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VOL. I AUGUST, 1920 NO. 11

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THE

RADIO REVIEW

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The Effect of Ionization on a Characteristic Curve of a Three-Electrode Valve containing a Trace of Gas.*

By B. HODGSON, O.B.E., M.Sc., Ph.D., and L. S. PALMER, B.Sc.

The phenomena to be described afford a simple and quick method of determining with relatively coarse measuring instruments the potential through which an electron must fall to produce ionization.

If the grid of a "hard" valve is maintained at a constant potential v positive with respect to the negative end of the filament and the plate potential V varied, the characteristics shown in Fig. 2 can be obtained. Fig. 1 shows the circuit used for obtaining them.

These characteristics differ from those commonly figuring in radio-telegraphy—in that the grid current i and the plate current I are given as functions of V (v being constant), instead of functions of v (V being constant). The dotted curve shows the variation of grid current i with plate voltage V.

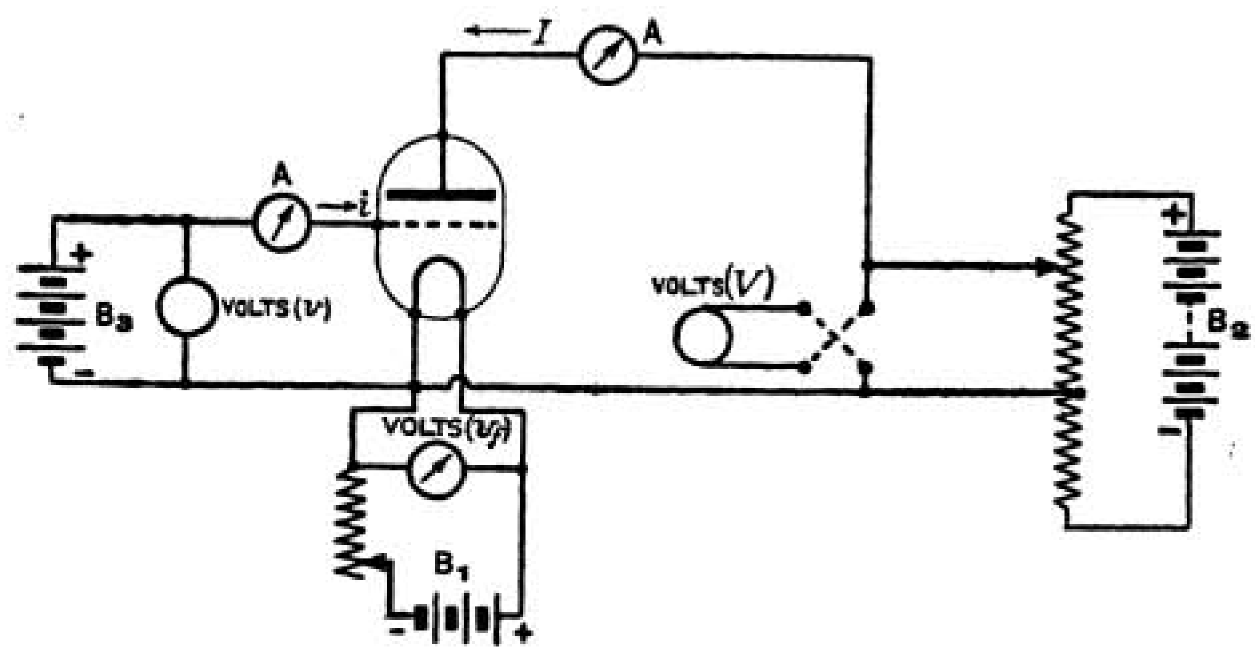

FIG. 1.

* Article received April 21st, 1920.

The current to the grid increases as the plate potential increases up to the value $V=0$ and then steadily decreases. The full curve of Fig. 2 shows the variations of the plate current I over the same range.

Up to the point $V=0$, the grid takes practically all the current, since

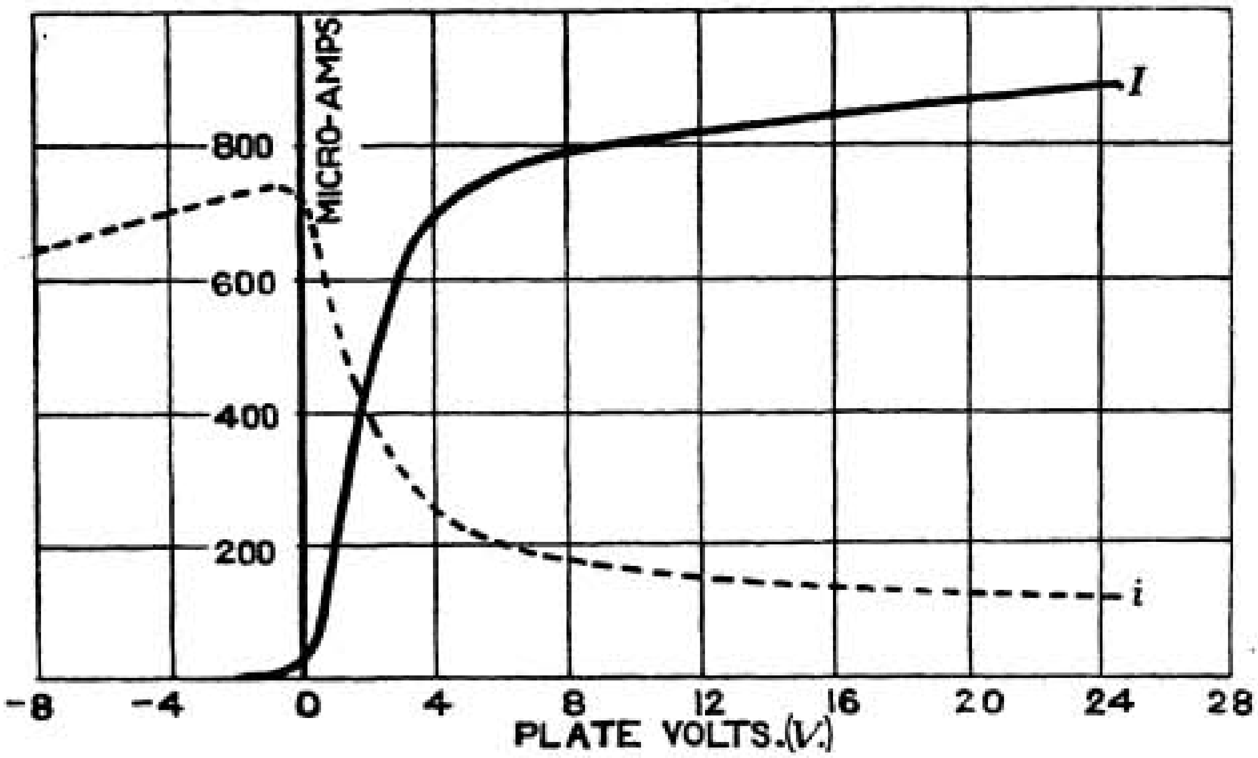

FIG. 2.

those electrons which pass through the grid wires are turned back to the grid by the retarding field between the grid and plate. When V becomes positive the plate current begins and increases with V very rapidly—more rapidly in fact than the electron emission from the filament in the case of an open grid valve, so that the grid current i decreases as V increases.

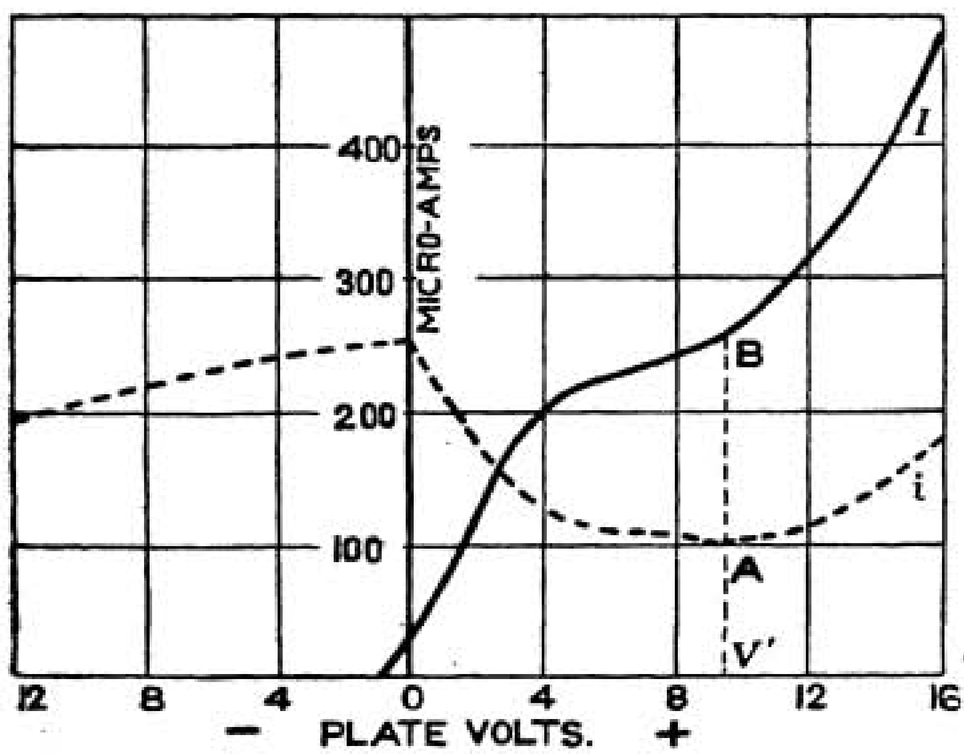

FIG. 3.

In the case of a valve containing a trace of gas the $(i-V)$ characteristic is shown by the dotted curve of Fig. 3. The grid current with V positive and increasing does not decrease continuously but at a point A (Fig. 3) commences to increase. This can be explained in the following way. When the plate potential is such that the electrons passing through the grid can acquire sufficient energy to ionize the gas by collision, then ionization will occur near the plate and some of the positive ions produced there will pass to the grid and some—the larger portion in the case of an open grid valve—will pass to the filament. This bombardment of the filament by positive ions produces an increased emission of electrons. It is this increased emission of electrons that yields to the grid the increased current at the point A on the dotted curve of Fig. 3, and to the plate, the increase shown at B on the full line curve of the same figure. The hard valve characteristics of Fig. 2 preclude any explanation of the increase in grid current due to the emission of positive ions from the grid wires or plate by electronic bombardment, for such emission would occur whether a gas were present or not.* The plate voltage V' (Fig. 3), at which the change in current is indicated is not the ionizing potential because the electrons are emitted from the filament with varying velocities and because the majority of them come from the mid-point of the filament—*i.e.*, from the hottest part of it. Thus the energy possessed by the majority of the electrons on arriving near the plate is that obtained by falling through a voltage of $V' - \frac{v_f}{2} + e$ where v_f is the voltage fall along the filament and e is the emission velocity of those electrons from the mid-portion of the filament. In the case of the audion which had a V filament the expression becomes $V' - \frac{v_f}{4} + e$. The method does not claim to be a precision method for finding the ionizing potential—but it gives results in good agreement with those obtained by other observers.

The value of e was obtained by a method similar to that adopted by Van der Bijl.† A small positive potential was applied to the plate, causing a small plate current to pass through a galvanometer. The grid potential was made negative so that this current just became zero. Then $-v = \gamma V + e$ where γ is a constant depending upon the geometrical arrangement of the electrodes. By obtaining zero current with two different values of v and V, γ can be eliminated and e found. Some electrons of greater emission velocity will be present in numbers too small to be indicated by the galvanometer, but as a coarser current measuring instrument was used to detect the ionization, no great error will be introduced by neglecting these.

The valves used were the N.P.L. No. 2 valve containing mercury vapour, the R2A receiving valve containing helium; an R receiving valve filled with pure argon to a pressure of 0·5 mm. Hg., and the audion—an air valve. In this valve the oxygen would be absorbed by the tungsten filament and finally sputtered to the sides of the valve as tungsten oxide, leaving as a gas residue nitrogen.

The values of e were measured before and after the ionizing voltage was found and the mean value used. The decrease in the value of e is due to the increase in resistance of the filament with use, caused by evaporation of the tungsten.

* *Proceedings of the Royal Society*, 95A, p. 408, April 1st, 1919.

† H. J. van der Bijl (*Physical Review*, 12, p. 171, 1918).

The voltage along the filament was kept constant during the experiments —and not the current through it.

Some values of e are given in Table I.

TABLE I.

Valve.	e		Mean e.	v_f
	Before.	After.		
N.P.L. No. 2 .	1·96	1·88	1·92	3·0
R2A . .	1·50	1·25	1·37	3·0
Audion . .	1·79	1·68	1·74	3·5
R (argon) .	—	—	3·9	3·4

Fig. 4 represents a family of curves obtained with the N.P.L. No. 2 valve. They represent the $(i - V)$ characteristics for different values of grid potential v, the filament voltage v_f being constant.

Fig. 5 shows the $(i - V)$ characteristics with constant v and varying v_f.

It will be seen from Figs. 4 and 5 that the sharpest bend on the $(i - V)$ curve is obtained when v_f is as big as possible and when v is nearly the ionizing potential.

From Fig. 5 it will also be seen that below a certain filament temperature there is no tendency for the current to increase when the plate potential reaches the value of the ionizing potential, because the number of collisions has decreased so much that the resulting ionization is inappreciable.

Some results for the ionizing potential for mercury are given in Table II.

TABLE II.—N.P.L. NO. 2 VALVE.

V'	v	Mean e.	v_f	Ionizing potential (volts).
9·8	8	2·2	3·0	10·5
9·4	6	2·2	3·0	9·9
9·6	4	2·2	3·0	10·3
9·5	2	2·2	3·0	10·2
10·4	8	1·6	2·95	10·5
10·3	6	1·6	2·95	10·4
9·8	4	1·6	2·95	9·9
9·7	8	2·2	3·0	10·4
10·0	8	1·9	3·0	10·4
11·5	8	0·1	2·0	10·6
11·0	8	0·2	2·1	10·2

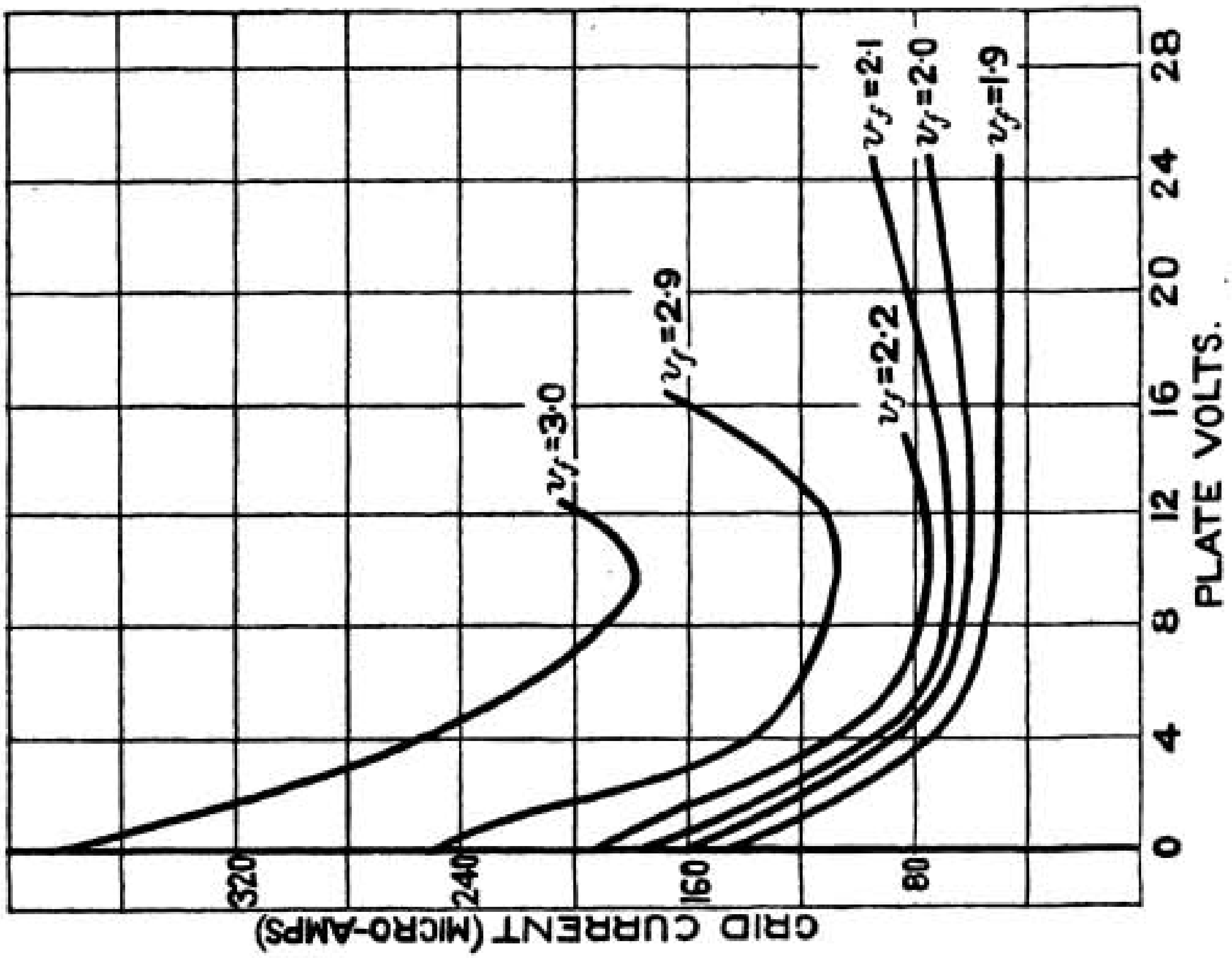
GRID CURRENT (MICRO-AMPS)
PLATE VOLTS.
320
240
160
80
0
4
8
12
16
20
24
28
v_f=3·0
v_f=2·9
v_f=2·2
v_f=2·1
v_f=2·0
v_f=1·9

FIG. 5.

