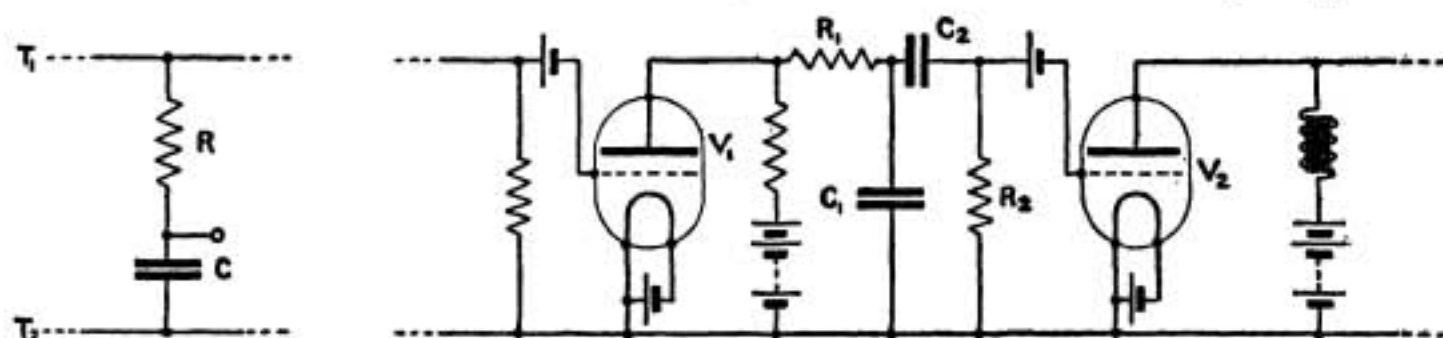
FIG. 6 (a).   FIG. 6 (b).

consists of a resistance R in series with the condenser C. The input circuit is connected to T_1 and T_2, and if the output circuit is joined across the terminals of the condenser C currents of lower frequency only will predominate in the output circuit, since the ratio of the voltages across the capacity and across the resistance will be greater the lower the frequency. By connecting the output circuit across the resistance R the device operates as an infra-filter. Alternatively the condenser may be replaced by an inductance but this results in an inversion of the frequencies transmitted in the two cases.

When using a number of such filters thermionic valve amplifiers may be connected between successive filters to prevent reaction of the output circuit

R R

on to the input circuit.   For minimising atmospheric disturbances in wireless
reception the aerial is arranged to be out of tune with the signal wave and is
connected to the detector through a series of filters of both types.   These should
be adjusted so as to transmit most efficiently a narrow band of frequencies in
the neighbourhood of the signalling frequency.   Fig. 6 (b) indicates another
combination of an ultra-filter composed of a series resistance R_1 and a shunt
capacity C_1 with an infra-filter composed of a series capacity C_2 and a shunt
resistance R_2 for the purpose of transmitting only such a band of frequencies.

524. Radio-Frequency Interference Balance.   (*Wireless Age*, 7, pp. 21
        —23, December, 1919.)

The arrangement described is an attempt to overcome the disadvantages of the use of two
aerials, one tuned to the signal and the other de-tuned and both coupled to the receiving
detector for the elimination of atmospherics.   In this case the coupling between the two
aerial systems is provided by a frequency converter of the Goldschmidt type with its rotor
circuit arranged to generate at frequency n.   One aerial circuit is tuned to the signal fre-
quency N and the other de-tuned to the frequency N_1.   The frequency n is chosen so that
$N - n = N_1 + n$ and the detector circuit is tuned to this intermediate frequency $N - n$.
By this means the impulses due to atmospherics may be cancelled out and the signal received
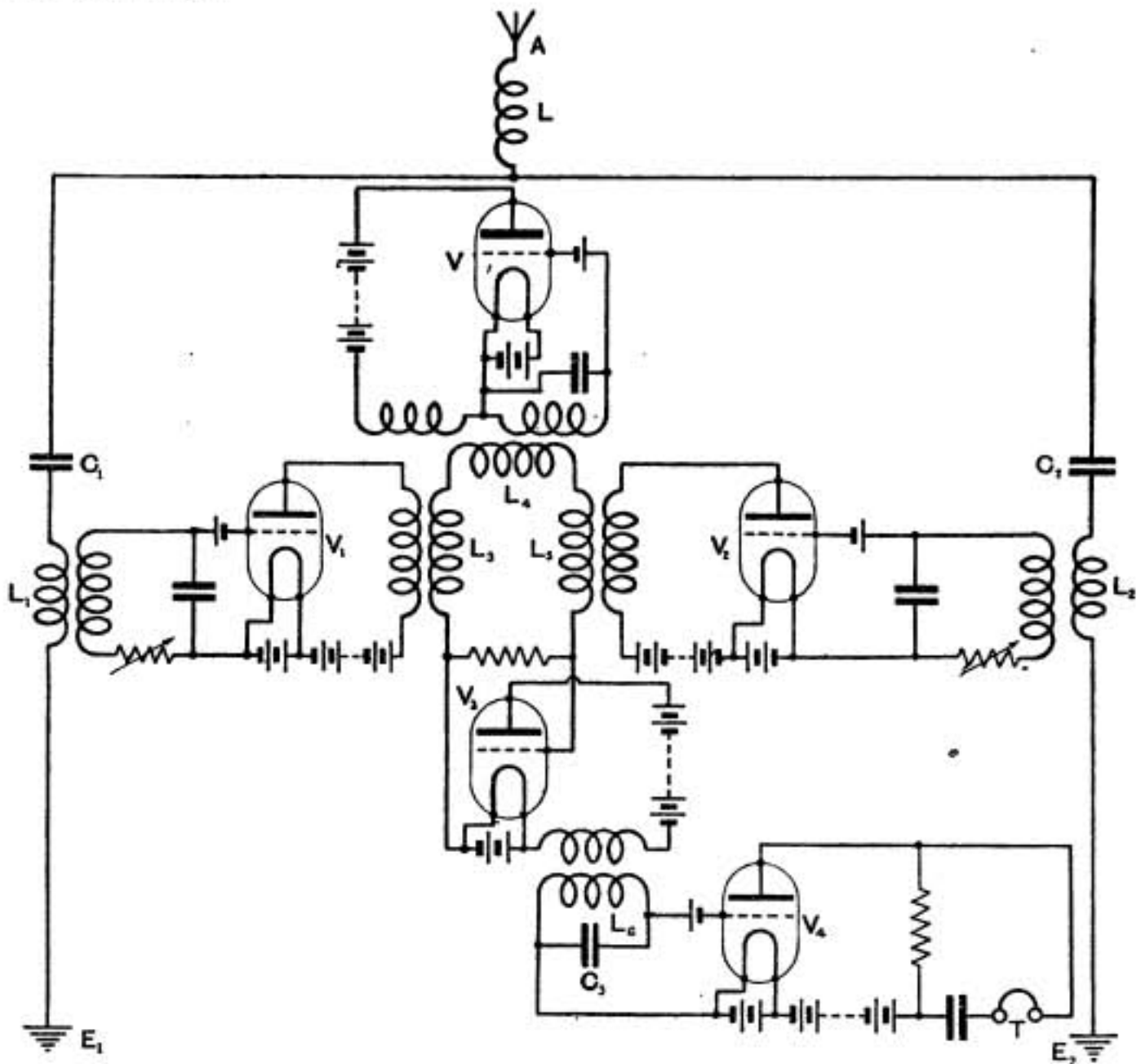on one aerial only.

Fig. 7.

In a modification a single aerial with two branches tuned to the two frequencies N and N_1 may be used in conjunction with a valve arranged to generate oscillations of frequency n. The circuit diagram is indicated in Fig. 7 in which the branch $C_1 L_1$ is tuned to the signal frequency N and $C_2 L_2$ to the frequency N_1. The valve V generates the frequency n. $V_1 V_2$ and V_3 are high frequency amplifiers, and the circuit $L_3 L_4 L_5$ is connected so that the currents of frequency $N - n$ from V_1 cancel out those of frequency $N_1 + n$ from V_2. The circuit $L_6 C_3$ is tuned to the frequency $N - n$. V_4 is the detecting valve.