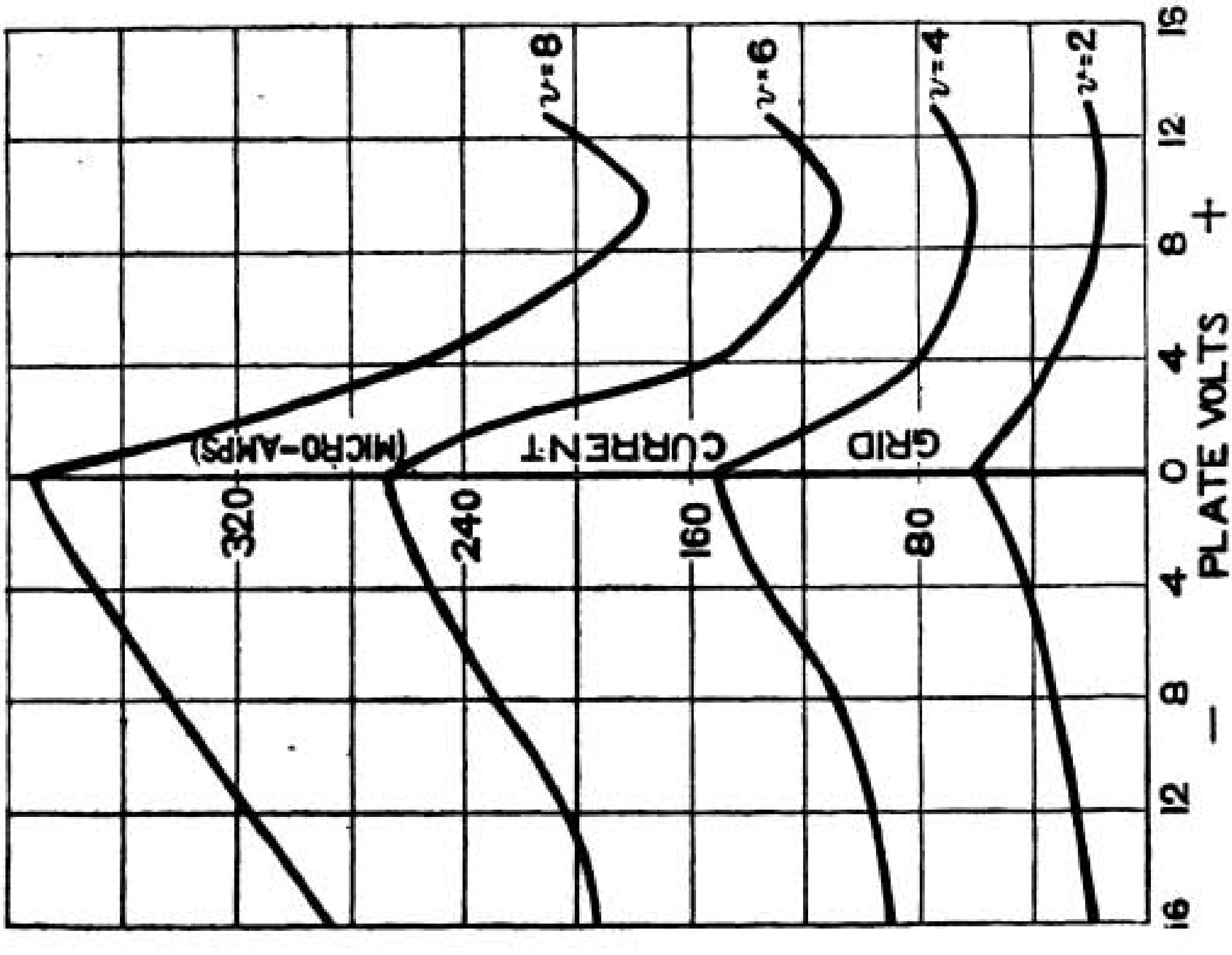
GRID CURRENT (MICRO-AMPS)
PLATE VOLTS
−
+
320
240
160
80
16
12
8
4
0
4
8
12
16
v=8
v=6
v=4
v=2

FIG. 4.

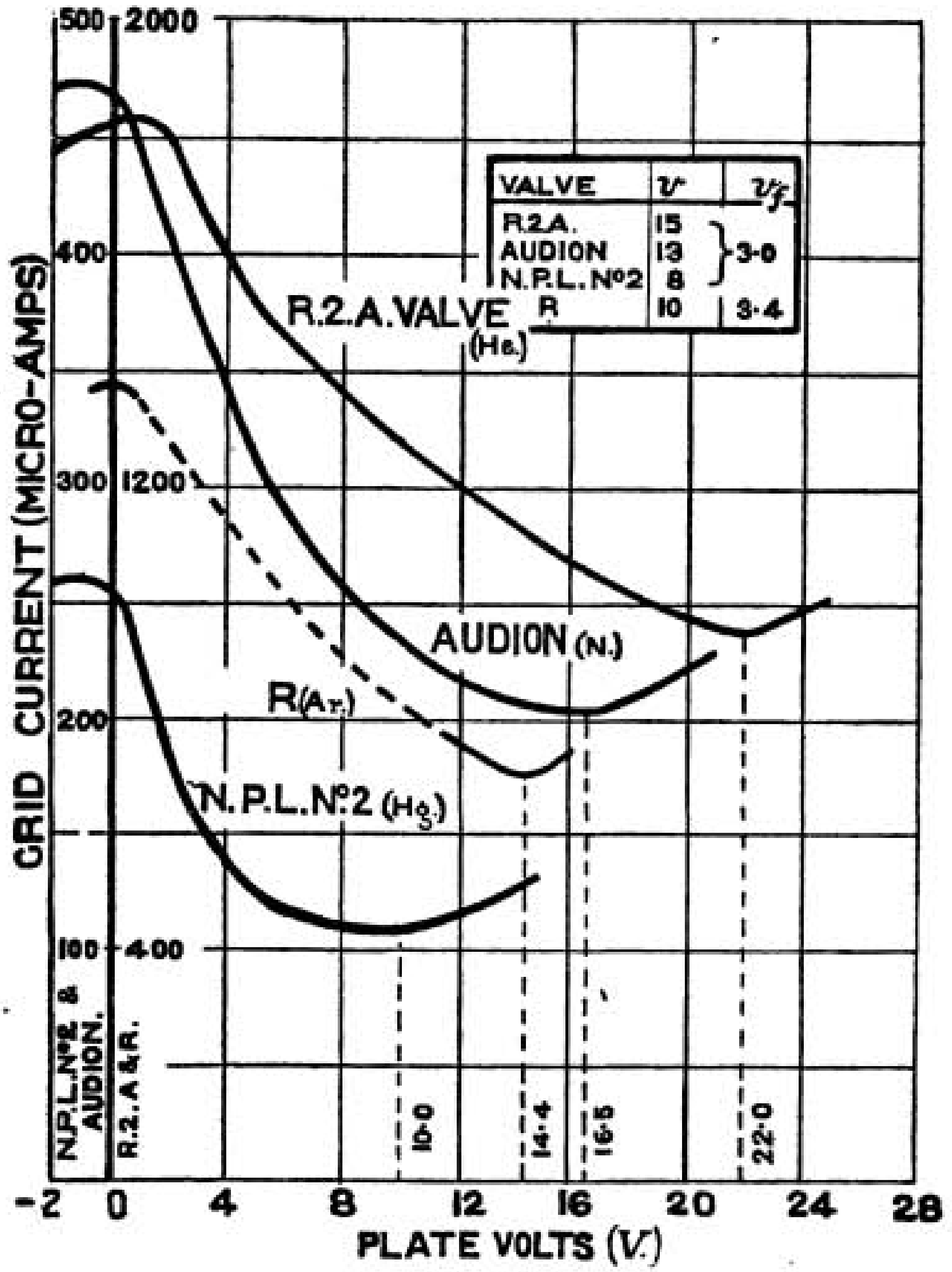

Fig. 6.

The mean value obtained from these experiments is 10·3 volts.

Typical curves from the four valves in question with the corresponding numerical data are given in Fig. 6 and Table III. respectively.

The values for the ionization potentials of mercury vapour, nitrogen, argon and helium are found to be 10·4, 17·4, 16·6 and 21·9 volts respectively.

The value obtained for mercury vapour agrees with the generally accepted value. In the case of nitrogen Davis and Goucher * obtained 18·5 volts, whilst Smyth † obtained a value of about 18 volts as the ionizing potential. Other observers have obtained 7·5 volts which is in all probability a resonance potential. The results obtained by the present method tend to confirm

TABLE III.

Valve.	V'	r	Mean e.	v_f	Ionizing potential (volts).
N.P.L. No. 2 (Mercury vapour) . . .	10·0	8·0	1·9	3·0	10·4
Audion (Nitrogen) .	16·5	15·0	1·7	3·5	17·4
R (Argon) . .	14·4	13·0	3·9	3·4	16·6
R2A (Helium) . .	22·0	10·0	1·4	1·5	21·9

* B. Davis and F. S. Goucher (*Physical Review*, 13, pp. 1—5, January, 1919).
† H. D. Smyth (*Physical Review*, 14, pp. 409—426, November, 1919).

the higher value as the true ionization potential of nitrogen. The value of 16·6 volts for the ionization potential of argon is in accordance with the result of 17 volts recently found by Rentschler.* Horton † obtained a value of 15·1 volts, with a marked increase in the ionization when the potential fall was increased to values ranging from 17 to 21 volts. In the case of helium there is considerable divergence of opinion as to its ionizing potential. Till recently 20·5 volts was generally accepted as the voltage through which an electron must fall to gain energy enough to ionize, but Richardson and Bazzoni found 29 volts ‡ and both Horton § and Rentschler * about 26. The present work indicates 22 as an upper limit for the ionizing potential. It was thought possible that the ionization indicated might be due to collisions—coincident in time—of two electrons with one molecule. To test this point the filament temperature was lowered just so far that ionization was not detectable at 22 volts, and V was then increased up to

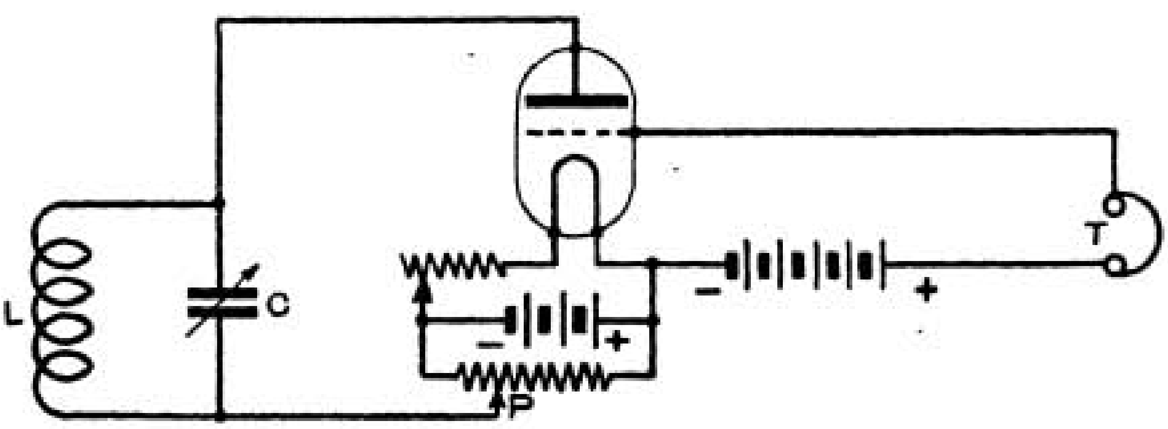

FIG. 7.

50 volts, but no ionization was observed, and with no adjustment of filament temperature could ionization be detected except at 22 volts.

The upper bend in the ($i - V$) characteristic suggests a new use of the valve as a detector of wireless signals. The rectification will be most efficient when the plate voltage V is approximately zero, since at this value the plate current is just commencing.

Fig. 7 shows the electrical arrangements for this use of the valve, but it was found that this method gave results decidedly inferior to any of the valve methods in general use.

SUMMARY.

The ($i - V$) characteristic of a soft three-electrode valve yields a quick method of obtaining the ionizing potential of a gas.

Physics Department,
The University, Bristol.

* H. C. Rentschler (*Physical Review*, 14, pp. 503—515, December, 1919). See also RADIO REVIEW Abstract No. 561, July, 1920.

† F. Horton and Miss A. C. Davies (*Proceedings of the Royal Society*, 97A, pp. 1—22, March 1st, 1920).

‡ O. W. Richardson and C. B. Bazzoni (*Philosophical Magazine*, 34, pp. 285—307, October, 1917).

§ F. Horton and Miss A. C. Davies (*Proceedings of the Royal Society*, 95A, pp. 408—429, April 1st, 1919).

The Diffraction of the Field by a Cylinder and its Effect on Directive Reception on Board a Ship.

By Commandant RENÉ MESNY.

I.—THEORETICAL PROBLEM.

1. Aim of the Paper.—The mathematical investigation developed below was undertaken with the object of discussing the outline of a theory for the deviations observed in a radiogoniometer aboard ship.

The conditions of the theoretical problem that we have assumed differ somewhat from the actual conditions and it is therefore difficult to predict to what extent the results of the calculation should agree with the observations.

As a matter of fact the coincidence is remarkable, and the distribution of the field which we have deduced may be regarded as accurate not only qualitatively but also quantitatively.

2. Nature of the Problem.—We shall consider a plane wave having a wavefront in a vertical plane. The fields are polarised, the magnetic field being horizontal. This wave impinges obliquely on an infinitely conducting cylinder with horizontal axis and we shall determine the field diffracted by the cylinder.

The problem is dealt with in an absolutely general manner, without, however, calculating the harmonics, and in conclusion the practical case is treated in which the radius of the cylinder is small compared with the wavelength.

In virtue of the principle of images, the solution of the problem is also that of the case in which the wave is confined to an indefinite horizontal conducting plane on which a semi-cylinder is resting (Fig. 1).

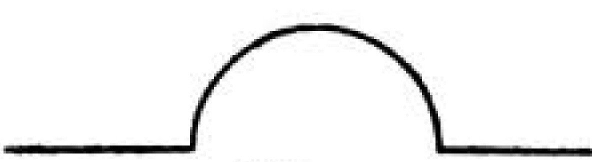

FIG. 1.

The chief differences between the actual case and the theoretical problem are as follows :—

(1) The ship is not an infinitely long cylinder.

(2) Its transverse section is not circular but nearly rectangular.

(3) The sea is not a perfectly conducting plane.

(4) The metal is likewise not infinitely conducting.

It may be noted that the length of a ship is from six to eight times its width, and about ten times its depth. If the wave direction is not inclined to the axis at too small an angle, the distribution of the field will then be very close to that of the theoretical case.

The second objection is more serious, but the study of a rectangular section involves difficult calculations which have not been completed, and as has been said above the results obtained for the circular cylinder are extremely close to the observed values.

As regards the imperfect conductivity of the sea and of the metal (or of the earth if the field on a hill is being considered) there is no need to trouble much about it. If the resistance of these elements is taken into account, it is found that the correcting terms do not exceed one-fortieth of the principal term as long as the conductivity is greater than 10^{-13} e.m. units, which is the average conductivity of damp soil, 10^{-11} being the conductivity of the sea. These correcting terms are moreover proportional to the square root of the conductivity.

3. Notation.—Cartesian co-ordinates x, y, z.
Cylindrical ,, x, ρ, θ.

Components of the magnetic and electric fields in Cartesian co-ordinates	X, Y, Z;	χ, η, ζ.
Components in cylindrical co-ordinates	X, N, T;	χ, ν, τ.

Unaccented symbols refer to the fields of the cylinder, whilst those with accents refer to the wave field, unless otherwise stated.

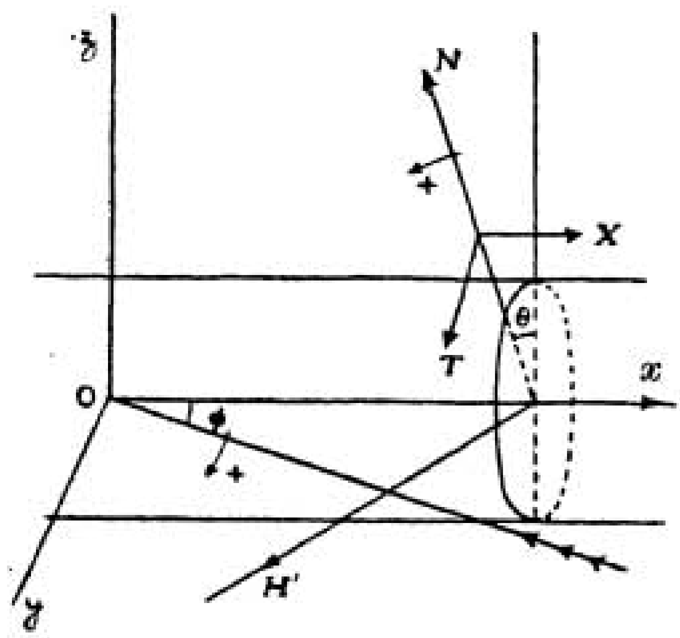

FIG. 2.

ϕ is the angle between the normal to the wavefront and the axis of the cylinder; the positive directions are indicated by arrows in the figures.

Finally, ρ_0 is the radius of the cylinder, and we may put

$$2\pi/\lambda = \alpha; \quad \alpha\rho \sin\phi = r; \quad \tfrac{1}{2}(\alpha\rho_0 \sin\phi) = \beta; \quad \rho_0/\rho = m.$$

Our equations will be expressed in the form due to Hertz, the magnetic quantities being measured in the e.m. system and the electric quantities in the e.s. system.

J and K are Bessel functions of the first and second kind, and Q_n the combination $\left\{ K_n(r) + r\frac{\partial K_n(r)}{\partial r} \right\}$.

4. Equations.—We have in the Cartesian and cylindrical systems,

$$\left.\begin{aligned}\frac{1}{c}\frac{\partial\chi}{\partial t}&=\frac{\partial Y}{\partial z}-\frac{\partial Z}{\partial y}\\ \frac{1}{c}\frac{\partial\eta}{\partial t}&=\frac{\partial Z}{\partial x}-\frac{\partial X}{\partial z}\\ \frac{1}{c}\frac{\partial\zeta}{\partial t}&=\frac{\partial X}{\partial y}-\frac{\partial Y}{\partial x}\end{aligned}\right\} \quad \ldots\ldots \quad (1)$$

$$\left.\begin{aligned}\frac{1}{c}\frac{\partial\chi}{\partial t}&=\frac{T}{\rho}+\frac{\partial T}{\partial\rho}-\frac{1}{\rho}\frac{\partial N}{\partial\theta}\\ \frac{1}{c}\frac{\partial\nu}{\partial t}&=\frac{1}{\rho}\frac{\partial X}{\partial\theta}-\frac{\partial T}{\partial x}\\ \frac{1}{c}\frac{\partial\tau}{\partial t}&=\frac{\partial N}{\partial x}-\frac{\partial X}{\partial\rho}\end{aligned}\right\} \quad \ldots\ldots \quad (2)$$

where $c =$ the velocity of light.

All these elements satisfy the equation

$$\Delta U = \frac{1}{c^2}\cdot\frac{\partial^2 U}{\partial t^2}$$

which in cylindrical co-ordinates may be written

$$\frac{\partial^2 U}{\partial\rho^2}+\frac{1}{\rho}\frac{\partial U}{\partial\rho}+\frac{1}{\rho^2}\frac{\partial^2 U}{\partial\theta^2}+\frac{\partial^2 U}{\partial x^2}=\frac{1}{c^2}\frac{\partial^2 U}{\partial t^2} \quad \ldots\ldots \quad (3)$$

In the steady state, the value of the function U of the system, in a section perpendicular of Ox, and passing through M is the same as it would have in the plane $y\ z$ when the wave had advanced by O P $=$ O M $\cos\phi = x\cos\phi$, that is to say at the end of an interval of time equal to $x\cos\phi/c$. The variable x is therefore necessarily associated with t in the expression for U, and these two variables can only occur there together in the form $(t + x\cos\phi/c)$.

We may therefore put

$$U = u\epsilon^{2\pi j\,(t/T\,+\,x\cos\phi/\lambda)}$$

whence, putting $\alpha = 2\pi/\lambda$ we get

$$U = u\epsilon^{j\omega t}\,.\,\epsilon^{j\alpha x\cos\phi} \quad \ldots\ldots\ldots \quad (4)$$

u is only a function of ρ and θ, so that equation (3) becomes

$$\frac{\partial^2 u}{\partial\rho^2}+\frac{1}{\rho}\frac{\partial u}{\partial\rho}+\frac{1}{\rho^2}\frac{\partial^2 u}{\partial\theta^2}=-\alpha^2\sin^2\phi u$$

If u is expanded by Fourier's series

$$u = u_0 + u_1\sin\theta + v_1\cos\theta + u_2\sin 2\theta + v_2\cos 2\theta + \ \ldots$$

the functions u_n and v_n of ρ will be solutions of the equation :

$$\frac{d^2u_n}{d\rho^2} + \frac{1}{\rho}\frac{du_n}{d\rho} + \left(\alpha^2 \sin^2\phi - \frac{n^2}{\rho^2}\right) u_n = 0$$

Putting $\rho\alpha \sin \phi = r$, this equation may be transformed into

$$\frac{d^2u_n}{dr^2} + \frac{1}{r}\frac{du_n}{dr} + \left(1 - \frac{n^2}{r^2}\right) u_n = 0$$

for which the solutions are Bessel functions of the n^{th} order.

The functions K correspond to the actual problem, so that we may put

$$u_n = 2A_n' K_n(r)$$
$$v_n = 2A_n'' K_n(r)$$

Hence

$$u = A_0 K_0(r) + 2\sum_r^{\infty} (A_n' \sin n\theta + A_n'' \cos n\theta)\, K_n(r) \quad . \quad . \quad . \quad . \quad (5)$$

Calling U' the value of the element considered if the wave existed alone and the cylinder were not present, it would evidently be a solution of (3). As the total element U is a solution, so likewise will be their difference since equation (2) is linear; in other words the part of U which refers to the field diffracted by the cylinder can be represented by equation (5).

In the following the unaccented symbols will be reserved for the components of an element referring to the diffracted field, while the accented ones will represent the corresponding elements of the wave.

Putting

$$M = \epsilon^{j(\omega t + \alpha x \cos\phi)}$$

we have

$$\left.\begin{aligned} X/M &= A_0K_0(r) + \sum_1^{\infty}(A_n' \sin n\theta + A_n'' \cos n\theta)\, K_n(r) \\ Y/M &= B_0K_0(r) + \sum_1^{\infty}(B_n' \sin n\theta + B_n'' \cos n\theta)\, K_n(r) \\ Z/M &= C_0K_0(r) + \sum_1^{\infty}(C_n' \sin n\theta + C_n'' \cos n\theta)\, K_n(r) \end{aligned}\right\} \quad . \quad . \quad (6)$$

Taking the amplitude of the magnetic field of the wave to be unity, and reckoning the positive direction that in which ϕ increases, we have

$$H' = \epsilon^{j[\omega t + \alpha(x\cos\phi + y\sin\phi)]} = M\,\epsilon^{j\alpha y \sin\phi} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

To combine this with the field of the cylinder it must be expanded by the Fourier series. In this connection it should be noted that $y = \rho \sin\theta$, and we then have

$$H' = M \left\{ \begin{array}{l} J_0(r) + 2J_2(r)\cos 2\theta + 2J_4(r)\cos 4\theta) + \ldots\ldots \\ + j\,[2J_1(r)\sin\theta + 2J_3(r)\sin 3\theta + \ldots\ldots] \end{array} \right\}$$

where the J_0, J_1, etc., are Bessel functions of the first kind.

5. Determination of the Coefficients.—The coefficients A_n, B_n, C_n may be determined by the limiting conditions which are given by the tangential electric field being zero on the surface of the conductor and by the magnetic field being perpendicular to it.

For this purpose it is convenient to utilise equation (2), and by noting that the electric field of the wave has no components parallel to the axis of the cylinder, we have for $\rho = \rho_0$,

$$\left.\begin{aligned} N + N' &= 0 \\ \frac{\partial(X + X')}{\partial\rho} &= 0 \\ \frac{T}{\rho} + \frac{\partial T}{\partial\rho} &= \frac{1}{\rho}\frac{\partial N}{\partial\theta} \\ &= -\frac{1}{\rho}\frac{\partial N'}{\partial\theta} \end{aligned}\right\}$$

which for convenience in calculation when $r = r_0$ may be replaced by

$$N = -N' \quad \ldots\ldots\ldots\ldots \quad (8)$$

$$\frac{\partial X}{\partial r} = -\frac{\partial X'}{\partial r} \quad \ldots\ldots\ldots\ldots \quad (9)$$

$$T + r\frac{\partial T}{\partial r} = -\frac{\partial N'}{\partial\theta} \quad \ldots\ldots\ldots\ldots \quad (10)$$

where $r = \alpha\rho\sin\phi$.

We have, moreover,

$$\begin{aligned} & & X &= -H'\sin\phi \\ N &= Y\sin\theta + Z\cos\theta & N' &= H'\cos\phi\sin\theta \\ T &= Y\cos\theta - Z\sin\theta & T' &= H'\cos\phi\cos\theta \end{aligned}$$

and we find by equating the coefficients of $\sin\theta$ and $\cos\theta$ in equations (8), (9) and (10)

$$\frac{X}{M\sin\phi} = \left\{\begin{aligned} &\frac{J_0'(r_0)}{K_0'(r_0)}K_0(r) + 2\frac{J_2'(r_0)}{K_2'(r_0)}K_2(r)\cos 2\theta + \ldots\ldots \\ &+ j\left[2\frac{J_1'(r_0)}{K_1'(r_0)}K_1(r)\sin\theta + 2\frac{J_3'(r_0)}{K_3'(r_0)}K_3(r)\sin 3\theta + \ldots\right] \end{aligned}\right\}$$

$$\frac{N}{M\cos\phi} = \left\{\begin{aligned} &\{D_0K_0(r) - E_2K_2(r)\}\sin\theta + \\ &\qquad + \{D_2K_2(r) - E_4K_4(r)\}\sin 3\theta + \ldots \\ &+ j\left[\frac{J_0'(r_0)}{K_1(r_0)}K_1(r) - \{D_1K_1(r) - E_3K_3(r)\}\cos 2\theta + \ldots\right] \end{aligned}\right\}$$

$$\frac{T}{M\cos\phi} = \left\{\begin{aligned} &\{D_0K_0(r) + E_2K_2(r)\}\cos\theta + \\ &\qquad + \{D_2K_2(r) + E_4K_4(r)\}\cos 3\theta + \ldots \\ &+ j\left[\{D_1K_1(r) + E_1K_1(r)\}\sin 2\theta + \ldots\ldots\right] \end{aligned}\right\}$$

where

$$D_p = -\,2J_{p+1}'(r_0)\,\frac{(p+2)K_{p+2}(r_0) + r_0K_{p+2}'(r_0)}{K_p(r_0)Q_{p+2}(r_0) + K_{p+2}(r_0)Q_p(r_0)}$$

$$E_p = -\,2\,J_{p+1}'(r_0)\;\frac{(p-2)\,K_{p-2}(r_0) - r_0K_{p-2}'(r_0)}{K_p(r_0)Q_{p-2}(r_0) + K_{p-2}(r_0)Q_p(r_0)}.$$

6. The Case when ρ/λ is small.—Let us now suppose that the radius of the circle is sufficiently small for $(\pi\phi/\lambda)^2$ to be neglected in comparison with unity, then $(r/2)^2$ will be negligible (since $r = (2\pi\rho \sin\phi)/\lambda$) and the results may be simplified.

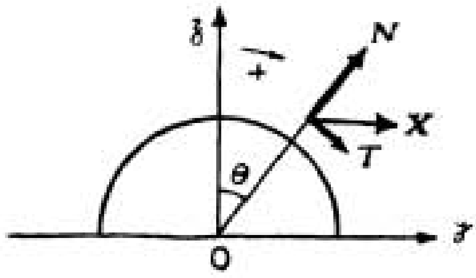

FIG. 3.

This hypothesis is quite permissible if we are considering the effect of a ship on waves of greater length than 600 m., when ρ_0 is in fact less than 15 metres. In this case we have

$$J_0 = 1; \qquad J_0' = -\,r/2; \qquad K_0 = \log_\epsilon \frac{2\gamma}{p}; \qquad K_0' = -\frac{1}{r}$$

$$J_p = \frac{1}{p!}\left(\frac{r}{2}\right)^p; \qquad J_p' = \frac{1}{2(p-1)!}\left(\frac{r}{2}\right)^{p-1};$$

$$K_p = \frac{1}{p!}\left(\frac{2}{r}\right)^p; \qquad K_p' = -\frac{1}{2(p-1)!}\left(\frac{2}{r}\right)^{p+1}$$

In these expressions γ is Euler's constant, which however will not affect the results. Putting $\beta = r_0/2$ we find,

$$\frac{J_0'(r_0)}{K_0'(r_0)} = 2\beta^2; \quad \frac{J_p'(r_0)}{K_p'(r_0)} = -\,\beta^{2p}; \quad \frac{J_0'(r_0)}{K_1(r_0)} = -\,\beta^2; \quad D_0 = 0; \quad D_p = 0;$$

$$Q_p(r_0) = -\,\frac{p-1}{p!}\,\beta^{-p}; \qquad E_2 = 2\beta^2; \qquad E_p = p\,(p-1)\,\beta^{2p-2}$$

7. Consideration of the Magnetic Field.—Let us further put $r_0/r = \rho_0/\rho = m$, then the expressions for the field become

$$\frac{X}{\epsilon^{j\omega t}} = 2\sin\phi\,.\,\epsilon^{j\alpha x\cos\phi}\left\{\beta^2 \log_\epsilon \frac{2\gamma}{r} - \frac{1}{2}\beta^2m^2\cos 2\theta + j[-\beta m \sin\theta]\right\}$$

$$\frac{N}{\epsilon^{j\omega t}} = \cos\phi\,.\,\epsilon^{j\alpha x\cos\phi}\left\{-\,m^2\sin\theta + j[-\beta m + \beta m^3\cos 2\theta]\right\}$$

$$\frac{T}{\epsilon^{j\omega t}} = \cos\phi\,.\,\epsilon^{j\alpha x\cos\phi}\left\{m^2\cos\theta + j[\beta m^3 \sin 2\theta]\right\}$$

Calculating the Y component, $Y = N \sin\theta + T\cos\theta$, of the magnetic field in the plane $y\,z$.

$$Y = \epsilon^{j\omega t} \,.\, \cos\phi\, \{m^2 \cos 2\theta + j[-\beta m \sin\theta + \beta m^3 \sin 3\theta]\} \quad . \quad . \quad (11)$$

Further to study the magnetic field we will neglect the terms in X which involve β^2 so that we can compare this field with others which contain terms independent of β; we then have in the plane $y\,z$

$$X = \epsilon^{j\omega t} \,.\, 2\sin\phi\, \{ j\,[-\beta m \sin\theta]\} \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

It is interesting to compare the X and Y components of the field due to the ship with that of the wave, which at the point R in the plane $y\,z$ has by equation (7) the value

$$H' = \epsilon^{j\omega t} \,.\, \epsilon^{j\alpha y \sin\phi} = \epsilon^{j\omega t} \,.\, \epsilon^{jr\sin\theta}$$

which may be written

$$H' = \epsilon^{j\omega t}(1 + jr\sin\theta)$$

If we evaluate the ratios X/H' and Y/H' the real parts will represent the ratio of the parts of the fields X and Y in phase with H' and the imaginary parts the ratios of the parts of X and Y in quadrature with H'. Writing these ratios as $(X_1 + jX_2)$, $(Y_1 + jY_2)$, and noting that $1/H' = \epsilon^{j\omega t}(1 - jr\sin\theta)$, we have

$$X_1 + jX_2 = j\,[-2\beta m \sin\theta \sin\phi]$$
$$Y_1 + jY_2 = \{m^2\cos 2\theta + j\,[\beta m\,(1 - m^2)\sin 3\theta]\}\cos\phi$$

Finally at a point exterior to the cylinder defined by the co-ordinates ρ and θ, the disturbing magnetic field has the following components in relation to the wave field at this point

Components in phase with the wave field $\left\{\begin{aligned} X_1 &= 0 \\ Y_1 &= (\rho_0/\rho)^2 \cos 2\theta \,.\, \cos\phi \end{aligned}\right\}$ . . (13)

Components in quadrature with the wave field. $\left\{\begin{aligned} X_2 &= \frac{\pi\rho_0}{\lambda}\left(\frac{\rho_0}{\rho}\right)\sin\theta\sin^2\phi \\ Y_2 &= \frac{\pi\rho_0}{\lambda}\left(\frac{\rho_0}{\rho}\right)\left[1 - \left(\frac{\rho_0}{\rho}\right)^2\right]\sin 3\theta \sin 2\phi \end{aligned}\right\}$ . . (14)

It may be noted that the field in quadrature vanishes if the point R is in

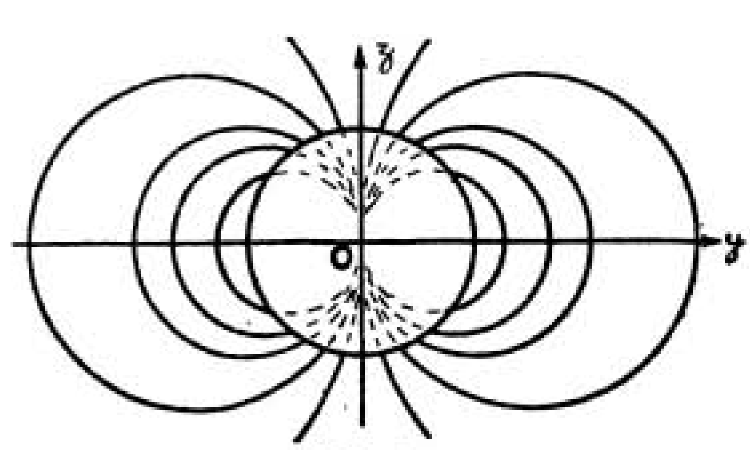

Fig. 4.

the vertical plane passing through the axis. Further that its component Y_2 is very small compared with X_2 in the neighbourhood of the cylinder.