525. STATIC ELIMINATION BY DIRECTIONAL RECEPTION. G. W. Pickard. (Radio Amateur News, 1, pp. 337—341, January, 1920.)

Paper read before the Institute of Radio Engineers. It opens with a summary of the various theories that have been proposed to account for the different varieties of atmospherics. A number of experiments carried out by the author are also detailed together with quotations from various American papers and other publications describing various forms of directional receivers particularly adapted to reducing static interference. The receiver using the combined loop and open antenna effects, described in RADIO REVIEW Abstract No. 75, December, 1919, Fig. 6, p. 152, is also described, together with various modifications of it. One of these is indicated in Fig. 8. The loop L was a rectangle of solenoidal form 30 metres long by 6
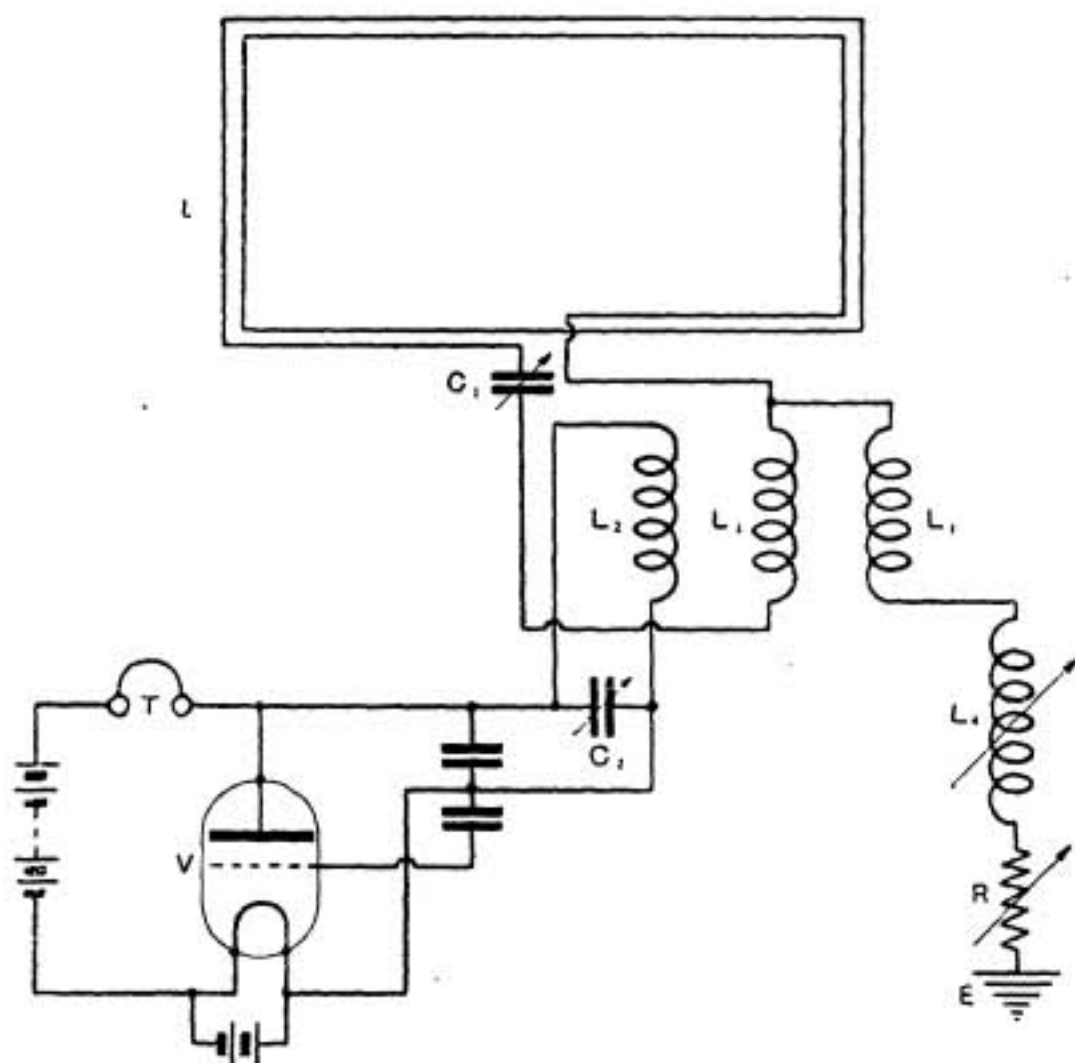
FIG. 8.

metres high, with its lower side 4 metres from the ground and having 4 turns spaced 30 cm. apart. It is tuned by the variable condenser C_1 and coupling coil L_1. The whole loop acting as an open antenna to the ground is tuned by the inductance L_4. The resistance R is necessary to equalise the currents in the two coils L_1 and L_3 and its value is usually about 3,000 ohms. L_1 and L_3 are closely coupled and L_1 and L_2 more loosely coupled. The circuit $L_2 C_2$ in conjunction with the valve V forms the usual receiver. A slight improvement may be obtained by arranging the earth lead from R to E in the form of an additional loop of wire placed

R R 2

parallel with and close to the main loop L. A further improvement is indicated in Fig. 9 and in this case no direct earth connection is made to the loop circuit but the open antenna A earthed through L_3C_3R is used with the earth connection. The coil L is of the same type
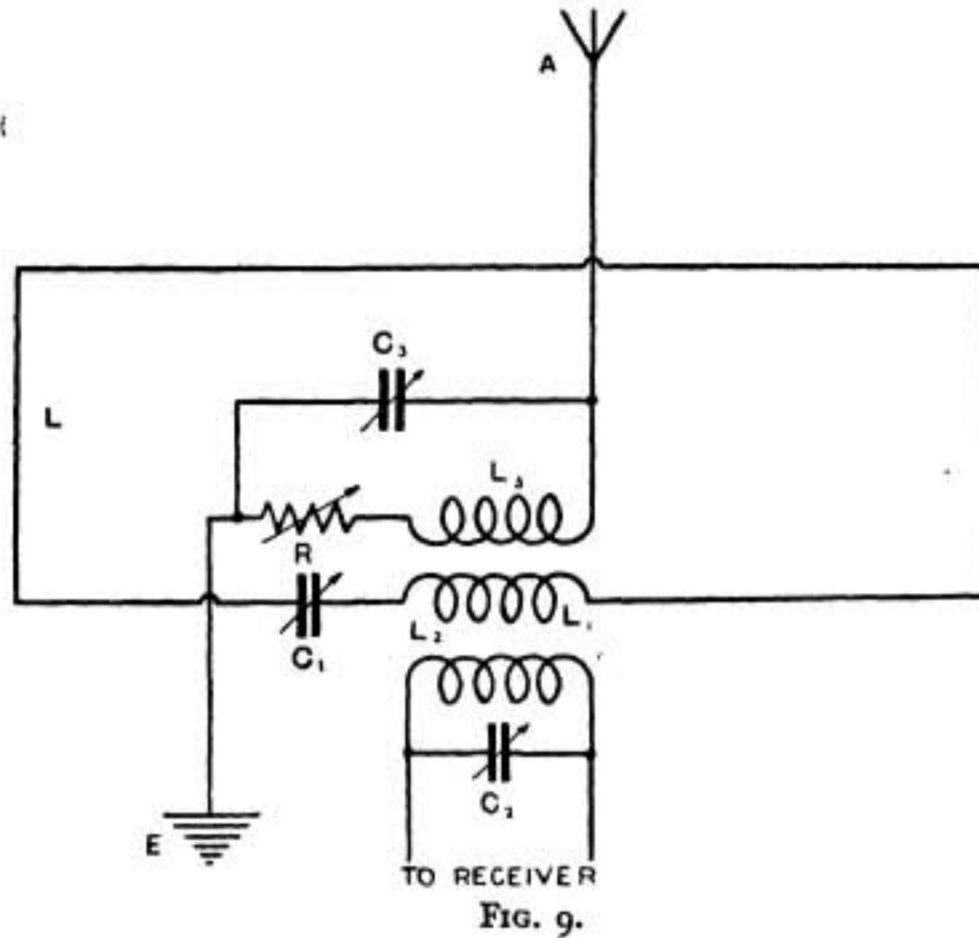
FIG. 9.