8. Consideration of the Electric Field.—Substituting the values given by equation (11) in equation (2), we get for a point situated in the plane $y\,z$,

$$\left.\begin{aligned} \chi &= 0 \\ \nu &= \epsilon^{j\omega t}\left\{\begin{aligned}&-\left(\frac{\rho_0}{\rho}\right)^2\cos\theta \\ &+j\left[-\frac{\pi\rho_0}{\lambda}\left(\frac{\rho_0}{\rho}\right)^3\sin 2\theta\sin\phi\right]\end{aligned}\right\} \\ \tau &= \epsilon^{j\omega t}\left\{\begin{aligned}&-\left(\frac{\rho_0}{\rho}\right)^2\sin\theta \\ &+j\left[-\frac{\pi\rho_0}{\lambda}\left(\frac{\rho_0}{\rho}\right)\left\{1-\left(\frac{\rho_0}{\rho}\right)^2\right\}\cos 2\theta\sin\phi\right]\end{aligned}\right\}\end{aligned}\right\} \quad . \quad . \quad (15)$$

whence

$$\eta = \epsilon^{j\omega t}\left\{\begin{aligned}&-\left(\frac{\rho_0}{\rho}\right)^2\sin 2\theta \\ &+j\left[-\frac{\pi\rho_0}{\lambda}\left(\frac{\rho_0}{\rho}\right)\cos\theta\sin\phi+\frac{\pi\rho_0}{\lambda}\left(\frac{\rho_0}{\rho}\right)^3\cos 3\theta\sin\phi\right]\end{aligned}\right\}$$

$$\zeta = \epsilon^{j\omega t}\left\{\begin{aligned}&-\left(\frac{\rho_0}{\rho}\right)^2\cos 2\theta \\ &+j\left[\frac{\pi\rho_0}{\lambda}\left(\frac{\rho_0}{\rho}\right)\left\{\sin\theta-\left(\frac{\rho_0}{\rho}\right)^2\sin 3\theta\right\}\sin\phi\right]\end{aligned}\right\}$$

The real part of this field ν_1, τ_2, represents the part in phase with the electric field of the wave along the axis Oz.

From the expressions

$$\nu_1 = -\epsilon^{j\omega t}\left(\frac{\rho_0}{\rho}\right)^2\cos\theta$$
$$\tau_1 = -\epsilon^{j\omega t}\left(\frac{\rho_0}{\rho}\right)^2\sin\theta$$

for the field in phase with the wave field at O we can easily show that the lines of force of this field are circles, tangent to Oz at O (Fig. 4).

The field in quadrature is very small in comparison with the above and is not of interest for the problem in hand.

The electric field of the wave is given by the third equation of (1). We find for a point in the plane $y\,z$

$$\zeta' = -\epsilon^{j\omega t}\,.\,\epsilon^{j\alpha y\sin\phi}$$

or

$$\zeta' = -\epsilon^{j\omega t}\,(1+j\alpha y\sin\phi)$$

Comparing the principal components of the fields due to this wave and to the cylinder we arrive at the following conclusions:—

(*a*) In the neighbourhood of the vertical plane through the axis of the cylinder, the field due to the cylinder is in the same direction as that due to the wave. They therefore add together arithmetically.

(*b*) At the surface itself the field due to the cylinder is equal to that due to the wave, so that the total field is double that which would be present without the cylinder.

(*c*) The field due to the cylinder is inversely proportional to the square of the distance from the axis.

(*d*) These properties of the electric field are independent of the direction of the wave.

(*To be concluded.*)

The Efficiency of Aerials.

By THE EDITOR.

Of the total power supplied to the aerial of a transmitting station a portion is dissipated in the resistance of the wires constituting the aerial, tuning coils, secondary winding of the oscillation transformer, and earth or counterpoise wires, a portion is dissipated in imperfect dielectrics situated in the electric field, such as wooden masts, buildings, soil, etc. and a portion is radiated. If R be the total effective resistance of the aerial and I the root-mean-square current, we may write

$$I^2R = I^2(R_w + R_d + R_r)$$

where the suffixes w, d, and r refer to wires, dielectrics and radiation, respectively. Of the three terms the first can be calculated with considerable accuracy and can be kept small by suitable design, the third can also be calculated with some degree of confidence, but it is very difficult to form even a rough estimate of the second term.

The power radiated from an antenna of height h at a wavelength λ is equal to $1584(h/\lambda)^2I^2$ watts on the assumptions that the upper capacity is so large that the current has the same value at every point of the vertical wire and that the height is small compared with the wavelength. The latter assumption is usually justified, and any doubt as to the former is removed by taking h to be the effective height, which is less than the actual height by an amount which can be calculated approximately in many cases. The radiation resistance R is therefore equal to $1584(h/\lambda)^2$ and is inversely proportional to the square of the wavelength. With regard to the dielectric losses it is known that the power-factor of a condenser, *i.e.*, the ratio of the power dissipated to the product of current and voltage is approximately independent of the frequency. Hence I^2R_d bears a fixed ratio to IV where V is the voltage to which the aerial is charged, or, since $I = \omega VC$ and $IV = I^2/(\omega C)$, R_d must bear a fixed ratio to $1/(\omega C)$ and ωCR_d must be constant. R_d is therefore inversely proportional to the frequency or directly proportional to the wavelength. Now not only can R_w be made small but it is less dependent on the frequency than either R_r or R_d. If the wavelength is increased by inserting additional turns in the inductance, the conductor resistance would thereby tend to increase, but this would be counteracted to some extent, if not entirely, by reduced skin-effect. As an approximation R_w may therefore be regarded as constant, and the equation $R = R_w + R_d + R_r$ may be written

$$R = a + b\lambda + \frac{c}{\lambda^2}$$

where a, b, and c are constants.

$$\frac{dR}{d\lambda} = b - \frac{2c}{\lambda^3}$$

If R be plotted against λ, the slope of the curve will therefore be negative for values of λ less than $\sqrt[3]{(2c/b)}$, but positive for higher values of λ. The total effective resistance is a minimum for that value of λ which is equal to $\sqrt[3]{(2c/b)}$. Calling this value of the wavelength λ_m, we have

$$\lambda_m = \sqrt[3]{\frac{2c}{b}}$$

and for the value of the total effective resistance at this wavelength we have

$$\begin{aligned} R_m &= a + b\lambda_m + \frac{c}{{\lambda_m}^2} \\ &= a + \frac{2c}{{\lambda_m}^3} \cdot \lambda_m + \frac{c}{{\lambda_m}^2} \\ &= a + \frac{3c}{{\lambda_m}^2} = a + 3R_{rm} \end{aligned}$$

where R_{rm} is the radiation resistance at the wavelength λ_m.

The total resistance is a minimum for that wavelength at which the dielectric losses are twice the radiated power. From the observed values of R at three different wavelengths it should be possible to calculate the three constants a, b, and c, and thus determine the three component resistances, but the measurements would have to be made with special care to give accurate values. If it be assumed that R_w is negligibly small, then at the wavelength λ_m, the radiation resistance is a third of the measured total resistance, and therefore

$$\frac{R_m}{3} = 1584 \frac{h^2}{{\lambda_m}^2}$$

from which the effective height can be calculated.

In the *Bulletin of the Bureau of Standards** L. W. Austin has given curves showing the measured effective resistances of a number of aerials at various

* *Bulletin of the Bureau of Standards*, 9, pp. 65—72, 1913.

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frequencies. Although the data given are rather scanty, we have applied the above formula to each case with the results shown in the following table:—

Aerial.	Length. Metres.	Capacity 10^{-9} farads.	Height. Metres.	λ_m	R_m	Effective Height.
Bureau of Standards, harp .	42·6	1·26	54·8	700	11·5	34·3
Signal Corps, flat top . .	44·5	1·71	39·6	1,300	6·7	48·5
Capitol, flat top . . .	85	2·32	44·2	1,000	7·0	38·0
Navy Yard, harp . . .	51·8	0·73	54·8	900	5·0	29·4
U.S.S. *Maine*, flat top . .	32·9	1·25	38·4	800	2·25	17·4
U.S.S. *Massachusetts*, flat top .	24·4	1·10	39	1,000	2·75	24·1
Arlington, sloping top . .	—	9·4	137 to 183	7,000	1·1	107

The last column gives the effective heights calculated in this way on the assumption that the wire resistance R_w is negligible; it is certainly not negligible but in the absence of further data it can only be said that the actual values of the effective heights must be less than these calculated values, and in some cases probably very much less. It has been stated that the Arlington antenna has an effective height of 137 metres, but how this was determined we do not know; the above calculation indicates a much smaller value. It should be pointed out that this aerial is supported by three steel towers in which currents will flow in opposition to that in the vertical portion of the aerial, thus reducing the radiated power for a given aerial current and lowering therefore the effective height. Insulating the feet of the towers instead of connecting them to the earthing system may reduce these currents to some extent, at the expense, however, of additional dielectric losses in the neighbourhood of the feet of the towers. The aerial together with the towers form a system of partially closed loops, and the losses in the towers should be included in I^2R_w.

The San Paolo aerial at Rome is supported by three wooden lattice towers 218 metres high; it is stated* that it has a minimum resistance of 3·25 ohms at a wavelength of 7,000 metres. Reception tests on a calibrated frame aerial indicate an effective height of 138 metres. Neglecting R_w the above formula gives an effective height of 183 metres; to obtain 138 metres, one must assume the conductor resistance R_w to be 1·4 ohms. This is an improbably high value of R_w and tends to confirm the doubt expressed in the paper referred to as to the accuracy of the measured resistances with undamped waves. Fig. 1 shows the measured effective resistance of the San Paolo aerial at various wavelengths. The curve is plotted from values calculated from the formula $R = 0{\cdot}5 + 0{\cdot}26\lambda + 54{\cdot}3/\lambda^2$. This formula gives the minimum resistance at a wavelength of 7·5 kilometres.

* *Proceedings of the Institute of Radio Engineers*, 8, p. 142, April, 1920. Radio Review Abstract No. 538, July, 1920.

It is evidently desirable that very accurate measurements should be made of the total effective resistance at various wavelengths of different types of aerials making allowance for the high-frequency resistance of the aerial, tuning coils, and earth wires, or counterpoise. By making such measurements on aerials with steel masts and wooden masts, with earthing wires and insulated counterpoises, much valuable information would be gained as to

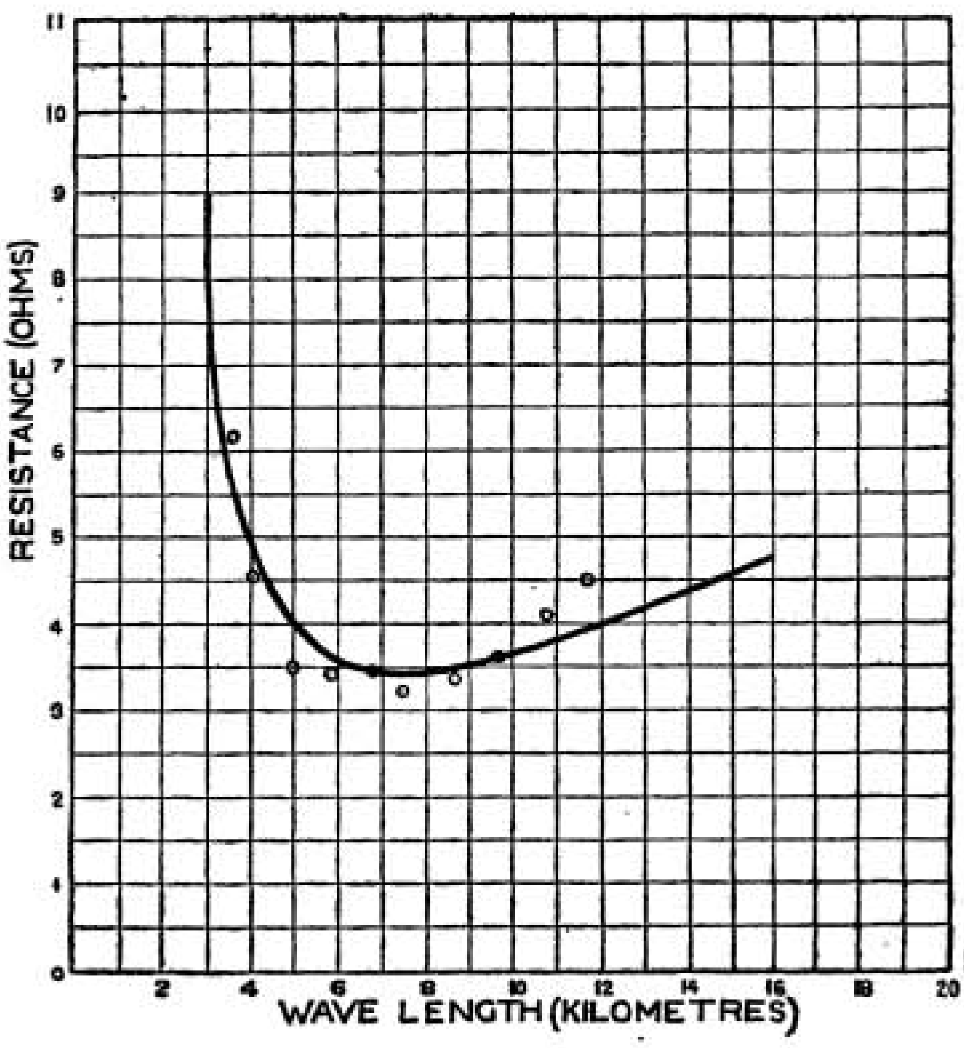

FIG. 1.—SAN PAOLO (ROME) AERIAL.
The points marked are measured values. The curve is plotted from the equation $R = 0{\cdot}5 + 0{\cdot}26\lambda + 54{\cdot}3/\lambda^2$.

the magnitude of the losses and as to the use or misuse of every kilowatt generated. With the limitations at present imposed by the stage of development reached in the construction of large thermionic valves, the last-named consideration is one of the greatest importance.

The Report of the Imperial Wireless Telegraphy Committee, 1919-1920.

The committee which was appointed on November 24th, 1919, by the Secretary of State for the Colonies, "to prepare a complete scheme of Imperial wireless communications in the light of modern wireless science and

Imperial needs" published its report at the end of June. The report covers twenty-eight pages and can be obtained from His Majesty's Stationery Office for sixpence. We propose here to do no more than review its main features.

As the result of continuous watches kept by the Post Office on the work of the chief European long range wireless stations, the committee came to the conclusion that the services do not reach a satisfactory commercial standard and they state that they are of opinion that no satisfactory commercial wireless service, as they define the expression, is in operation anywhere to-day over a distance exceeding 2,000 miles. For distances over 2,000 miles the power required increases as the sixth power of the distance. The power considered necessary for the transatlantic service has gradually grown from 25 kW., with which Mr. Marconi attempted it in 1901 to 1,000 kW. which is the power of the Poulsen arc being installed at Bordeaux and this in spite of the vastly increased sensitiveness of the receiving apparatus. The committee therefore recommend that the links in the Imperial chain be not greater than 2,000 miles each. With the exception of the Poulsen arcs at present being constructed for the Oxford-Cairo service, the committee recommend the use of thermionic valve generators for all the transmitting stations. The merits and demerits of the various systems are discussed and the reasons set out for the policy recommended. At the request of the Imperial Communications Committee, the proposal put forward by the Marconi Company was considered and is discussed in the report. The committee decided against it on various grounds, but mainly on the ground that the scheme is so ambitious and costly that the possibility of its financial success is very remote. They report that from the point of view of wireless technics the Marconi Company's proposal is much too vague to allow of useful comment.

The committee recommends that the former German station at Windhuk, which is connected with Cape Town by land lines, be fitted up at once as a valve transmitting station to communicate with Cairo *viâ* a new station to be erected at Nairobi.