as in the previous example. This arrangement was said to enable transatlantic messages to be copied continuously through the heaviest static. Still another arrangement giving good results is indicated in Fig. 10. In this case two horizontal aerials A_1 and A_2 are used and no
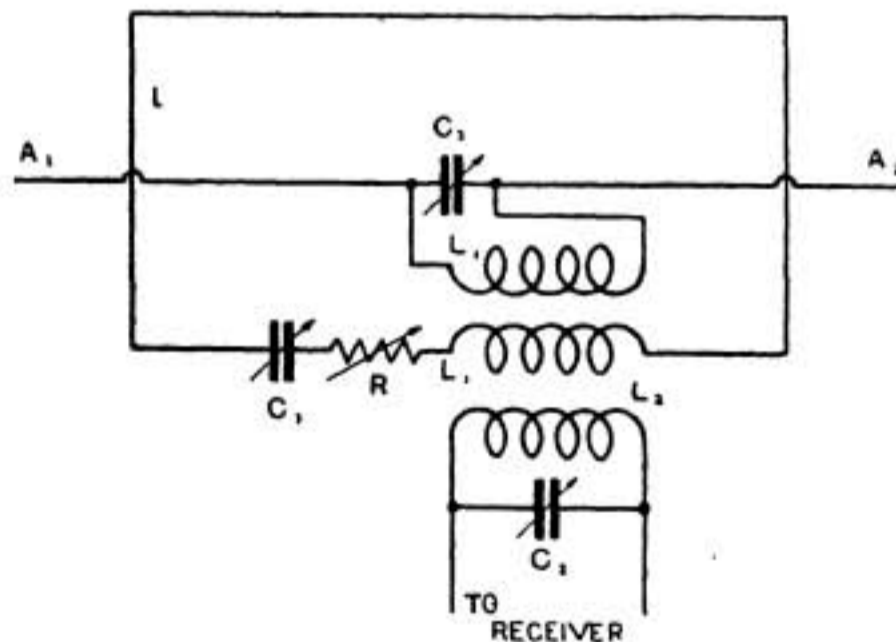
FIG. 10.

earth connection. The resistance R in this case of about 1,000 ohms is also used as before to equalise the currents in the two circuits.

An interesting point mentioned in the paper is that on the northern Atlantic seaboard of the U.S. the predominant static arrived from the western or south-western horizon. This effect vanished a short distance inland.

526. Wireless Signals. Compagnie Française pour l'Exploitation des Procédés Thomson-Houston. (*French Patent* 499212, May 8th, 1919. Published February 4th, 1920.)

This specification describes a system of radio-signalling, and more particularly a system in which means are provided for overcoming the effect of static disturbances in the receiving instruments.

For further particulars of this invention, see British Patent No. 134585.[*]

527. Portable Wireless Receiving Apparatus. R. C. Clinker. (*British Patent* 135932, December 3rd, 1918. Patent accepted, December, 3rd, 1919.)

The portable apparatus covered by this specification is that described on pp. 292—293, of the Radio Review (March, 1920).

528. Aerial Construction. Marconi's Wireless Telegraph Co., Ltd. (*French Patent* 498940, March 23rd, 1917. Published January 27th, 1920.)

The invention described in this specification relates to directive propagation and reception of wireless signals. For this purpose the transmitting or receiving antenna is placed in the focus of a row of aerials arranged in a parabola, all of which are tuned to the wavelength employed by means of adjustable capacities or inductances. The auxiliary aerials act as reflectors and may be earthed or not. The aperture of the parabolic row should not be less than the wavelength employed and the distance between the aerials may be one-tenth of their height, the focal distance of the parabola being preferably, 1, 3, 5, etc., quarters of the wavelength.

For further particulars of this invention, see British Patent No. 105909.

529. Development of Loop Aerial for Submarine Radio Communication. J. A. Willoughby and P. D. Lowell. (*Revue Générale de l'Électricité*, 7, p. 84D, March 13th, 1920, Abstract.)

See Radio Review Abstract No. 85.

530. The Priess Loop Sets. W. J. Henry. (*Radio Amateur News*, 1, p. 270, December, 1919.)

This article briefly describes the development of portable loop aerial transmitters and receivers for use in trench warfare and operating on wavelengths between 66 and 180 metres. Damped wave transmission was used throughout. Reliable communication was established between two of these sets in dug-outs separated by 6 km. using 30 watts at the transmitter. The complete set weighed 28 lbs. including the loop aerial, tools and spare parts.

531. The Wireless Station at Nauen : (1) The Development. Count G. Arco. (*Elektrotechnische Zeitschrift*, 40, pp. 665—667, December 18th, 1919. *Science Abstracts*, 23B, pp. 215—217, Abstract No. 426, April, 1920, Abstract.)

A brief sketch of the development of the Nauen Station from 1906 to the present day.

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[*] Radio Review Abstract No. 371 (May, 1920).

532. THE WIRELESS STATION AT NAUEN: (2) THE HIGH FREQUENCY ALTERNATOR AND TRANSFORMERS. W. Dornig. (*Elektrotechnische Zeitschrift*, 40, pp. 687—689, December 25th, 1919. *Science Abstracts*, 23B, pp. 215—217, Abstract No. 426, April, 1920, Abstract.)

There are two aerials the larger a **T** aerial over 2 km. long with a capacity of 30,000 cm. and the smaller a triangular aerial of 15,000 cm. The former is supplied from the 400-kW. high-frequency machine and the latter from the 100-kW. quenched spark set. Details and a photograph of the 400-kW. machine are given. The 7-ton cast steel inductor of 1·65 metre diameter runs at 1,500 r.p.m. and having 240 teeth gives a frequency of 6,000. The rotor carries two ventilators and water-cooling tubes run through the armature stampings behind the winding tunnels. The output is 1,200 amperes at 450 volts. This passes through a step-up transformer and then through two or three frequency-doubling transformers in cascade. The Morse key causes a relay to short-circuit a resistance inserted between the step-up transformer and the first doubler. A somewhat detailed description is given of the 400-kW. frequency-doubler for $f = 12,000/24,000$. The stampings are 0·07 mm. thick but only weigh 26 kg., whilst the weight of copper is only 20 kg. Two such transformers constitute the doubler. They are oil immersed and also have forced oil circulation with external oil cooling. The motor input is 620 kW. on a long dash and 325 kW. when sending. The power supplied to the antenna is 410 kW.

533. GERMAN RADIO WAR INSTRUMENTS. (*Radio Amateur News*, 1, p. 271, December, 1919.)

Illustrated descriptions of a two-valve amplifier, crystal detector and high note buzzer.

534. RADIO COMMUNICATION BETWEEN GERMANY AND AMERICA, SPAIN AND SWEDEN. (*Elektrotechnische Zeitschrift*, 41, pp. 121—122, February 5th, 1920.)

Nauen is now in regular communication with Annapolis and New Brunswick and telegrams should be marked " Cable " or " Radio "; the rate is the same. Many of the cables are still unrepaired, the Entente having taken the German cable ships. Telegrams for Sweden are transmitted from Konigswusterhausen to Carlsborg and those for Spain from Eilvese to Madrid and Aranjuez.

535. THE ANNAPOLIS RADIO STATION. (*Wireless Age*, 7, pp. 10—15, December, 1919. *Science Abstracts*, 23B, pp. 217—218, Abstract No. 427, April, 1920, Abstract.)

A general description with illustrations and circuit diagrams of the Annapolis (NSS) radio station with views of the 350 kW. arc apparatus.

536. THE KAMINA WIRELESS STATION, ITS CONSTRUCTION AND DESTRUCTION. (*Wireless World*, 7, pp. 491—495, December, 1919.)

An illustrated description of the capture of the station by the British.*

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* See also RADIO REVIEW Abstract No. 537.

537. Destruction of the German Wireless Station at Kamina in Togoland. M. Roscher. (*Elektrotechnische Zeitschrift*, 41, p. 116, February 5th, 1920.)

The author had erected and was in charge of the station, which was utterly destroyed by his orders on the approach of the British. He criticises sharply the references to this event in the *Wireless World.** His description of the destruction by those who had watched over the growth of the station and had great hopes of its achievements is very touching, but the article is marred by a spirit of bitter animosity.

538. The Radio Telegraphic Station at Rome (San Paulo). B. Micchiardi, G. Pession and G. Vallauri. (*Proceedings of the Institute of Radio Engineers*, 8, pp. 142—163, April, 1920. *Technical Review*, 6, p. 506, June 8th, 1920, Abstract.)

Describes in detail the high power arc station erected by the personnel of the Royal Italian Navy for the Italian Government during the months May—October, 1917. The station was designed to communicate with the Italian colonies on the Red Sea and also with the American high-power stations. The antenna has the form of an equilateral triangle supported by three cables (spreaders) more than 610 feet in height with the down leads coming from one of the sides. It is supported on wooden masts having a triangular lattice-work structure. The set is, like most of the Naval sets, of the Poulsen arc type being provided with a rectangular magnetic circuit with an air gap of 8·2 cm. giving a field intensity of 6,700 gauss with a supply current of 220 amperes.

Normal operation of the station is carried out on a wavelength of 11,000 metres signalling being accomplished by short circuiting a number of turns of the antenna inductance. The " working " and " stand-by " waves are thus made to differ by 180 metres. Experiments are in progress on methods of eliminating the " stand-by " wave by the use of an artificial absorbing antenna circuit.

By measuring the current absorbed at resonance in an experimental loop antenna at Fiumicino when the station of San Paulo was transmitting the effective height of the aerial at the latter has been shown to be 462 feet on wavelengths between 6,800 and 10,000 metres.

Two small receiving stations are worked in conjunction with the transmitter. One station adjoins the transmitting station and is lined with metallic netting to protect the receiver from excessive induction. The other which possesses a loop antenna permits of duplex working with America. Detailed data of reception with American stations are given.

539. Completion of the Wireless Inland Network by the Funk-Betriebsamt. V. T. D. Thurn. (*Telegraphen- und Fernsprech-Technik*, 8, pp. 121—124, November, 1919, Abstract.)

The German Government have appointed the Funk-Betriebsamt to control the installation and operation of a network of wireless telegraphic stations throughout the country. Small stations communicate with their district stations and these district stations can communicate with Berlin. For reasons of economy, army and navy apparatus is being utilised for the purpose, the standard system being a continuous wave one with thermionic valve generators and beat reception. The organisation is very fully described in this article which is officially communicated.

540. The Construction of a Radio-Frequency Transformer. (*Everyday Engineering Magazine*, 8, pp. 310—312, February, 1920.)

Constructional details with dimensioned drawings are given for iron cored radio-frequency inter-valve transformers for use in a high-frequency multi-stage valve amplifier.

541. Constructional Details of the Double Condenser. (*Everyday Engineering Magazine*, 8, pp. 114—115, November, 1919.)

The condenser described has a double set of fixed and moving vanes, each

* Radio Review Abstract No. 536.

set of fixed vanes being connected to one set of moving vanes. Double the capacity is thus obtained without increasing the size of the instrument.

542. THE DESIGN OF CONTACTS AND SOCKETS FOR WIRELESS VALVES OR VACUUM TUBES. W. J. Polyblank. (*British Patent* 135792, June 13th, 1919. Patent accepted, December 4th, 1919.)

Constructional details are given for the base and contact pins of triode valves.

543. DATA ON THE INTERNATIONAL RADIO OSCILLATION TRANSFORMER. (*Everyday Engineering Magazine*, 8, p. 117, November, 1919.)

Wavelength curves of apparatus manufactured by the International Radio Co. (U.S.A.).

544. WIRELESS RECEIVING APPARATUS AT GELTOW (POTSDAM). (*Elektrotechnische Zeitschrift*, 41, pp. 41—42, January 8th, 1920. *Telefunken Zeitung*, Nos. 17 and 18, January, 1920.)

In order to work duplex at Nauen, the receiving station has been placed at Geltow, 30 km. away. A description is given of the frame aerial 28 metres square with 6 turns, tuned, and coupled to a secondary tuned circuit which is connected through a cascade amplifier to the detector, and then through a low frequency amplifier, an acoustic resonance transformer and a rectifying tube to the inker, which is capable of working at 100 words per minute. Although 30 km. away they cannot work within the range 10 per cent. above and below the wavelength emitted by Nauen. They receive satisfactorily, however, both New Brunswick ($\lambda = 13,500$ m.) and Annapolis ($\lambda = 17,000$ m.) simultaneously on two frames 1 metre apart.

545. SOME RECENT DEVELOPMENTS IN RADIO TRANSMITTERS. M. W. Sterns. (*Wireless Age*, 7, pp. 17—20, December, 1919.)

Describes the direct current buzzer transmitters manufactured by The Sperry Gyroscope Company. They consist of a vibrating contact which interrupts the current from the source at about 400 volts. Across the contacts is shunted a capacity-inductance circuit coupled to the aerial. The article is accompanied by several illustrations of the sets. Transmission power is up to 200 watts.

546. THE VIBRATORY CONVERTER AS AN A.C. GENERATOR FOR SMALL RADIOTELEGRAPH STATIONS. F. Falkenthal. (*Jahrbuch der Drahtlosen Telegraphie*, 14, pp. 526—534, October, 1919. *Science Abstracts*, 23B, p. 162, Abstract No. 326, March, 1920, Abstract.)

The article describes the application for low-power radio transmission of vibratory apparatus normally used for rectifying A.C. With a primary energy of 250 watts, 80 per cent. efficiency of conversion is obtained. Heavy contact pressure was necessary to avoid loss of energy. Sparking rates of 400 to 600 per second were obtained. It was necessary to maintain the armature continuously in vibration in order to ensure resonance with the low frequency circuits necessary to prevent sparking. Signalling was effected by short-circuiting a resistance in the primary circuit.

547. CHARACTERISTICS OF MICA TRANSMITTING CONDENSERS. L. R. Jewett. (*Radio Amateur News*, 1, pp. 272—273, December, 1919.)

An illustrated description of the construction of 0·004 microfarad units of mica transmitting condensers enclosed in aluminium cases. A very low power-factor, small losses, compactness and high efficiency are the chief features.

548. Electric Condensers. W. Dubilier. (*British Patents* 140045 and 140046, July 24th, 1919. Patents not yet accepted but open to inspection.)

Special methods of construction of multi-section condensers are detailed. The arrangement is particularly suitable for high-voltage condensers comprising a number of sections connected in series and subjected to mechanical compression. This compression may be provided by suitable clamping bolts and plates, or the condenser sections may be clamped between the sides of the metallic containing case which then forms one terminal of the complete condenser.

549. Condensers. W. Dubilier. (*French Patent* 498639, April 25th, 1919. Published January 16th, 1920.)

This specification describes a high potential condenser suitable for use in wireless telegraphy. For further particulars, see British Patent No. 140046.*

550. A New Type of Non-Inductive Resistance. H. L. Dodge. (*Physical Review*, 15, pp. 223—224, March, 1920.)

A special arrangement of winding is detailed so that every part of the conductor is closely adjacent to a similar part carrying current in the opposite direction. Self-capacity is small.

551. New Marconi Wireless Call Signal Device. (*Shipbuilding and Shipping Record*, 15, pp. 108—109, January 22nd, 1920. *Technical Review*, 6, p. 226, March 2nd, 1920, and p. 342, April 13th, 1920, Abstract. *Wireless World*, 7, pp. 695—698, March, 1920. *Telegraph and Telephone Age*, 38, p. 149, March 1st, 1920. *L'Électricien*, 50, p. 157, April 15th, 1920.)