To carry out their suggestions the committee recommends the appointment of a Wireless Commission of about four members to plan the stations, the construction of which would be carried out by the engineering departments of the Post Office. The committee consider that the complete chain of eight or ten stations could be completed within two years of the issue of plans and specifications. They recommend that long distance wireless traffic with foreign countries be left to commercial companies. "Both services would profit by this healthy competition."

G. W. O. H.

The Development of Thermionic Valves for Naval Uses.*

By B. S. GOSSLING.

During the period of the war the thermionic valve passed through all the various stages of transition from an instrument whose operation was erratic and theory obscure to a product

* Abstract of paper read before the Wireless Section of the Institution of Electrical Engineers on June 23rd, 1920.

as reliable and as standardised in manufacture as the incandescent lamp. The first four sections of this paper trace out the course of this transition as exemplified by the development of valves of various kinds by the wireless telegraphy department of H.M.S. *Vernon*, and later by H.M. Signal School, Portsmouth. They describe the introduction of valves into naval wireless telegraph installations and the early experimental and theoretical work in the elucidation of their observed behaviour. In the first place the valves were employed for the generation of low power oscillations for heterodyne reception. De Forest's ultraudion arrangement was first employed. The original audions were subsequently replaced by R.2, Q or R.4 valves as these were developed.

One of the first things observed in the study of well exhausted valves was that the anode and grid voltages are in a sense interchangeable and that in any formulæ they may always be associated together in an expression of the form $(e/m + e')$, where e is the anode voltage and e' the grid voltage. A formula was developed by Sir J. J. Thomson for the calculation of the valve constant m for the case of a cylindrical anode and a grid of parallel wires inside it:—

$$m = \frac{\pi N d' \log (d/d')}{\log [1/(\pi N d_g)]}$$

where d and d' are the anode and grid diameters respectively, and d_g is the diameter of the grid wires which are spaced out N per centimetre round the circumference of the grid cylinder or as successive turns of a helix. In the French and many other later valves of cylindrical form the observed and calculated values of m agree to within about 10 per cent.

The fifth section of the paper treats with the design and development of power valves. For this purpose the following equation was taken as the basis of the design,

$$I = 2{\cdot}92 \times 10^{-5} \frac{l_f}{\beta^2 d'} \left\{ \frac{e/m + e'}{1 + 1/m} \right\}^{\frac{3}{2}}$$

where l_f is the length of the filament system measured along the axis of the concentric electrode cylinders. The values of the anode-current—grid-voltage slope k_1 and of the anode-current slope k_2 are then given by

$$k_1 = \frac{3}{2} \frac{I}{e/m + e'}; \qquad k_2 = k_1/m.$$

The design of the valve filaments was carried out by using the curves worked out by G. Stead.* As regards the heating of the anode it is stated in the paper that a radiation loss of about six watts per square centimetre may be allowed to keep within the limiting temperature for nickel. Numerical examples are given in the paper of the method of calculation, and also scale diagrams of two of the patterns of valve designed in that way and manufactured at the Osram-Robertson Lamp Works. Sections 6, 7 and 8 deal with the investigation and improvement of small valves for use in reception including both high-vacuum and gas-filled types. Successive stages of approximation in the calculation of characteristics of small valves with low operating voltages are illustrated in section 9, which includes a consideration of the effect of the temperature gradient near the ends of the filament. The final result of the calculation indicates the degree of closeness in which the observed behaviour of a high-vacuum valve can be accounted for in terms of known physical phenomena. The concluding section deals with the standardisation of valves and with their specification for quantity production, and refers to the various electrical tests that were applied to valves in order to secure a reasonable degree of uniformity.

As regards the gas-filled valves a number of experiments are referred to with different gases and at different pressures. In the case of the nitrogen-filled valves it was found that the gas gradually disappeared during the running of the valves. More satisfactory results were obtained with helium. In addition this gas does not cause disintegration of the filament as in the case of argon. For a given pressure a helium valve is much harder than a nitrogen valve, and for the same characteristics the pressure of helium required is about ten times the corresponding pressure of nitrogen. The best results were obtained with these valves by exhausting them as if they were to have a permanent high vacuum and then admitting the helium gas. By this process valves were obtained which were as constant throughout their life as the majority of high-vacuum valves.

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* See RADIO REVIEW Abstract No. 635.

Review of Radio Literature.

1. Articles and Patents.

580. ON UNDAMPED OSCILLATING SYSTEMS, AND IN PARTICULAR ON OSCILLATIONS SUSTAINED BY SELF-EXCITATION. A. Blondel. (*Journal de Physique*, 9, pp. 117—151, April, 1919, and pp. 153—162, May, 1919. *Science Abstracts*, 23A, p. 289, Abstract No. 742, May, 1920—Abstract.)

The author considers undamped oscillations under three headings :—(1) Self-sustained oscillations ; (2) Oscillations consisting of a large number of partial discharges each generating a chain of damped oscillations ; and (3) Oscillations produced by inversion of the driving force (series-wound dynamo and separately-excited motor). The present article deals only with the first class of oscillations and discusses these mathematically by the application of the Hurwitz method.* A number of polar diagrams are given illustrating the conditions existing in the case of Duddell and hissing arcs and oscillations sustained by triode valves.

581. VARIABLY COUPLED VIBRATIONS : GRAVITY-ELASTIC COMBINATIONS. MASSES AND PERIOD EQUAL. L. C. Jackson. (*Philosophical Magazine*, 39, pp. 294—304, March, 1920.)

This paper gives the mathematical theory of a coupled mechanical system which can be used as an analogy to the electrical case of circuits of equal inductance and frequency. The paper is illustrated with a number of curves of the oscillations of the system.

582. THE HIGH-FREQUENCY RESISTANCE OF WIRES AND COILS. G. W. O. Howe. (*Journal of the Institution of Electrical Engineers*, 58, pp. 152—170, February, 1920. *Electrical Review*, 86, pp. 25—26, January 2nd, 1920—Abstract. *Revue Générale de l'Électricité*, 7, pp. 791—794, June 12th, 1920. *Telegraphen- und Fernsprech-Technik*, 8, pp. 33—34, May, 1920—Abstract.)

See RADIO REVIEW, 1, pp. 225—234, February, 1920, for abstract. Professor Howe's full reply to the discussion is included with the original paper in the *Journal of the I.E.E.*

583. HIGH-FREQUENCY MAGNETISATION. H. Fassbender. (*Science Abstracts*, 23A, p. 54, Abstract No. 157, January 30th, 1920—Abstract.)

See RADIO REVIEW Abstract No. 96, January, 1920.

584. A COMPARISON OF COILS AND AERIALS FOR RECEPTION. M. Abraham. (*Electrical World*, 75, p. 687, March 20th, 1920—Abstract.)

See RADIO REVIEW Abstract No. 72, December, 1919.

585. SOLID *v.* STRANDED WIRE FOR HIGH FREQUENCIES. W. Rogowski. (*Electrical World*, 75, p. 909, April 17th, 1920—Abstract.)

See RADIO REVIEW Abstract No. 273, April, 1920.

586. A BEAT METHOD OF TESTING THE SLUGGISHNESS OF CONTACT DETECTORS. R. Ettenreich. (*Physikalische Zeitschrift*, 21, pp. 208—214, April 15th, 1920.)

The detector tested consisted of a fine nickelin wire in light contact with a crystal of galena. A circuit containing the detector was inductively coupled to two oscillating triodes. A wavemeter brought near the detector circuit indicated the two frequencies of these triodes and also the frequency of the beats. By working at wavelengths of 30 metres, the frequency of the beats was raised to five million cycles per second. The fact that these beats were

* See also RADIO REVIEW Abstract No. 419, June, 1920.

indicated on the wavemeter without any diminution proves that the detector showed no sign of sluggishness. If the detector action is due to thermal effects, the heating and cooling must occur with this frequency—a highly improbable assumption.

587. STANDARDS OF HIGH FREQUENCY. A. Campbell. (*Electrician*, 84, p. 66, January 16th, 1920. *Science Abstracts*, 23A, pp. 164—165, Abstract No. 436, March 31st, 1920—Abstract.)

A method previously described by A. Dey, by which the oscillations of a pendulum can be maintained by an alternating current of very much higher frequency, is referred to, and it is suggested that the method might be applicable to the standardisation of radio frequencies. For instance a tuning fork of natural frequency, say 5,000, might be maintained by means of an alternating current of 50,000 or even 500,000 ∼.

588. MEASURING THE NATURAL WAVELENGTH OF AN ANTENNA. H. W. Houck. (*Everyday Engineering Magazine*, 8, pp. 318—319, February, 1920.)

The method described is very similar to an arrangement used in the French Radio Laboratories during the war. To carry out the test a small inductance is joined in series with the aerial and oscillations excited by joining a buzzer and cell in parallel with this inductance. The wavemeter is loosely coupled to the inductance and the wavelength measured for various numbers of turns in the circuit. By plotting the wavelength against the number of turns a straight line is obtained and from its intercept on the wavelength ordinate scale the fundamental of the aerial may be obtained. It is mentioned that a suitable coil for such measurements is wound with twenty-four turns of No. 12 B. & S. gauge* copper wire on a former 3 in. diameter by 3 in. long.

589. HIGH VOLTAGE, HIGH FREQUENCY APPARATUS AND ITS APPLICATIONS. F. P. Vaughan. (*Journal of the Engineering Institute of Canada*, October, 1919. *Technical Review*, 5, p. 180, November 25th, 1919.)

Various methods of generating high frequency currents are described, and a wiring diagram is also given of apparatus for experimental researches with these currents.

590. THE TELEPHONE RECEIVER: ITS MECHANICAL ACOUSTIC CHARACTERISTICS. W. Hahnemann and H. Hecht. (*Elektrotechnische Zeitschrift*, 41, p. 378, May 13th, 1920—Abstract.)

See RADIO REVIEW, 1, Abstract No. 405, June, 1920. The theory of the vibrating membrane is developed by replacing the mechanical quantities by their electrical equivalents. They find the efficiency of a receiver between 500 and 1,000 cycles per second to be from 0·1 to 1 per cent.

591. SOME APPLICATIONS OF TRIODES TO HIGH-FREQUENCY MEASUREMENTS. G. Leithauser. (*Verhandlungen der deutschen Physikalischen Gesellschaft*, 1, Series 3, pp. 23—28, March 31st, 1920.)

A communication from the Telegraphen-Versuchsamt describing (1) the use of a triode as a dynatron to maintain oscillations in a wavemeter, (2) the use of an oscillating triode to determine the natural frequency of a circuit with which it is loosely coupled, (3) the measurement of signal strength by an amplifier operating a galvanometer through a barretter bridge, (4) the measurement of small capacities by beats between two oscillating triodes; the unknown capacity being added to the capacity of one of the triode circuits.

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* Approximately the same as No. 14 S.W.G.

592. The Shortest Waves produced with Vacuum Tubes. H. Barkhausen and K. Kurz. (*Physikalische Zeitschrift*, 21, pp. 1—6, January 1st, 1920.)

See editorial article in Radio Review, 1, p. 435, June, 1920.

593. The Comparison of Inductances and Capacities by an Electrometer Method. A. W. Smith. (*Science Abstracts*, 23A, p. 53, Abstract No. 154, January 30th, 1920—Abstract.)

See Radio Review Abstract No. 104, January, 1920.

594. On some Experiments in which Two Neighbouring Maintained Oscillatory Circuits effect a Resonant Circuit. J. H. Vincent. (*Proceedings of the Physical Society of London*, 32, pp. 84—91, February 15th, 1920. *Science Abstracts*, 23A, p. 240, Abstract No. 612, April, 1920—Abstract.)

See Radio Review, 1, pp. 285—287, March, 1920, for abstract.

595. Spark Gap for Impulse Excitation. C. Lorenz. (*German Patent* 299098, March 22nd, 1917. Patent published, October 7th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, p. 245, March, 1920—Abstract.)

An arrangement of plate electrodes between which the *optimum* amount of ionisation can be maintained. The ionisation may be produced either by heating the electrodes or by allowing ultra-violet light, Röntgen or Becquerel rays to impinge on the plates.

596. Rotary Discharger. W. D. Owen. (*Radiograph*, 1, pp. 185—187, June, 1920.)

A brief *resumé* of the advantages of the rotary spark gap over the fixed spark gap, and of the method of adjusting the same to obtain a steady discharge.

597. A Quenched Spark Gap. (*Wireless Age*, 7, p. 12, November, 1919.)

In the spark gap described the spark takes place between two concentric annular rings of metal so that its length remains constant and independent of variations of thickness of the insulating washers.

598. Methods of Signalling with Arc Transmitters. H. L. d'E. Skipworth, H. A. Madge and H. Morris-Airey. (*British Patent* 142141, September 27th, 1916. Patent accepted, May 31st, 1917. Published May 27th, 1920.)

For the purposes of signalling with an arc radio transmitter it is proposed to connect two independent oscillatory circuits permanently across the arc, one of them being the aerial circuit and the other a closed circuit tuned to the same frequency. Signalling is effected by connecting a resistance in parallel with a part of the inductance in one or other of the circuits so as to control the expenditure of energy in those circuits. For the radiation of interrupted C.W. signals it is suggested that a commutator contact may be connected in place of the signalling key. A construction for the signalling key is given in which the contacts are enclosed in a hermetically sealed vessel which may be supplied with compressed or other gas to reduce the sparking of the contacts. The moving contact is controlled from outside by means of a solenoidal spring, the frame carrying the moving contact being attached to a flexible diaphragm.

599. THE POULSEN ARC IN WIRELESS TELEGRAPHY. (*Electrical Review*, 86, pp. 423—426, April 2nd, 1920. *Science Abstracts*, 23B, p. 278, Abstract No. 548, May 31st, 1920—Abstract.)

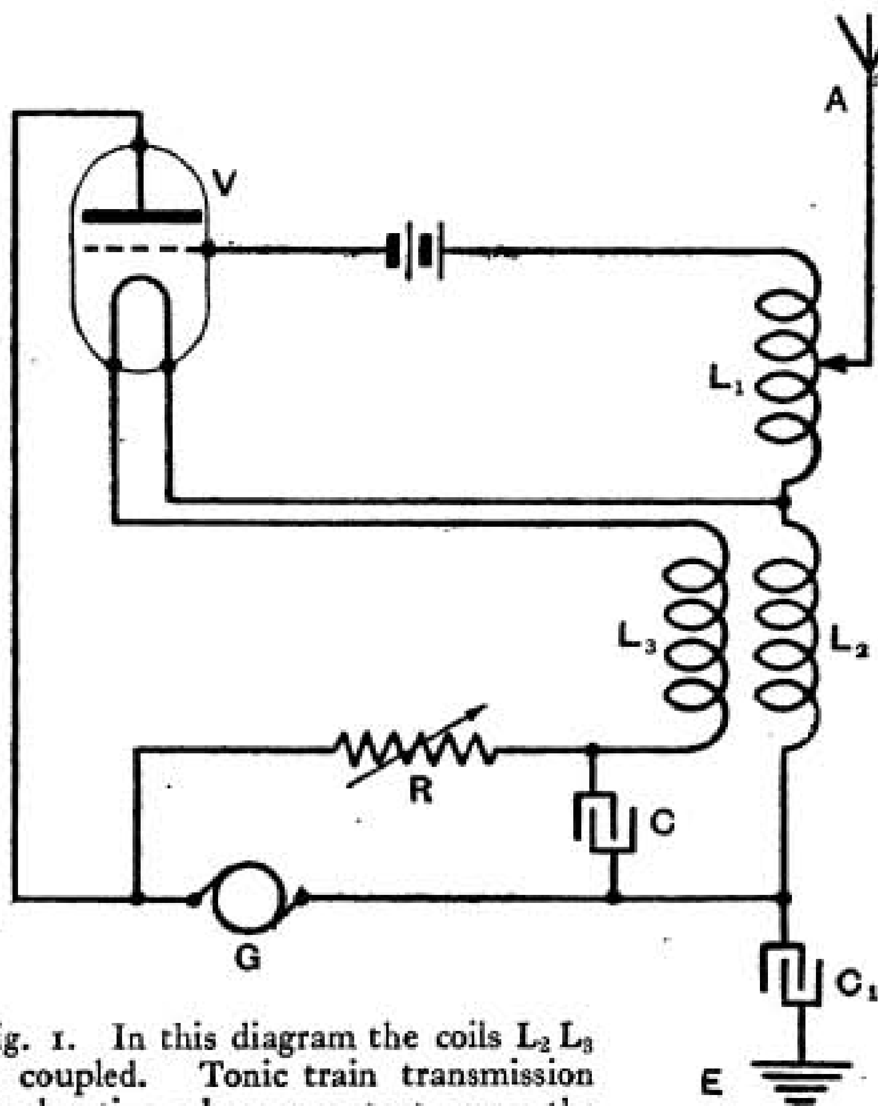
This article briefly summarises without much technical detail the equipment used in various high-power arc wireless stations. It is illustrated with a number of photographs of the apparatus.

600. HOW TO BUILD ARC GENERATORS. H. W. Secor. (*Radio Amateur News*, 1, pp. 352—354, January, 1920.)

Constructional details are given of a ½ kW. water cooled enclosed arc set.