See also Radio Review, 1, p. 293, March, 1920. (*Note.*—The complete illustrated description is given in *Wireless World*—above reference.)

552. The Application of Ultra Violet Rays to Signalling. I. G. Priest and K. S. Gibson. (*Revue Générale de l'Électricité*, 7, p. 75D, March 6th, 1920, Abstract.)

553. The Detection of Invisible Bodies by means of Infra Red Rays. S. O. Hoffman. (*Revue Générale de l'Électricité*, 7, p. 75D, March 6th, 1920, Abstract.)

554. The Utilisation of Infra Red and Ultra Violet Radiations during the War. (*Illuminating Engineer*, 12, pp. 295—296, October, 1919. *Revue Générale de l'Électricité*, 7, p. 98D, March 27th, 1920, Abstract. *Telegraphen- und Fernsprech-Technik*, 8, pp. 112—113, October, 1919. *Elektrotechnik und Machinenbau*, 38, p. 34, January 18th, 1920. *Technical Review*, 6, p. 425, May 11th, 1920, Abstract.)

See also Radio Review Abstract No. 71, November, 1919.

555. On the Relation between Illumination and Electrical Conductivity in Selenium. A. O. Rankine. (*Philosophical Magazine*, 39, pp. 482—488, May, 1920.)

Experiments are described proving that the change of conductivity of selenium cells is proportional to the fourth root of the intensity of illumination, and not to the square root as usually assumed.

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* Radio Review Abstract No. 548.

556. A SECRET TELEPHONE. P. Maurer. (*L'Électricien*, 50, pp. 199—201, May 15th, 1920.)

For the purposes of secret telephony for wartime use along badly insulated wires, a small radiotelephone transmitter was employed coupled between the line and earth. An oscillating valve was used with the transmitting microphone coupled to the oscillation circuit.

557. A TELEPHONE TO EUROPE ? C. H. Claudy. (*Scientific American*, 122, p. 513, May 8th, 1920.)

A *resumé* of experiments on the use of radio frequency currents for the transmission of telephone or telegraph signals along bare wires laid in sea water.

558. THE ELECTRICAL EQUIPMENT OF AIRCRAFT. P. Maurer. (*L'Électricien*, 35, pp. 265—269, December, 1919.)

Deals amongst other matters with generators, etc., for use with the wireless installation.

559. NAVAL AIRCRAFT RADIO. T. Johnson, Jr. (*Proceedings of the Institute of Radio Engineers*, 8, pp. 87—141, April, 1920. *Technical Review*, 6, p. 466, May 25th, 1920; and p. 506, June 8th, 1920, Abstract.)

Constitutes the second half of the author's paper in the same Proceedings of February, 1920.[*] The development of the earlier types of radio sets used on American Naval Aircraft is described. The standard transmitting sets, of which full details (dimensions, circuits, ranges, etc.) are given, were practically all developed by the Western Electric Company and may all be regarded as modifications of the fundamental circuit shown in Fig. 11, which provides for transmission by unmodulated, buzzer-modulated, or telephonic-modulated continuous waves.

Power is supplied for the set by the battery B which supplies current both for the filaments and the dynamotor D. The latter supplies a high tension to the anode circuits. Modulation of the radio frequency energy is effected by imposing the audio-frequency output of the
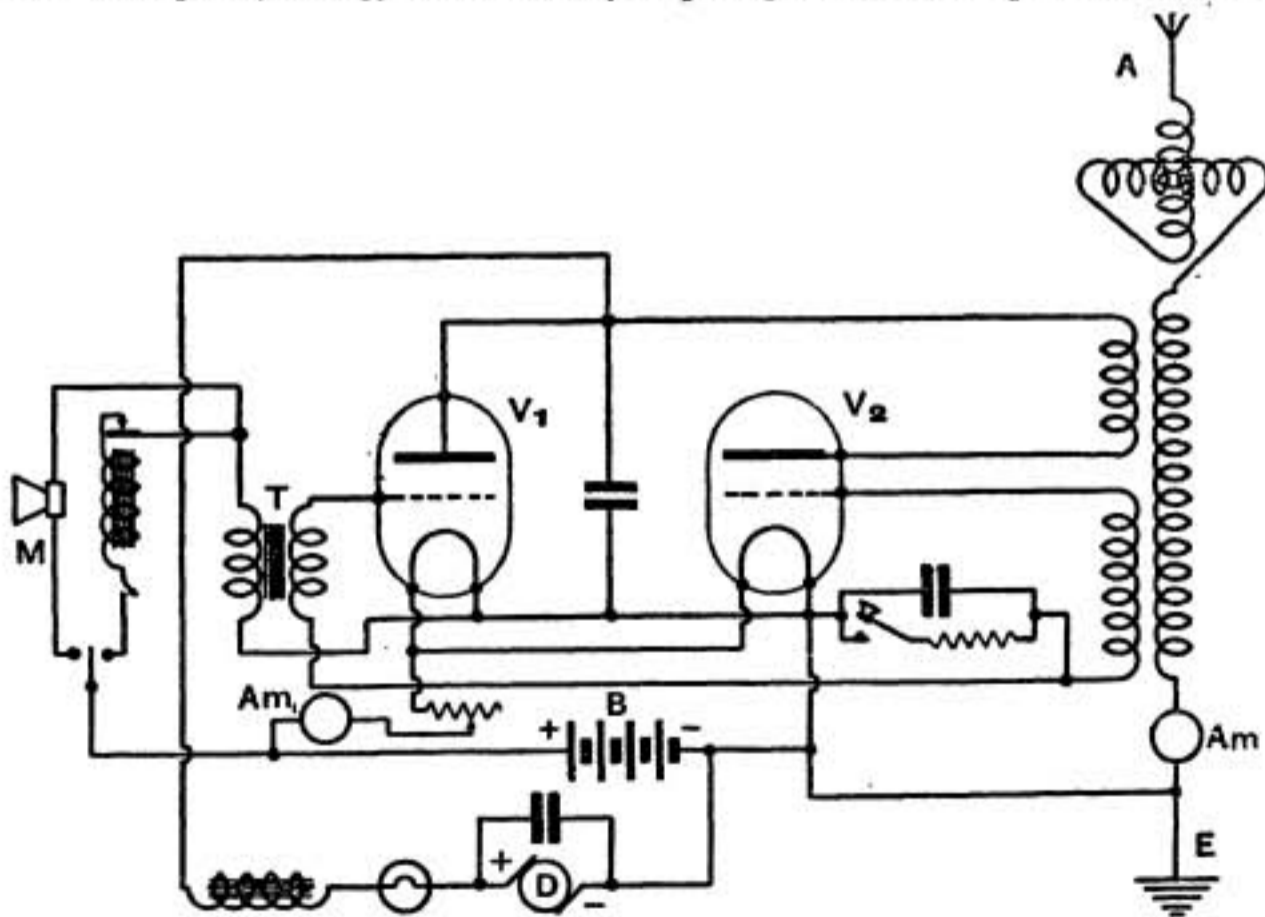

FIG. 11.

[*] See RADIO REVIEW Abstract No. 461.

microphone transformer T on the grid of the modulator tube V_1. The amplified audio-frequency output of the modulator tube is then introduced into the anode circuit of the radio frequency generating tube V_2.

It is found that with all these sets the range with a trailing antenna in flight is always greater than that obtained with a skid fin antenna in water.

A one-valve transmitter designed by the Marconi Wireless Telegraph Company has also been used in the large flying boats and dirigibles, but as no modulation amplifier was included the modulation was found inferior to that of the Western Electric circuits.

The difficulties of aircraft reception due to acoustic disturbances (wind-rush and engine noise) and electrical disturbances (induction from engine ignition system) are discussed and the type of helmet-receiver finally developed described.   Of the two valves used mainly in receiver circuits one is of the coated filament type and was designed by the Western Electric Company, while the other possesses a tungsten filament and is of Navy Department design.   The receivers are mainly of the ordinary type with one tube with inductive coupling for regeneration and detection and two further stages of audio frequency amplification with iron-cored transformer coupling ; though newer amplifiers with three stages of radio-frequency amplification have been developed.

The development of radio compass work has been on the lines of the balanced maximum method, using a main and an auxiliary coil at right angles to one another, similar to the arrangements used in the British R.A.F.*

The complete radio compass therefore includes main and auxiliary coils, a reversing switch, a compensating device for the auxiliary coil when it is omitted from the circuit, a tuning device for the system and a receiver.   Most of the sets actually used have had revolving coils mounted within the bodies of the flying boats and dirigible cars.

For telephonic communication with aircraft U.S. naval air stations are to be equipped with a standard generator designed by the General Electric Company with a range of 200 nautical miles. A system of remote control conducted over the regular telephone lines is being developed.

560. Thermal Expansion of Insulating Materials. W. H. Souder and P. Hidnet. (*Bulletin of Bureau of Standards,* 15, pp. 387—417. *Bureau of Standards Scientific Paper,* No. 352, December 27th, 1919.)

This paper contains selected results of an extensive research upon the thermal expansion of insulating materials. The following materials were investigated : porcelain, bakelite, condensite, formica, celluloid, hard rubber, marble and limestone. The range of expansion coefficients was found to vary between 1.6×10^{-6} for certain porcelains and 10.9×10^{-6} for a specimen of celluloid. A summary is first given of the previous work on the expansion of porcelain and marble, and this is followed by a description of the apparatus used in this research. Each specimen tested was in the form of a straight rod of about one square centimetre cross section and 30 cm. in length. The specimens were heated in a furnace and the expansions measured by microscopes. Several tables and a number of curves are given summarising the results obtained for the various specimens tested. The test on various specimens of porcelain showed that this material exhibited no marked permanent set or change in dimensions due to the heat treatment. Porcelains having low coefficients of expansion were found to exhibit marked resistance to sudden temperature changes. On the other hand the various types of bakelite and similar materials generally showed marked diminution in length after heating and cooling again to room temperature.

* See Radio Review, 1, pp. 213—219, 265—275, February and March, 1920.

Most of these phenol condensation products—bakelite, condensite, formica, hard rubber and celluloid—when kept at some constant temperature above 60° C., showed a shrinkage in length, and lost weight by giving off vapour. When the temperature of the material increases it expands, but when kept at a constant temperature above 60° C. it contracts.

After heating, each specimen of marble was found to show an increase in length. This growth was approximately the same whether the specimen was heated by cycles or heated directly to the maximum temperature. Repeated heatings tend to bring the marble to a constant or permanent state. On cooling below room temperature the specimens expand again contrary to the usual behaviour of most materials and this peculiar phenomenon of minimum length was common to all the specimens tested. Length measurements made after a period of two years indicated that the growth of marble after heating is permanent. The data given in the paper as to the thermal behaviour of these materials should be valuable when considering their use in various forms of apparatus.

561. RESONANCE AND IONISATION POTENTIALS FOR ELECTRONS IN THE MONATOMIC GASES ARGON, NEON AND HELIUM. H. C. Rentschler. (*Physical Review*, 14, pp. 503—515, December, 1919.)

A special type of three-electrode valve was employed for these experiments. The results indicated a resonance potential of 12 volts and an ionising potential of 17 volts for argon, while neon and helium did not show resonance potentials.

562. THE IONISATION GAUGE. S. Dushman and C. G. Found. (*Journal of the Franklin Institute*, 188, p. 819, December, 1919.)

563. REFLECTION OF ELECTRONS FROM METAL SURFACES. H. M. Dadourian. (*Physical Review*, 14, pp. 434—439, November, 1919.)

564. THE FUSION OF TUNGSTEN. (*Scientific American*, 121, p. 420, October, 1919.)

Describes a new process of working this metal, due to Hugo Lohman, of Berlin. In view of the extensive use of tungsten for the manufacture of triode filaments the process is important as it is said to be the first to afford any promise of fusing the metal into pieces large enough to give wires of all required gauges.

565. HIGH FREQUENCY CURRENTS ON WIRES. J. O. Mauborgne. (*Physical Review*, 14, pp. 452—453, November, 1919.)

An abstract of a paper presented to the American Physical Society dealing with the subject matter referred to in RADIO REVIEW Abstract No. 175, January, 1920.

566. The Augereau System for the Reception of Signals on Locomotives. (*Revue Générale de l'Électricité*, 7, pp. 506—507, April 10th, 1920.)

In the arrangement described a horizontal aerial is stretched out alongside the railway track, and a small aerial is mounted on each side of the locomotive. A simple form of spark transmitter controlled by the position of the signals is joined to the fixed aerial, and a coherer receiver employed on the locomotives to operate the necessary indicating apparatus.

567. An Automatic Wireless Transmitting Mechanism for Signal Buoys. W. E. Sansom. (*British Patent* 135441, June 20th, 1919.   Patent accepted, November 27th, 1919.)

The transmitting mechanism comprising accumulator battery, motor generator and transmitting apparatus, and an automatic signalling key operated by a message drum upon which the message to be sent is set up, is all contained inside the casing of the buoy and is arranged to be set in operation by a float switch operated as soon as the buoy is placed in the water. The aerial is mounted on a mast projecting from the upper part of the buoy.

568. International Submarine and Radio Communication as Related to American Commerce. J. J. Rogers. (*Telegraph and Telephone Age*, 37, pp. 614—617, December, 1919.)

Deals with international communications and the need for effective legislation.

569. Empire Wireless Chain. (*Electrical Review*, 85, p. 690; also p. 675, November, 1919.   *Electrician*, 83, p. 597.)

Particulars of the Committee appointed by the British Government to advise *re* Imperial Wireless Communications.

570. Long-Distance Telegraphy and German "Welt-politik." H. Thurn. (*Elektrotechnische Zeitschrift*, 41, p. 36, January, 1920.)

Review of a book by Dr. R. Hennig entitled "Überseeische Telegraphie und Auswärtige Politik."

571. Regulation of Radio by Department of Commerce Favoured. (*Electrical World*, 75, p. 565, March 6th, 1920.)

A summary of a number of suggestions made by J. L. V. Hogan relative to Federal regulation of radio communications.

572. Direct Commercial Wireless with England Established. (*Electrical World*, 75, p. 565, March 6th, 1920.)

Refers to the reopening of the direct commercial wireless service between England and America *via* the New Brunswick (N.J.) radio station.

573. Licences for Wireless Telegraphy. (*Electrician*, 83, p. 598, November, 1919. *Wireless World*, 7, p. 535, December, 1919.)

Particulars of regulations *re* experimental radio licences.

574. Wireless Meteorological Information to and from Ships at Sea. (*Admiralty Notice to Mariners*, No. 8 of 1920.)

A *résumé* is given of plans for collection and distribution of meteorological data, and a list of wireless stations sending weather reports.

575. The Times of Transmission and the Characteristics of the Principal Wireless Stations. (*Revue Générale de l'Électricité*, 6, p. 135B, November, 1919.)

A table setting out the data of a number of large stations.

576. General Information with Regard to Wireless Time Signals. (*London Gazette*, No. 31651, pp. 14057—14059, November 21st, 1919. *Admiralty Notice to Mariners*, No. 7 of 1920. See also *London Gazette*, No. 31788, pp. 2089—2090, February 20th, 1920, and *Admiralty Notice to Mariners*, No. 316 of 1920, for revision of earlier notice.)

A list is given of thirty-six stations throughout the world, which send wireless time signals. The list gives the name of the station, the name of the observatory, the time of sending, the wavelength of transmission and whether sent on " spark " or continuous wave.

577. Longitude by Wireless Telegraphy. (*Nature*, 105, p. 370, May 20th, 1920.)

A scheme for connecting Greenwich and Sydney observatories by radio time signals for accurate determinations of longitude, etc., is discussed briefly.