601. THE EFFECT OF DIRECT CONNECTION OF PLATE CIRCUITS WITH THE ANTENNA. (*Wireless Age*, 7, pp. 23—24, November, 1919. *Science Abstracts*, 23B, p. 170, Abstract No. 342, March, 1920—Abstract.)

The arrangement described is attributed to W. C. White. It is designed with a view to overcoming the disadvantage that when using direct coupling of the valve generator with the aerial, the filament batteries are not at earth potential. The recommended circuit diagram



is indicated in Fig. 1. In this diagram the coils L_2 L_3 are very closely coupled. Tonic train transmission may be effected by shunting a buzzer contact across the coil L_3.

FIG. 1.

602. TRANSMITTING AND RECEIVING APPARATUS. L. de Forest. (*French Patent* 499661, May 25th, 1918. Published February 18th, 1920.)

This specification describes a system of radio signalling. For further particulars, see British Patent 131361.*

* RADIO REVIEW Abstract No. 121, January, 1920.

603. APPARATUS FOR GENERATING HIGH-FREQUENCY OSCILLATIONS. F. Huth and S. Loewe. (*German Patent* 316793, November 14th, 1917. Patent published, October 7th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, pp. 79—80, January, 1920—Abstract.)

A valve circuit for the generation of oscillations in which the heating current for the filament is derived from the oscillatory current circuit.

604. A METHOD OF USING TWO TRIODE VALVES IN PARALLEL FOR GENERATING OSCILLATIONS. W. H. Eccles and F. W. Jordan. (*Revue Générale de l'Électricité*, 7, p. 24, January 3rd, 1920.)

See RADIO REVIEW, 1, pp. 80—83, November, 1919, for Abstract.

605. HIGH-FREQUENCY INDUCTOR ALTERNATORS. K. Schmidt; M. Osnos. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, pp. 154—158, February, 1920.)

A discussion on nomenclature and patent priority arising from a paper by Osnos on this subject.*

606. RADIO-FREQUENCY ALTERNATORS. W. Dornig. (*Elektrotechnische Zeitschrift*, 41, p. 420, May 27th, 1920.)

A criticism of a paper by Latour in the *Wireless World* of July, 1919.† Dornig regards machines for 30,000 cycles as "Wunderwerke der Technik," but considers it more practical and reliable to use machines for about 6,000 cycles with frequency transformers as at Nauen.

607. INSULATION OF ELECTRICAL MACHINES. C. Lorenz. (*German Patent* 298890, November 10th, 1916. Patent published, September 29th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, p. 499, June, 1920—Abstract.)

A circuit for reducing the insulation necessary in electric machines, particularly high-frequency machines, in which the winding of the machine is divided and led to the primary winding of a transformer, the secondary of which is coupled to the antenna circuit.

608. STABILISING THE ENERGY OUTPUT OF TRANSMITTERS. (*Wireless Age*, 7, p. 20, November, 1919.)

The arrangement described, due to G. Reuthe, consists of a medium frequency alternator used in conjunction with three frequency multipliers. More stable results are claimed to be secured by de-tuning the intermediate circuits between the multipliers to a frequency higher than that corresponding to resonance.

609. TELEPHONE RECEIVERS FOR WIRELESS TELEGRAPHY AND TELEPHONY. (*Technical Review*, 6, p. 79, January 20th, 1920.)

It is announced that the Bureau of Standards, Washington, is conducting a comprehensive study of telephone receivers for radio work. It is probable that much other useful information will also be obtained as regards methods of measuring the strength of wireless signals.

610. TELEPHONE REPEATERS. B. Gherardi and F. B. Jewett. (*Electrician*, 84, pp. 517—519, 543—544, 571—575, 618—620, May 7th, 14th, 21st, and June 4th, 1920—Abstract. *Science Abstracts*, 23B, pp. 172—174, Abstract No. 348, March, 1920—Abstract.)

See RADIO REVIEW Abstract No. 228, March, 1920.

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* *Jahrbuch der drahtlosen Telegraphie*, 13, p. 270, November, 1918. Abstracted in *Wireless World*, 7, pp. 15—18, April, 1919.

† See also RADIO REVIEW, 1, p. 491, July, 1920.

611. WIRELESS TELEPHONE TRANSMITTERS. L. B. Turner and R. H. Wagner. (*British Patent* 137098, December 24th, 1918. Patent accepted, January 8th, 1920.)

The transmitter described comprises a relatively feeble valve oscillator V_2 in which the amplitude of oscillation is controlled by the voice, and a valve amplifier V_3 serving to amplify

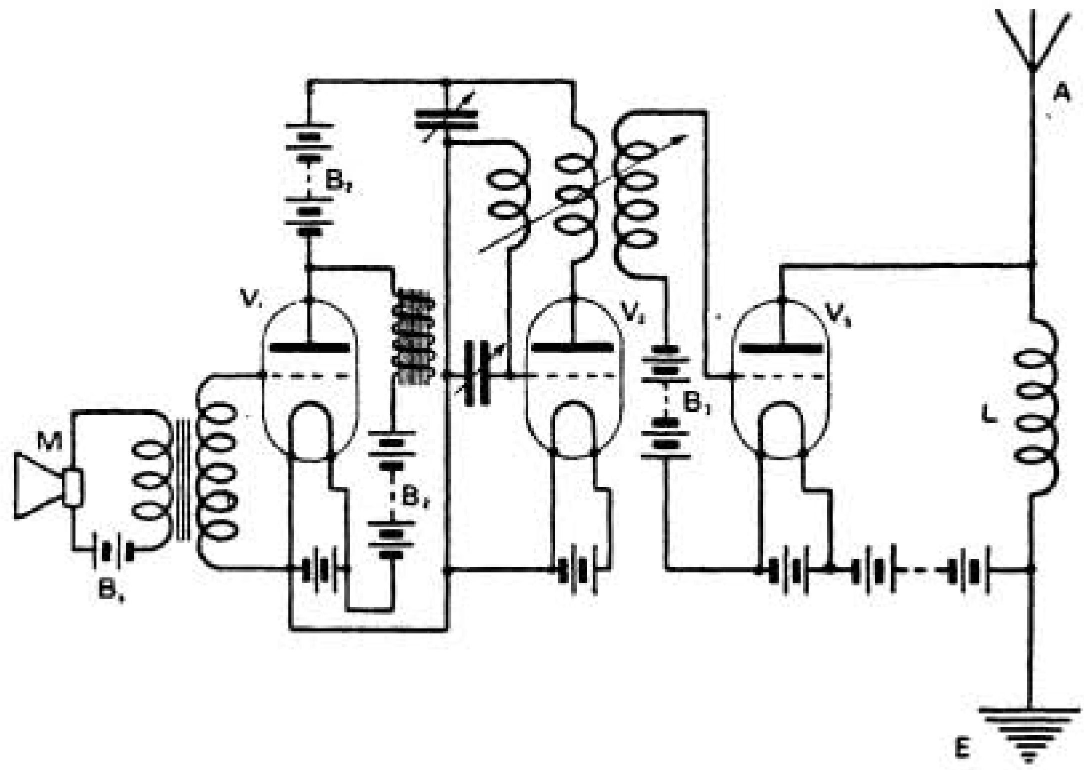

FIG. 2.

the voice controlled oscillations. The oscillations of V_2 may be modulated by the oscillation valve V_1 in the manner indicated using the "choke-control" method, or alternatively the microphone or the control valve may vary the grid potential of the oscillating valve. The voltage of B_3 is adjusted so that the grid potential of V_3 never becomes positive during transmission.

612. MICROPHONE CIRCUIT FOR LINE OR WIRELESS TELEGRAPHY. Allgemeine Elektrizitäts-Gesellschaft. (*German Patent* 300171, January 23rd, 1917. Patent published, September 24th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, pp. 161—163, February, 1920—Abstract.)

A modulation circuit for telephony in which the microphone M forms one arm of a Wheatstone bridge. With such an arrangement the ratio of the steady current to the telephone current through the modulating coil is independent of the ratio of the steady current to the telephonic current through the microphone itself. Fig. 3 shows a scheme of connections for wireless telephony.

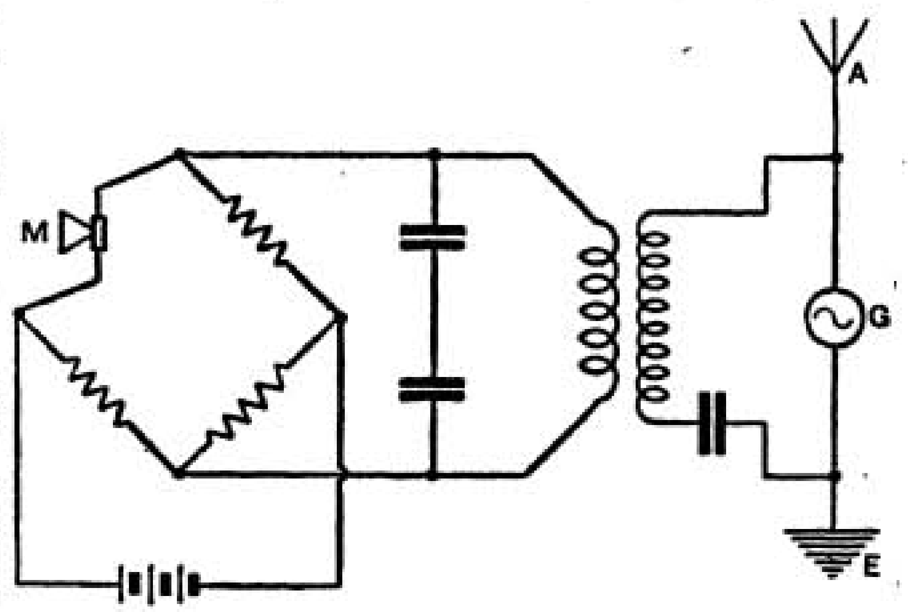

FIG. 3.

613. Mounting Two Transmitters in Parallel. M. B. Sleeper. (*Everyday Engineering Magazine*, 8, p. 319, February, 1920.)

An illustration is given of a simple mounting for two ordinary pattern microphone transmitters to enable them to be used in parallel for radiotelephony. Both transmitters are spoken to simultaneously.

614. New Wireless Telephone. (*Journal of the American Institute of Electrical Engineers*, 39, p. 176, February, 1920.)

Note *re* tests of a radiotelephone outfit over ranges up to 900 miles using ½ kW., and working through considerable interference. See also Abstract No. 618.

615. A Marconi Wireless Telephone Cabinet. (*Electrical Review*, 86, p. 350, March 12th, 1920. *Science Abstracts*, 23B, p. 280, Abstract No. 551, May 31st, 1920—Abstract.)

A brief illustrated description of a new ½ kW. cabinet set. Daylight telephony range = 100 nautical miles (or 300 miles for C.W. telegraphy). The constant-current "choke" control method of modulation is indicated in the circuit diagram.

616. Wartime Advance in Wireless Telephony. (*Nature*, 105, p. 145, April 1st, 1920.)

A brief reference to a demonstration at Chelmsford of wireless telephony and direction finding on a Handley Page aeroplane.

617. Wireless Telephony. (*Electrical Review*, 86, p. 145, January 30th, 1920. *Telegraph and Telephone Age*, 38, p. 18, January 1st, 1920.)

Relates to an installation of wireless telephone apparatus by the Public Electric Supply Co., N. Illinois.

618. Wireless Telephony. (*Electrical Review*, 86, p. 688, May 28th, 1920.)

Refers to recent wireless telephony tests by the de Forest Radio Company, New York, over 1,500 miles using only ½ kW. at the transmitter. See also Abstract No. 614.

619. Wireless Telephony Tests. (*Electrical Review*, 86, p. 336, March 12th, 1920.)

Refers to reports of successful radiotelephone tests between Berlin and Sweden (435 miles), and Berlin and Moscow (1,060 miles).

620. Multiplex Radiotelephony. (*Scientific American*, 122, p. 481, May 1st, 1920.)

Refers to a demonstration of multiplex radiotelephony using different frequencies on a single antenna. No technical details are given.

621. A Radiotelephone Transmitter. M. B. Sleeper. (*Everyday Engineering Magazine*, 8, pp. 222—224, January, 1920.)

An illustrated description of a simple form of valve radiotelephone transmitter.

622. Wireless Telephony on Aeroplanes. C. E. Prince. (*Journal of the Institution of Electrical Engineers*, 58, pp. 377—390, May, 1920; also abstracts in *Times Engineering Supplement*, No. 544, p. 89, February, 1920. *Nature*, 105, pp. 55—56, March 11th, 1920. *Electrical Review*, 86, pp. 441—442, April 2nd, 1920. *Electrician*, 84, pp. 448—449, April 23rd, 1920. *Technical Review*, 6, p. 341, April 13th, 1920. *L'Elettrotecnica*, 7, p. 329, June 25th, 1920.)

See Radio Review, 1, pp. 281—283 and 341—342, March and April, 1920, for abstract.

623. DUPLEX WIRELESS TELEPHONY. P. P. Eckersley. (*Nature*, 105, p. 154, April 1st, 1920—Abstract. *Technical Review*, 6, p. 384, April 27th, 1920—Abstract.)
See RADIO REVIEW, 1, pp. 338—340, 383—385, April and May, 1920, for abstract.

624. DUPLEX WIRELESS TELEPHONY AND SELECTIVE RECEPTION. E. F. W. Alexanderson, (*Electrical Review*, 84, p. 681, May 28th, 1920—Abstract.)
See RADIO REVIEW Abstract No. 75, for the original paper.

625. HIGH-SPEED WIRELESS TRANSMISSION. (*R.E. Journal*, 21, p. 60, February, 1920. *Electrical Review*, 86, p. 240, February 20th, 1920—Abstract. *Technical Review*, 6, p. 263, March 16th, 1920—Abstract.)

Reference is made to some experiments which are said to have been in progress for some time at the Signals Experimental Establishment, Woolwich, relative to high speed reception. It has been found quite practicable to handle wireless traffic at speeds up to 100 words per minute, using punched tape transmission and Wheatstone inker reception. The received message could also be used to operate a Creed printer or a land line transmitter, thus permitting direct coupling of the wireless with the land lines.

626. APPARATUS FOR MODULATING HIGH-FREQUENCY OSCILLATIONS. E. F. Huth. (*German Patent* 307192, December 23rd, 1917. Patent published, October 4th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, p. 159, February, 1920—Abstract.)

A method of modulating the electrical oscillations of a triode generator on aircraft in which electrical impulses derived from an alternating current siren attached to the shaft of the propeller, are communicated to the grid and filament of the triode.

627. INTERESTING KEY CONTROLS. W. Dornig. (*Elektrotechnische Zeitschrift*, 41, pp. 367—368, May 13th, 1920.)

A description of several methods of signalling. In one system the key operates relays which cut inductance out of one circuit and put inductance in another circuit thereby tuning the working circuit and de-tuning a dummy circuit or *vice versâ*. In another system two transformers have their primaries in series but their secondaries in the aerial and dummy circuits respectively. By means of relays auxiliary primary windings are so connected in one or other of the transformers that the main primary is exactly neutralised. Normally the aerial transformer is neutralised but on depressing the key the dummy transformer is neutralised and the aerial transformer made operative. The object throughout is to maintain a steady load on the generators and thus avoid the change of speed with load.

628. RADIO RELAY STATIONS. Western Electric Company, U.S.A. (*British Patent* 142371, July 29th, 1919. Patent accepted, May 6th, 1920.)

In order to avoid reaction between the transmitting and receiving apparatus at a radio station employed for automatically relaying a message from one station to another it is proposed to arrange the transmission from the station to be on a different wavelength from the signals that are received. This change in wavelength may be effected by combining the incoming signal with a heterodyne oscillation of a different frequency; thus if the carrier wave of the incoming signal is of frequency N_1 and is modulated with a speech or signal frequency of n, the resultant frequency of the incoming signals will vary between $N_1 + n$ $N_1 - n$. It is proposed that this incoming signal shall be combined at the relay station with an oscillation of frequency N_2 so that the resultant frequencies will then vary between $N_1 + N_2 + n$ and $N_1 + N_2 - n$ and also between $N_1 - N_2 + n$ and $N_1 - N_2 - n$. These currents may be passed through amplifier circuits tuned to either the higher or lower ranges of frequency so that the output from the transmitting side of the relay station takes place with a carrier wave frequency of either $N_1 + N_2$ or $N_1 - N_2$. In the case of a series of such relay stations one station may be arranged to raise the frequency of carrier waves and the next one to lower it again.

629. A NEW THERMIONIC VACUUM TUBE. J. Scott-Taggart. (*Electrical Review*, 86, pp. 261—262, February 27th, 1920. *Science Abstracts*, 23B, p. 223, Abstract No. 436, April, 1920—Abstract.)

A special form of experimental tube is described in this note. The filament (tungsten) is 25 mm. long mounted vertically in the bulb. The plate is 10 mm. × 10 mm. × 0·008″ nickel sheet mounted 9 mm. away from the filament. The control electrode is also in the form of a plate (22 mm. × 10 mm. × 0·008″ nickel sheet) mounted parallel to the plate electrode but on the opposite side of the filament and 2 mm. away from it. Some characteristic curves are given. These are of the same general type as for a normal triode, but when the potential on the control electrode is positive and greater than about two volts the anode current curves begin to bend over. Eventually saturation is reached and for greater potentials the current falls, as the control plate is more easily able to absorb electrons than the usual wire grid. The tube makes a good amplifier and detector, the latter property being especially good at the point of maximum anode current—since then both half waves of the oscillation cause a decrease of the anode current.