578. An Electrical Signalling Method for Guiding Craft. R. H. Marriott. (*Telegraph and Telephone Age*, 38, pp. 4—7, January, 1920. *Revue Générale de l'Électricité*, 7, pp. 127—129, January 24th, 1920. *Science Abstracts*, 23B, p. 214, Abstract No. 423, April, 1920, Abstract.) See also R. H. Marriott and H. H. Lister. (*Electrical Review*, Chicago, January 10th, 1920. *Technical Review*, 6, p. 385, April 27th, 1920, Abstract. Also *Electrical Experimenter*, 7, p. 746, December, 1919 ; *La Nature*, 48, pp. 167—168, April 10th, 1920.)

Paper read before the Seattle Section of the Institute of Radio Engineers.

Vessels can be guided through various channels by means of cables laid along the sides or bottom of the channel, the cables carrying intermittent or alternating currents of audible frequency which are picked up by a coil and telephone receiver carried by the vessel. Outgoing and ingoing routes can be distinguished by sending different signals. Details are given of some experiments at Puget Sound Navy Yard. The author advocates the question being taken up by the Government on account of its great importance, *e.g.* in enabling vessels to enter New York Harbour during fog.

579. Professor Elihu Thomson's Early Experimental Discovery of the Maxwell Electromagnetic Waves. M. B. Snyder. (*General Electric Review*, 23, p. 208, March, 1920.)

Briefly recounts some experiments made by Professor Elihu Thomson in 1875 (twelve years before Hertz's researches) and witnessed by the writer, in which the effects of electromagnetic waves were demonstrated at distances up to 100 feet.

2. Books.

WIRELESS TELEGRAPHY : A Handbook for the Use of Operators and Students. By W. H. Marchant. (London : *Sir Isaac Pitman & Sons, Ltd.* Second Edition, 1920. Pp. ix. + 305. Price 7s. 6d. net.)

The writer of a text-book on wireless telegraphy at the present time suffers from the disadvantage that, owing to the rapidity of the progress in the art, he may not only give undue prominence to apparatus which is becoming obsolete, but, what is far more important, he may find that in the period between the time the manuscript left his hands and the time the work is published, new and important methods and apparatus have been developed which should have found a place therein.

The present work, which is a small and elementary text-book, in preparing which the author, as stated in the preface, has chiefly had in mind the seafaring operator and students preparing for the Postmaster-General's certificate, suffers in this manner. At the present moment the three-electrode valve is already being fitted on ships for receiving purposes, and the Marconi Company has commenced to supply direction-finding outfits which will undoubtedly have a great influence on navigation in the future, and will extend that which is perhaps the most important characteristic of the art of wireless telegraphy, its great aid to the saving of life at sea.

The direction finder is not mentioned and the allusions to the three-electrode valve are of the briefest, and no doubt this will be a disappointment to many to whom the book would otherwise appeal.

As will be expected, the theoretical treatment is limited to elementary explanations of a few important conceptions such as " electric oscillations," " electric waves," etc. The explanations given are however clear, and the author has not loaded his book with the chapters on elementary electricity which are often to be found in general text-books on wireless telegraphy.

The work consists of sixteen chapters and a glossary of terms, and is well supplied with diagrams and illustrations. The major portion is devoted to a description of the small-power sets of the Telefunken, Lepel, Poulsen, and Marconi systems. The description of the Marconi ship sets is very thorough ; the wiring of all important circuits, including switchboard and power circuits, is given in clearly-drawn diagrams. In fact the treatment of some parts of the apparatus, such as the multiple tuner and magnetic detector, is almost too full, since these are becoming obsolete, while the crystal receiver and three-electrode valve circuits, which in a few years will probably be universally employed, have not had adequate space devoted to them.

The progress in the adaptation of the three-electrode valve to wireless telegraphic and telephonic reception and transmission is so rapid that a large amount of the apparatus which might have been treated of in this work has probably (as in the instance given above) been put on the market whilst it was being printed, but even then a general description of the ordinary types of circuit employed together with an elementary account of the theory

would be of great service to an operator who may have to use one of these instruments. The space devoted to the three-electrode valve is only four pages, whilst the coherer—which is now of only historical interest—occupies about as much.

The sets described in some detail include the Marconi $1\frac{1}{2}$, $\frac{1}{2}$, and $\frac{1}{4}$ kW. ship sets, Poulsen, Lepel and Telefunken sets of small power including a Telefunken airship set, and the Goldschmidt alternator. Special chapters are devoted to the transmitter, detector, and receiver, in which the general principles of the circuits and appliances of these parts of a wireless installation are set out.

The twelfth chapter is devoted to measurements, and includes a description of the De Sauty bridge for capacities, and methods for measuring the dielectric losses in condensers, capacities of aerials and resistance, wavelength, coupling and decrement of circuits, together with the strength of received signals, etc. Most of the information given is correct and in keeping with the general style of the book, but the section on measurement of high-frequency current is rather misleading, since, after stating that the ordinary or shunted type of hot-wire ammeter is of no use for measuring high-frequency currents, a description of the Reiss thermometer is given as though it were a convenient instrument for the purpose, and the unshunted (or " shuntless ") type of hot-wire ammeter, which is to be found on large numbers of small radio sets, is not mentioned.

It is standard practice with many companies to supply an ammeter with transformer for measuring the aerial current, especially in small continuous wave sets where some indicator of the sort is essential.

The loss due to *eddy currents* in conductors which pass close to an energised aerial is wrongly ascribed as due to its not being *well insulated* for oscillatory currents.

In the thirteenth chapter is given a page of conventional symbols for representing various electrical apparatus in diagrams, and the fourteenth and fifteenth are devoted to the regulations and instructions for stations licensed by the Postmaster-General, with a list of abbreviations and the Morse codes.

The sixteenth chapter gives an account of various faults which may occur and how they may be localised, the Marconi $1\frac{1}{2}$ kW. set being selected as an example.

In the glossary most of the definitions given are correct, although one or two are loosely expressed. The function of a telephone receiver is hardly " to make evident the presence of *oscillatory* currents in the circuits of the receiver." This is the function of the detector which rectifies these currents, the actual current in the telephone being a varying direct current and not an alternating one.

Under miscellaneous receiving apparatus is given a full description of the Brown telephone relay type A, but we believe that where relays of this nature are still used preference is given to the more stable G type employing a carbon microphone cell.

W. H. N.

ROBISON'S MANUAL OF RADIOTELEGRAPHY AND TELEPHONY,
for the use of Naval Electricians. By Captain S. S.
Robison, U.S. Navy. Revised by Captain D. W. Todd,
U.S.N., and Commander S. C. Hooper, U.S.N. (Annapolis,
U.S.A.: *The United States Naval Institute.* London:
S. Rentell & Co. Fifth Edition, 1919. Pp. 307. Price
10s. net.)

This volume is the fifth edition of the work originally written by Lieutenant
(now Rear-Admiral) S. S. Robison, U.S. Navy, in 1907. The aim of the
author and revisers has been to present the facts of radiotelegraphy and
telephony in a form suitable for the use of naval student operators, and it
may be admitted at the outset that the general reader who is not interested
in the details of working of the U.S. Navy sets will find little in the general
wireless sections that is fresh either in facts or treatment. It is natural to
compare such a work as this with the volume recently issued by the U.S.
Military Signal Corps under the title of " The Principles underlying Radio
Communication." The latter volume proves quite clearly that it is not
necessary to be inaccurate or to find refuge in hazy phraseology in an elemen-
tary treatment of wireless theory, and increases the debt, already large,
which all radio workers owe to the Bureau of Standards. The volume under
review, in the comparison mentioned, is at an obvious disadvantage.

Of the seventeen chapters of the book the first five deal with general
wireless theory, including facts relating to high-frequency currents, pro-
duction and detection of ether waves, units, and power expenditure and
efficiency of sending and receiving apparatus. The treatment throughout is
as non-mathematical as possible, but the fact that such statements as the
following are allowed to pass in a *fourth* revision seems to indicate that
accuracy sometimes suffers at the hands of simplicity :—

" The electric field " [between the plates of two geometrically similar
condensers charged to the same potential difference] " when glass is the
dielectric is nine times as strong as that created when the medium inter-
vening between the charges is air " (page 35).

" But in all other features receiving circuits are the exact analogue of
sending circuits and the detector could occupy the place of the spark gap "
(page 68).

" Lines of magnetic force " [inside a permanent magnet] " run from
south pole to north pole " (page 13).

The discussion of capacity and condensers could certainly be improved.
To verify that it is possible to explain in an elementary way how an alter-
nating current does " pass through " a condenser in terms of the displace-
ment current one need only turn to the other volume of similar pretensions
mentioned above.

The subject of the transfer of energy between coupled circuits is illustrated
by the very useful analogy of two pendulums connected by a flexible support,
the other immediately afterwards being introduced to the quenched gap
and its advantages. It seems a pity that the way had not been paved for

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this by discussing the trend of events in the mechanical analogy if the primary pendulum is held rigid (corresponding to an open primary circuit) when its energy has been first transferred to the secondary pendulum.

Chapters VI., VII. and VIII. are devoted to detailed descriptions of the transmitting gear of merchant ships and battleships, the subject being treated under the headings of Spark, Continuous Wave and Telephonic Transmitters. The descriptions are adequately illustrated by photographs, circuit and wiring diagrams. The Western Electric Circuit for the modulation of high-frequency oscillations, so ubiquitous in American service sets, is described in detail. The treatment of vacuum tubes is simple and on the whole interesting, though again one meets the old fallacy that a triode functions as an amplifier because the particular anode current—grid voltage characteristic is shown with a maximum slope greater than 45°.

Chapters IX. and X. though devoted mainly to the subject of service receivers contain a useful discussion of the problems of reception in general including short accounts of very recent American progress such as the experiments of Commander A. H. Taylor on underground antennæ, Weagant's method of reception through interference, and the Alexanderson barrage receiver. Chapter XI. is devoted to a description of the high-power stations of U.S.A., and the following chapter to direction-finding. The description of the radio compass seems unnecessarily laboured seeing that fully six pages are required to point out the directional property of a coil and the ambiguity of the bilateral minima. The naval radio compass set is described in detail and a chapter on aircraft radio concludes the descriptive section of the book.

The remaining four chapters deal with the installation, adjustment, care and operation of sets, wireless procedure and the commercial traffic regulations of the U.S. Naval Communication Service. The section on high-frequency measurements is exceedingly clear so far as it goes, but it requires bringing up to date. For example no mention is made of the now well-known methods of measuring antenna resistance with sustained waves.

The book is illustrated by good diagrams and is in bold readable type— almost free from misprints. No index is included, the only guide to the various sections being a table of contents.

E. V. APPLETON.

Books Received.

ELECTRIC OSCILLATIONS AND ELECTRIC WAVES. By G. W. Pierce. (New York : *McGraw Hill Book Company, Inc.* London : *McGraw-Hill Publishing Co., Ltd.*, 1920. Pp. ix. + 517. Price 30s. net.)

THE YEAR BOOK OF WIRELESS TELEGRAPHY AND TELEPHONY. (London : *The Wireless Press, Ltd.* 1920. Pp. 1148. Price 10s. 6d. net.)

DESIGN AND CONSTRUCTION OF AUDION AMPLIFYING TRANSFORMERS. By E. T. Jones, Assoc.M.I.R.E. (New York : *The Experimental Publishing Company.* 1920. Pp. 16. Price 75 c.)

This little pamphlet gives constructional details for both radio frequency and audio frequency transformers for coupling the stages of a multi-valve amplifier. In the radio

frequency case details are given of a sectionalised winding with the primary coils sandwiched between the secondary coils, while for the audio frequency case an iron-core transformer is described.

Although the first transformer described is designated as a "radio frequency type" it nevertheless appears to be designed for low frequency amplification subsequent to the detection of the signals, but this point is not made clear either in the text or in the circuit diagrams. This view is strengthened by the statement that the iron-core transformer can be used to replace the air-core one in the same circuit, while no mention is made of the position of the detecting valve in the two cases. Apart from this point, however, the details given appear to be amply sufficient for the construction of such transformers.

<div align="right">P. R. C.</div>

Correspondence.

TRIODE NOMENCLATURE AND SYMBOLS.
TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—Dealing further with triode nomenclature and symbols referred to in the March issue of the RADIO REVIEW, may I suggest that the word "amplification" be limited to the domain of actual voltage or current amplification? This would then leave the phrase "relay action" for use in connection with the two mutual conductance ratios $\partial i_a/\partial v_g$ and $\partial i_g/\partial v_a$. That is, the word "relay" would imply the transformation of potential to current or *vice versâ*.

From this standpoint the word "detector" should be limited to a symmetrical relay action. Thus, also, with the range of grid potentials in which no grid current actually flows in a triode, we can refer to a pure relay or detector action.

<div align="right">A. PRESS.</div>

East Pittsburg, Pa.,
   April 28th, 1920.

THE KALLIROTRON.
TO THE EDITOR OF THE "RADIO REVIEW."

SIR,—I have now seen a copy of Mr. Marius Latour's recently published French specification No. 501472, referred to in his letter of April 19th, 1920. I shall be glad if you will allow me to express my views as to its bearing on the Kallirotron.

The arrangement shown in the figure accompanying Mr. Latour's letter can not, in my opinion, correctly be designated an amplifier. As the patent specification states, "L'invention se rapporte à un système de lampes, à trois électrodes, susceptible de réaliser par le montage même l'équivalent d'une impédance négative de valeur quelconque." This is the whole of the "Résumé" of the specification, and the single arrangement disclosed is that illustrated in Mr. Latour's letter. That a negative impedance can be used in the construction of an amplifier of E.M.F. is well known—witness the elementary alternating-current laboratory experiment with an inductance and a capacity in series, designed to show the student that the P.D. across

a part may be greater than the P.D. across the whole; but amplifier is surely an inaccurate description of a box of apparatus with only two terminals for connection to an external circuit. The Kallirotron amplifier, on the other hand, is a true amplifier of change of P.D., with two input terminals and two output terminals.

This distinction between Mr. Latour's negative-impedance producer and the Kallirotron amplifier, as shown for example in Figs. 1 and 3 of my paper, is emphasised by a comparison between them when the circuit values are symmetrical in each case. In the former, owing to the absence of anything corresponding to my resistances R_1 and R_2, change of anode potential in either triode never numerically exceeds the change of grid potential; whereas in the latter there is the ordinary amplifier ratio (viz. up to the triode amplification factor $\nu = g/a$) between the anode and grid changes.

In arriving at the ratio between the repeat E.M.F. appearing between the output terminals and the E.M.F. applied between the input terminals of the Kallirotron, the theory was conveniently stated in terms of negative resistance. It is to be noted that the negative resistances are *within* the amplifier, and the external circuit in which the magnified repeat E.M.F. appears has no cognisance of them, nor is its presence necessary to produce them. The negative resistance (expression 9, page 320 of my paper), is a term in the resistance of the anode-filament circuit of a triode; in Mr. Latour's device, the negative impedance appears between the grid of one triode and the anode of another if and when an external circuit is connected across these points. With regard to originality in the negative-resistance presentation, I think my statement on page 317, " It is well understood that the most important effect of such retroaction is the reduction of the ohmic resistance of the circuits," clearly shows that I made no claim in this respect; and I referred to the Dynatron because it was mainly from Mr. A. W. Hull's article that I gained an appreciation of the utility of the conception. I am quite prepared to accept Mr. Latour's statement that he has " been the first to introduce the idea of negative resistance in the conception of certain amplifier connections."

For the rest, asymmetric amplification (rectification) and limiter-amplification, being particular ses of amplification, are not referred to in Mr. Latour's specification. Neither do's he mention the use of his device to generate oscillations. It can, of course, be used for this purpose, but the circuits are not the same as those of Fig. 8 of my paper. The ingenious division of the anode batteries into two parts in order to make grid batteries unnecessary, as described by Mr. Latour, seems an excellent arrangement.

L. B. TURNER.

King's College, Cambridge.
June 12*th*, 1920.

ERRATUM.

Page 397, *Abstract No.* 355 (*May,* 1920), *the* " *Radio Review* " *reference should read:* 1, pp. 178—181, January, 1920.