630. A NEW THERMIONIC VALVE. S. R. Mullard. (*Electrical Review*, 86, p. 330, March 12th, 1920.)

Correspondence relative to an article by J. Scott-Taggart with the above title, and referring to some experimental valves made up by the writer to Dr. J. Erskine-Murray's design which give similar characteristics.

631. VACUUM TUBES. General Electric Company, U.S.A. (*British Patent* 142207, February 7th, 1919. Patent accepted, May 6th, 1920.)

This patent deals with the construction of triode valves of the flat plate type. The most important feature described relates to the winding of the grid around a rectangular frame in the interior of which the filament is stretched. The sides of the frame are wound with a spiral of fine wire so that the turns of the grid wire may be evenly spaced between turns of the side spirals thus maintaining an even spacing for the grid wires.

632. VALVE CONSTRUCTION. Osram-Robertson Lamp Works, Ltd. (*French Patent* 499871, August 30th, 1918. Published February 25th, 1920.)

This specification relates to the arrangement of the support for the electrodes in ionic tubes, more particularly for wireless telegraphy. A cylindrical electrode is supported at each end by a set of longitudinally extending bars attached to elastic fingers, which are sprung into a recess at the junction of the bulb with its neck. The elastic fingers are held distended by a locking-ring. In the form illustrated in the patent the elastic fingers consist of blade springs which are bent back towards the anode and double on themselves to form clips for securing the locking-ring, and they may be riveted to sockets fitting carrier bars for the electrode.

For further particulars of the invention, see British Patent 119088.

633. VALVE CONSTRUCTION. Osram-Robertson Lamp Works, Ltd. (*French Patent* 499872, August 30th, 1918. Published February 25th, 1920.)

The invention described in this specification relates to an ionic tube, such as is used in wireless telegraphy. A cylindrical anode is supported at each end by longitudinally extending pliable fingers which have outward bends which engage a shoulder at the junction of the bulb with its neck. The said fingers are pressed outwards against the next by an expanding spring ring which may be seated in kinks in the fingers.

For further particulars, see British Patent 119089.

634. THE THEORY OF VALVE RECTIFICATION. W. S. Barrell. (*Wireless World*, 7, pp. 181—186, 244—246, 337—340, July—October, 1919. *Telegraphen- und Fernsprech-Technik*, 8, pp. 185—188, February, 1920—Abstract.)

The theory of rectification in a two-electrode and in a three-electrode valve is discussed.

635. THE SHORT TUNGSTEN FILAMENT AS A SOURCE OF LIGHT AND ELECTRONS. G. Stead. (*Journal of the Institution of Electrical Engineers*, 58, pp. 107—117, January, 1920. *Science Abstracts*, 23A, p. 242, Abstract No. 617, April, 1920—Abstract.)

The experiments described in this paper were carried out in the Cavendish Laboratory during the early part of 1918 to provide data for the design of tungsten filaments for thermionic valves for use in the Navy. In the introduction Langmuir's experiments on the variation of the physical properties of tungsten with temperature are discussed and it is then pointed out that the factors which determine filament voltage, emission (and candle power), for pure tunsgten are: filament length, filament diameter, filament temperature, and the cooling of the ends of the filament by the leads. In this paper the following symbols are used: I_f, E_f, R_f, W_f, l_f, d_f, P_f, and i, for the filament current, voltage, resistance, watts, length, diameter, candle power, and emission respectively. Comparing two filaments of different diameters working at the same temperature, and including end corrections :—

The filament currents are in the ratio of the 3/2 powers of the diameters.

The voltages per centimetre are in the inverse ratio of the square roots of the diameters.

The resistances per centimetre are in the inverse ratio of the squares of the diameters.

The watts per centimetre are proportional to the diameters.

The emissions per centimetre are proportional to the diameters.

A determination was made of certain characteristics of the tungsten filament as functions of the diameter. Some of these are shown in Fig. 4. In this figure the symbols used have the meanings already given or those stated under the figure.

The distribution of temperature along the tungsten filament in the neighbourhood of one of the leads was determined by means of an optical pyrometer which was mounted on a cathetometer in front of a bulb containing a long " hairpin " filament. This was done for a series of maximum temperatures, and by combining the results with those previously obtained for a uniform filament a series of end correction curves was obtained for voltage, electron emission, etc. These are given in Fig. 5. The procedure for designing a filament to produce a given electron emission when the overall voltage is given, and the filament diameter is provisionally chosen, is then worked out. Several examples are given in the paper illustrating the method of procedure. The method is an accurate one, but is rather laborious as it involves a certain amount of trial and error and interpolation between calculated results.

The case is also considered for a very short filament when the end correction overlaps the " central " part of the filament so that the maximum temperature at the middle does not reach its normal value that it would have if the filament were longer, and it is shown that this design can also be proceeded with in the manner previously outlined.

The paper concludes with an approximate method for the more rapid design of filaments. The results obtained are generally accurate within a few per cent. for filament temperatures between 2,000° K. and 2,500° K. and for filament diameters between 0·0035 cm. and 0·012 cm. The object of the method is, first, to find the overall voltage which would be necessary if the whole filament were as hot as the middle part; the filament length can thus be found at once from the $E_f\sqrt{d_f}/l_f$ curve (Fig. 4). Next the length is found of a filament which gives the same emission as the actual filament and whose temperature is everywhere the same as that of the central portion of the actual filament. The emission can then be found from the $i/l_f d_f$ curve in Fig. 4.

The procedure may be summarised as follows :—

FILAMENT LENGTH.

(*a*) Subtract 300 from the absolute temperature of the central portion of the filament, multiply the result by 4, and divide by 10,000.
(*b*) Subtract filament diameter in cms. from 0·0088 cm. and multiply the result by 100.
(*c*) Subtract (*b*) from (*a*) and add the result to the required overall voltage.
(*d*) Find E_f/l_f from Fig. 4 and divide it into the result of (*c*). This gives the required filament length.

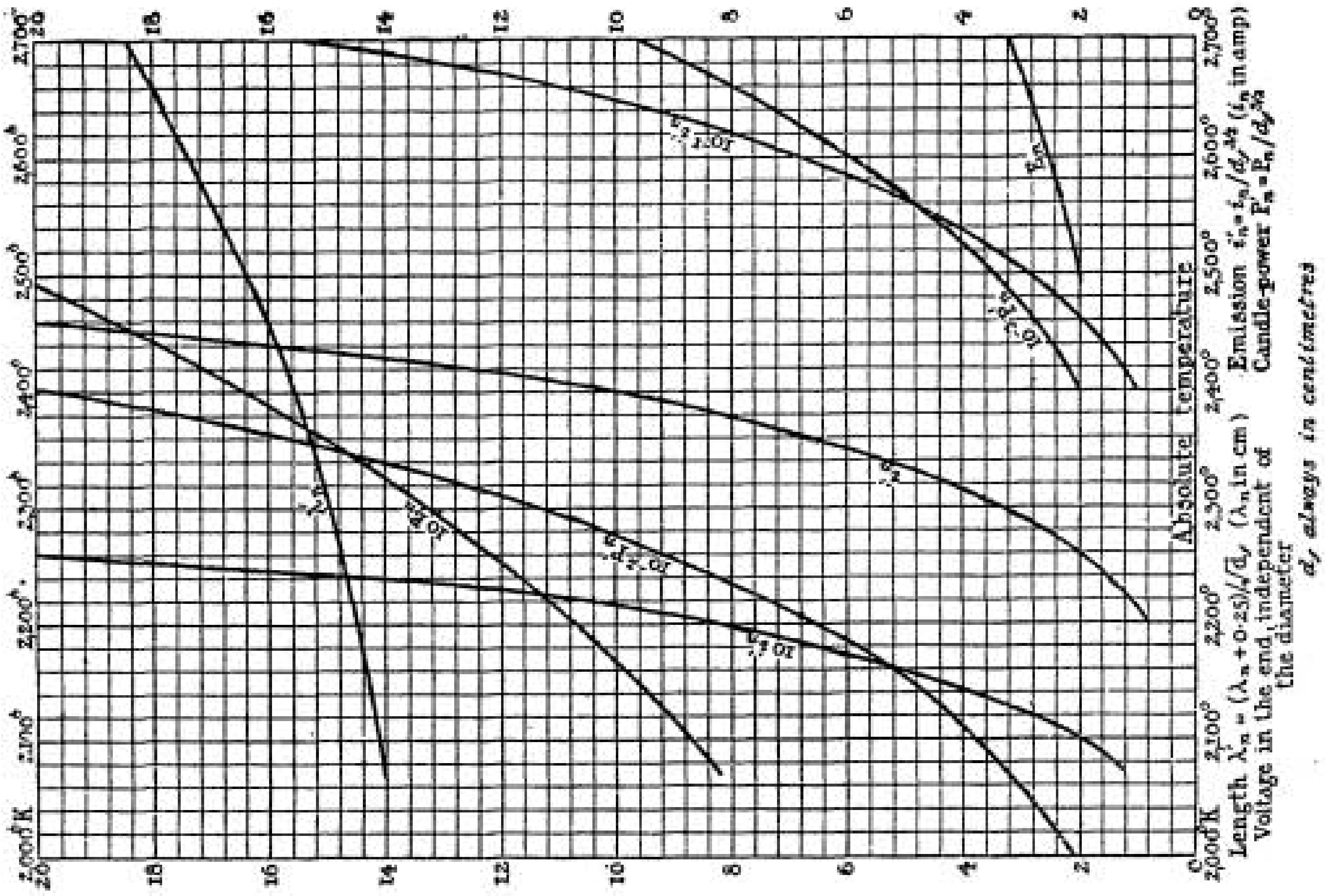
Absolute temperature
Length $\lambda'_n = (\lambda_n + 0.25)/\sqrt{d_f}$ (λ_n in cm)
Voltage in the end, independent of the diameter
Emission $i'_n = i_n/d_f^{3/2}$ (i_n in amp)
Candle-power $P'_n = P_n/d_f^{3/2}$
d_f always in centimetres

Fig. 5.

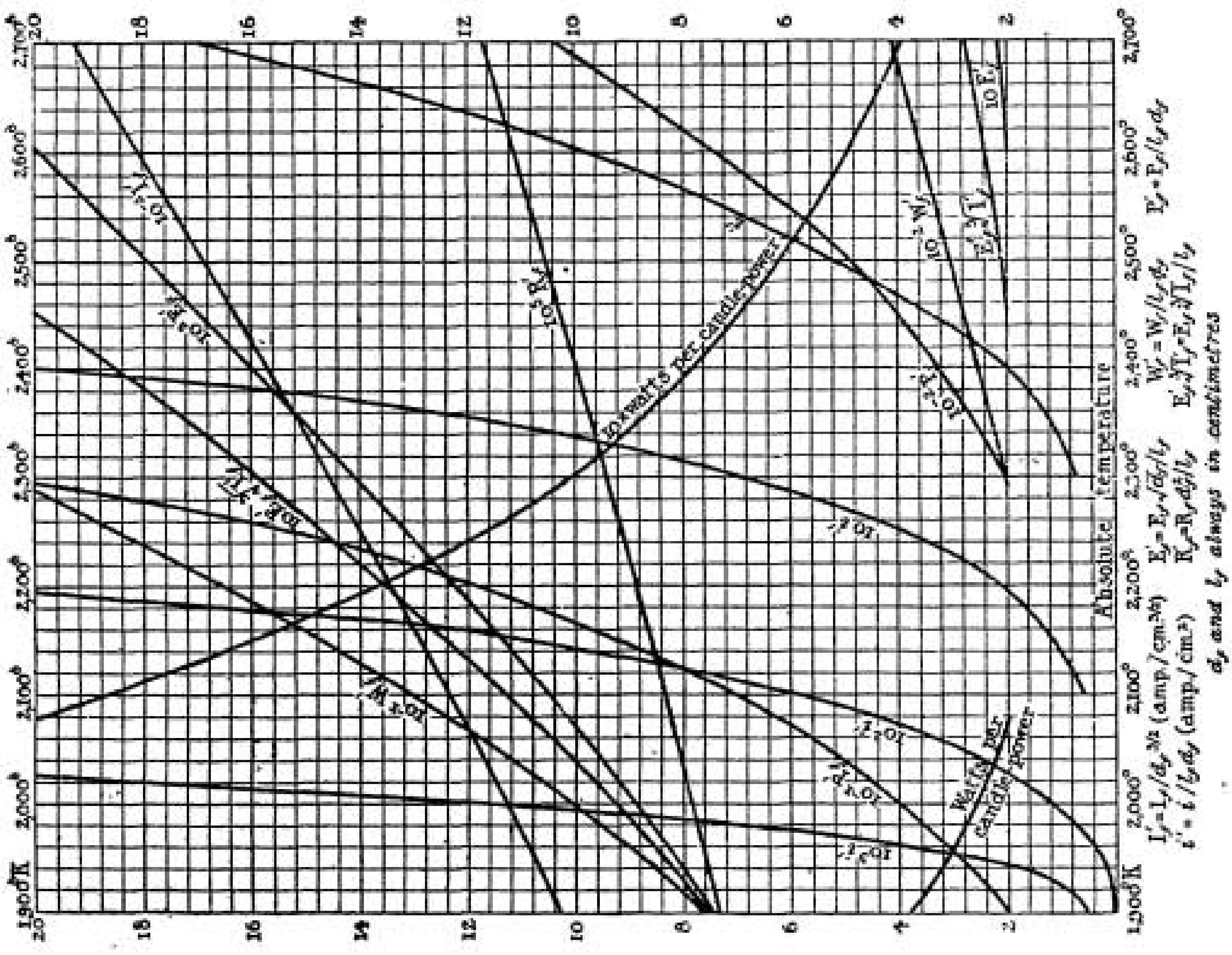
Absolute temperature
10×watts per candle-power
Watts per candle-power
d_f and l_f always in centimetres

Fig. 4.

EMISSION.

(*e*) Multiply the length of the end λ_n (obtained from the λ_n' curve of Fig. 5) by 1·20 and subtract the result from the length of the filament found in (*d*). Call the result l'.

(*f*) Find the emission i corresponding to l' by means of the i' curve in Fig. 4.

The following example is chosen from amongst those given in the paper to illustrate the above approximate method:—

Design of a 4-volt filament of diameter 0·0058 cm., temperature of central portion 2,390° K.

(*a*) $(2{,}390 - 300) \times 4 \times 10^{-4} = 0{\cdot}8160$.
(*b*) $(0{\cdot}0088 - 0{\cdot}0058)\ 100 = 0{\cdot}30$.
(*c*) $(0{\cdot}8160 - 0{\cdot}30) + 4$ volts $= 4{\cdot}516$.
(*d*) From Fig. 4, $E_f/l_f = 2{\cdot}073$ using the $E_f\sqrt{d_f}/l_f$ curve, then $4{\cdot}516/2{\cdot}073 = \underline{2{\cdot}18 \text{ cm.} = \text{filament length.}}$
(*e*) $\lambda_n' = 15{\cdot}5, \quad \therefore \lambda_n = 0{\cdot}92; \quad 0{\cdot}92 \times 1{\cdot}20 = 1{\cdot}10; \quad 2{\cdot}18 - 1{\cdot}10 = 1{\cdot}08 = l'$.
$\therefore i/l_f = 10{\cdot}3; \quad \therefore i = 10{\cdot}3 \times 1{\cdot}08 = \underline{11{\cdot}1 \text{ milliamps.}}$

636. THE DESIGN OF TRIODE GENERATOR CIRCUITS. M. Vos and R. Ziegler. (*Science Abstracts*, 23B, pp. 162—163, Abstract No. 327, March, 1920—Abstract.)
See RADIO REVIEW Abstract No. 292, April, 1920.

637. THE DESIGN OF MULTIPLE STAGE AMPLIFIERS USING THREE ELECTRODE THERMIONIC VALVES. C. L. Fortescue. (*Journal of the Institution of Electrical Engineers*, 58, pp. 65—82, January, 1920. *Radio Amateur News*, 1, pp. 344—345, January, 1920—Abstract. *Science Abstracts*, 23B, pp. 221—222, Abstract No. 433, April, 1920—Abstract.)

Paper read at a wireless sectional meeting of the Institution of Electrical Engineers, see RADIO REVIEW, 1, pp. 178—181, January, 1920, for abstract.*

Some further discussion (communicated) from Professor E. W. Marchant, as well as Professor Fortescue's reply are also included in the original.

638. AN INVESTIGATION OF THE EFFECTS OF ELECTRON COLLISIONS WITH PLATINUM AND WITH HYDROGEN. F. Horton and A. C. Davies. (*Proceedings of the Royal Society*, 97A, pp. 23—43, March, 1920. *Nature*, 104, p. 618, February 5th, 1920—Abstract.)

639. TRIODE VALVES AS ELECTRIC AMPLIFIERS. W. H. Eccles. (*Nature*, 104, pp. 501—502, January, 1920. *Science Abstracts*, 23B, p. 221, Abstract No. 432, April, 1920—Abstract.)

This article briefly describes the nature and properties of triode valves and indicates the magnitudes of the current, voltage, and energy amplifications that are obtainable with such valves. The article is particularly devoted to indicating the manner in which such valves may be employed for magnifying very low frequencies or steady potential differences. The resistance coupled amplifier arrangement devised in the French military radiotelegraphic laboratory is described and the simplified connection of this using common filament and high tension batteries is also given. It is shown that when the anode circuit resistances are about 80,000 ohms and taking average values for the valve constants, that the potential magnification of the single valve may be about 7·5, and with two valves about 56. A connection scheme due to the author is also given in the article in which each valve forms one arm of a balanced Wheatstone bridge. With this circuit arrangement the magnification obtainable is of the same order as with the French arrangement when the balancing bridge arm resistances are taken at the same values as the anode resistances in the previous arrangement.†

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* See also RADIO REVIEW Abstract No. 355, May, 1920.

† See also RADIO REVIEW Abstract No. 237, March, 1920, where very similar arrangements are described by A. Blondel.

640. ELECTRON DISCHARGE TUBES AND THEIR APPLICATIONS. P. Letheule. (*Le Génie Civil*, 76, pp. 199 *et seq.* All issues between February 21st, 1920, and March 20th, 1920; also May 1st to June 5th, 1920. *Technical Review*, 6, p. 342, April 13th, 1920—Abstract.)

A very detailed description of vacuum tube apparatus and phenomena, with many references to early work on the subject. The following are the main headings: Elster and Geitel, Edison Effect, Fleming Valve, Richardson, Langmuir, Coolidge, Kenotron, Tungar, Audion, Oscillating Audion, Production of Very High and Very Low Frequencies, Heterodyne and Endodyne Reception, Amplification, Lieben and Reisz, Pliotron, Dynatron, Pliodynatron.

641. APPLICATIONS OF AMPLIFYING VALVES. L. Bloch. (*Revue Scientifique*, 58, pp. 12—19, January 10th, 1920. *Nature*, 104, pp. 647—648, February 12th, 1920—Abstract.)

A general article dealing with the industrial applications of amplifying valves. Reference is made to their use for telephonic relays, rectifiers, wireless amplifiers and receivers, earth telegraphy, and oscillation generators.

642. THE VACUUM TUBE. P. H. Boucheron. (*Scientific American*, 122, pp. 64—65, January 17th, 1920.)

A general article describing three-electrode valves and various circuits for use with them.

643. PRACTICAL OPERATION OF THERMIONIC DETECTORS. H. J. van der Bijl. (*Popular Science Monthly*, 96, pp. 130—140, February, 1920.)

A general article summarising the various modes of operation of triode detectors when receiving damped and continuous waves.

644. STRUCTURE AND OPERATION OF THE VACUUM VALVE. R. W. A. Brewer. (*Journal of Electricity*, 44, pp. 102—105, February 1st, 1920. *Electrical World*, 75, p. 744, March 27th, 1920—Abstract.)

The writer brings out some of the features upon which depend the uniformity of vacuum valves based upon extensive experiences in testing.

645. THERMIONIC VACUUM TUBE AS DETECTOR, AMPLIFIER AND GENERATOR OF ELECTRICAL OSCILLATIONS. W. H. Eccles. (*Electrician*, 84, pp. 522—524, May 7th, 1920. *Engineering*, 109, pp. 724—725, May 28th, 1920.)

Abstracts of two lectures delivered at the Royal Institution. A general summary was given of the properties of two and three-electrode valves, which were illustrated by a number of experiments. The use of the tubes in cascade amplifiers and for heterodyne work was also discussed, as well as a number of novel applications of such valves, including the indication of very minute changes in the specific inductive capacity of a dielectric.

646. WHO INVENTED THE VACUUM TUBE? T. A. Edison; P. H. Boucheron. (*Scientific American*, 122, p. 185, February 21st, 1920.)

Correspondence relative to the first publication of the discovery of the Edison effect (a paper by E. J. Houston before the American Institute of Electrical Engineers, October, 1884, is quoted), and of Dr. Fleming's share in its application to radio work.

647. ON THE THREE-ELECTRODE VALVE. P. Trichard. (*Revue Générale de l'Électricité*, 7, p. 178, February 7th, 1920.)

Correspondence relative to the paper by Dr. W. H. Eccles and F. W. Jordan on the use of two triode valves in parallel for generating oscillations.* The writer claims that the arrange-

* RADIO REVIEW, 1, pp. 80—83, November, 1919.

ment described is a particular case of the more general arrangement described in his French Patents of September 6th, 1918 (Frequency multiplier), and September 13th, 1918 (Generator of high frequency current), and also in his British and U.S. applications of August, 1919.

648. "THE THERMIONIC VALVE AND ITS DEVELOPMENT IN RADIOTELEGRAPHY AND TELEPHONY." L. de Forest. (*Electrician*, 84, p. 226, February 27th, 1920.)

Further correspondence relative to the book with the above title. See also RADIO REVIEW, 1, pp. 259—261, February, 1920.

649. "THE THERMIONIC VALVE AND ITS DEVELOPMENTS IN RADIOTELEGRAPHY AND TELEPHONY." M. Latour; J. A. Fleming. (*Electrician*, 84, pp. 41—42, January 9th, 1920.)

Correspondence relative to the book by J. A. Fleming with the above title*; see RADIO REVIEW, 1, pp. 259—261, February, 1920; also M. Latour (RADIO REVIEW, 1, pp. 367—368, April, 1920), and RADIO REVIEW Abstracts Nos. 648, 650.

650. "THE THERMIONIC VALVE AND ITS DEVELOPMENTS IN RADIOTELEGRAPHY AND TELEPHONY." J. Scott-Taggart. (*Electrician*, 84, p. 66, January, 1920.)

Further correspondence relative to Dr. Fleming's book with the above title. See also RADIO REVIEW, 1, pp. 259—261, February, 1920, and pp. 367—368, April, 1920; also RADIO REVIEW Abstracts Nos. 648 and 649.

651. THERMIONIC VALVES ON AIRCRAFT. R. Whiddington. (*Nature*, 104, p. 630, February 12th, 1920.)

Correspondence relative to the variation of wavelength of oscillations set up by triodes by variations of the filament current and plate voltage. Reference is also made to a recent paper by Drs. W. H. Eccles and J. H. Vincent (see RADIO REVIEW Abstracts Nos. 503, July, 1920, and 655, August, 1920).

652. NAVY VACUUM TUBE COLLECTION. (*Popular Science Monthly*, 96, p. 144, February, 1920.)

Photographs and particulars are given of thirty-eight different patterns of triode vacuum tubes.

653. WHAT THE DE FOREST AUDION HAS DONE AND WHAT IT MAY YET DO. C. H. Claudy. (*Scientific American*, 122, p. 540, May 15th, 1920.)

A brief *resumé* of Dr. de Forest's work in the development of the audion.

654. TECHNICAL DEVELOPMENT OF THERMIONIC TRANSMITTERS. L. Kühn. (*Elektrotechnische Zeitschrift*, 41, p. 141, February 12th, 1920—Abstract.)

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

655. FURTHER EXPERIMENTS ON THE VARIATION OF WAVELENGTH OF THE OSCILLATIONS GENERATED BY AN IONIC VALVE DUE TO CHANGES IN FILAMENT CURRENT. J. H. Vincent. (*Proceedings of the Royal Society*, 97, pp. 191—196, April 15th, 1920. *Nature*, 105, p. 121, March 25th, 1920—Abstract. *Chemical News*, 120, p. 165, April 1st, 1920—Abstract.)

It has previously been found that the wavelength of the valve oscillations is a function of the filament current.† This paper studies the effect more in detail. Special rheostats

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* See review in RADIO REVIEW, 1, pp. 156—159, December, 1919.

† See RADIO REVIEW Abstract No. 503, July, 1920; also pp. 481—489, July, 1920.

were designed to avoid change of inductance of the filament circuit when varying the filament current. It is suggested that changes in several of the variables of a valve-maintained circuit produce effects of the same sign in the wavelength and amplitude of the oscillations; the wavelength and amplitude decrease with decrease of grid voltage or of plate voltage; they also decrease when the coupling of the grid coil with the main oscillating coil decreases; increasing the resistance in either the condenser or the inductance branch of the main oscillating circuit lessens the amplitude and wavelength, while altering the filament current in either direction from that giving the maximum wavelength gives also a decreased amplitude.

656. Absorption of Gases in the Electric Discharge Tube. F. H. Newman. (*Proceedings of the Physical Society of London*, 32, pp. 190—195, April 15th, 1920. *Chemical News*, 120, p. 166, April 1st, 1920—Abstract.)

The paper describes a method of showing that absorption of nitrogen takes place in the discharge tube when sodium and potassium are used as the electrodes. The amount of gas absorbed increases with the temperature.

In the discussion Professor Fortescue commented upon the possibility of some of the electrode films having absorbed gases when exposed to the atmosphere, and on the different effects of positive and negative ions.

657. Discharge in High Vacuum. J. E. Lilienfeld. (*Annalen der Physik*, 61, pp. 221—263, February, 1920.)

By using long cylindrical tubes with various distances between the electrodes the author finds a linear fall of potential along the discharge in confirmation of his previous results with exploring electrodes. The author sees in his results a proof of the absence of space charge and of the insufficiency of the 1·5 power law criterion of the quality of the vacuum.

658. Measurements on Vacuum Tubes. H. G. Möller. (*Archiv. für Elektrotechnik*, 8, pp. 46—58, July 15th, 1919. *Electrical World*, 75, p. 687, March 20th, 1920—Abstract.)

A number of laboratory methods are outlined in this paper. To overcome difficulties arising from current inequalities at the ends of the filament when comparing different triodes the author suggests that the plate current be adjusted to a prescribed value rather than the filament current. An emission of 4 mA. per watt of heating power is recommended.

659. Measurement of the Chief Parameters of Triode Valves. W. H. Eccles. (*Proceedings of the Physical Society of London*, 32, pp. 92—104. February 15th, 1920.)

See Radio Review, 1, pp. 283—285, March, 1920, for abstract. The original also contains additional discussion by Professor A. O. Rankine relative to the use of triodes for amplifying thermo-electric e.m.f.'s.

660. A Comparative Method of Testing Thermionic Valves for Passing no Reverse Current at High Voltages. N. W. McLachlan. (*Proceedings of the Physical Society of London*, 32, pp. 72—77, February 15th, 1920.)

See Radio Review, 1, pp. 239—240, February, 1920, for abstract.

661. A Method of Measuring the Amplification of a Radio Frequency Amplifier. F. W. Jordan. (*Proceedings of the Physical Society of London*, 32, pp. 105—115, February 15th, 1920.)

See Radio Review, 1, pp. 288—289, March, 1920, for abstract.

662. ON THE MEASUREMENT OF AMPLIFICATION GIVEN BY TRIODE AMPLIFIERS AT AUDIBLE AND AT RADIO FREQUENCIES. F. E. Smith and H. C. Napier. (*Proceedings of the Physical Society of London*, 32, pp. 106—132, February 15th, 1920.)

See RADIO REVIEW, 1, pp. 287—288, March, 1920, for abstract. The original also contains additional discussion by Mr. P. R. Coursey.

663. STANDARD VACUUM TUBE NOTATIONS IN GERMAN LITERATURE. (*Electrical World*, 75, p. 687, March 20th, 1920—Abstract. *Telegraphen- und Fernsprech-Technik*, 8, p. 58, July, 1919.)

See RADIO REVIEW, 1, p. 437, June, 1920, for full particulars of the proposed symbols.

664. ELECTROLYTIC RECTIFICATION. G. Schulze. (*Zeitschrift für Instrumentenkunde*, 40, p. 98, May, 1920.)

A brief abstract from the annual report of the Reichsanstalt (March, 1920), stating that the investigation had been resumed especially with regard to aluminium rectifiers using very pure aluminium. The points under investigation are :—Rate of formation, sparking voltage, maximum voltage, thickness of oxide film and of gas film, the remanent current and the minimum voltage in the conduction direction.

665. THE WAVE FORM OBTAINED FROM AN ALUMINIUM RECTIFIER. N. H. Williams and J. M. Cork. (*Science Abstracts*, 23B, p. 27, Abstract No. 55, January 30th, 1920. *Electrical Review*, 86, p. 682, May 28th, 1920—Abstract.)

See RADIO REVIEW Abstract No. 358, May, 1920.

666. THE GENERATION OF HIGH TENSION DIRECT CURRENTS. M. Schenkel. (*Science Abstracts*, 23B, pp. 28—29, Abstract No. 56, January 30th, 1920—Abstract.)

See RADIO REVIEW Abstract No. 117, January, 1920.

667. DIRECTIONAL WIRELESS SIGNALLING. F. A. Kolster. (*British Patent* 137069, December 24th, 1919. Convention date, March 31st, 1916. Patent not yet accepted but open to inspection. *Wireless Age*, 7, pp. 24—25, November, 1919 — Abstract. *Science Abstracts*, 23B, p. 165, Abstract No. 333, March, 1920 —Abstract.

The subject-matter of this patent deals with direction finding with two or more frame aerials. The use of two coils crossing one another at any angle is claimed, the coils being connected in series and tuned by one or more variable condensers in the usual manner. Directions are determined by observation of the position of minimum signals. A special modification indicated in Fig. 6 is also described. The two receiving coils A and B enclose the metal gauze capacity areas indicated. The gauze is connected to one terminal of the coil and a double thermionic valve detector is used in the manner shown.

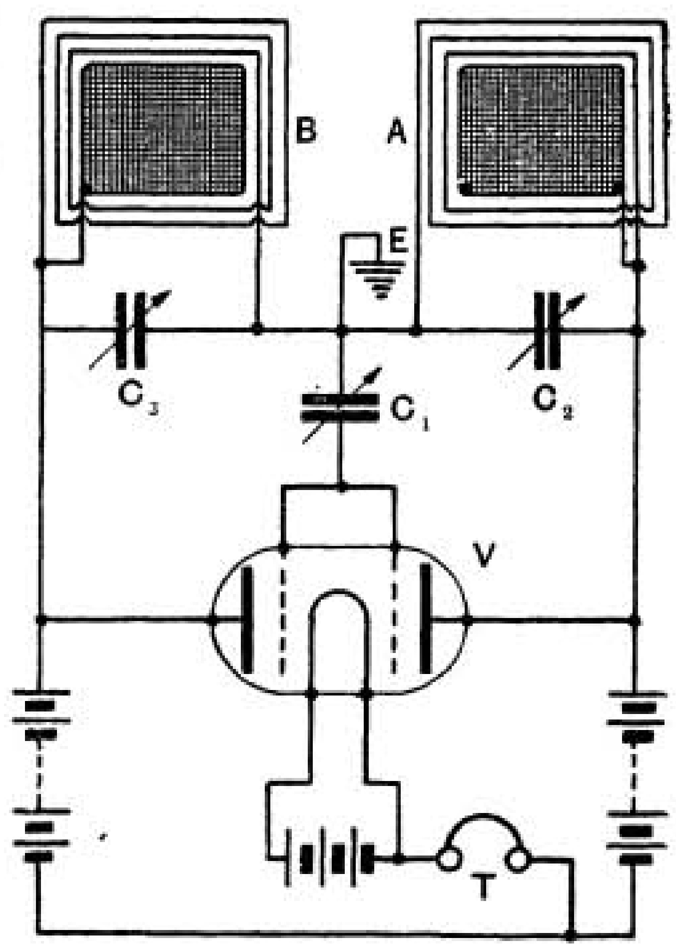

FIG. 6.

For the determination of distance as well as direction an arrangement is described of two pairs of crossed coil receivers placed at the ends of a base line of known length. The coils may be rotated by distant controls from a central observation station.

668. WIRELESS TELEGRAPHY AND AERIAL NAVIGATION. Franck. (*L'Aéronautique* 1, pp. 291—295, December, 1919. *Technical Review*, 6, p. 177, February 17th, 1920—Abstract.)
The author makes a plea for the organisation of radiogoniometric stations, and after explaining the principles of wireless direction finding, points out the advantages of the installation of such stations at definite points. The system of stations could be used for aerial navigation during fog.

669. DIRECTION FINDING. J. Robinson. (*French Patent* 500003, May 24th, 1919. Published February 28th, 1920.)
Apparatus for finding the direction of Hertzian waves described in this specification, is of the kind in which two vertical coils are arranged at an angle to each other and are rotatable about a vertical axis. For further particulars, see British Patent 134560.*

670. WIRELESS DIRECTION FINDER. J. Robinson. (*British Patent* 134560, May 27th, 1918. Patent accepted, May 9th, 1919. Patent published, December 11th, 1919.)
The method of direction finding set out in this specification is that customarily known as the " R.A.F. Crossed-coil method " which has been fully described by the same author.†

671. A METHOD OF DIRECTION FINDING OF WIRELESS WAVES AND ITS APPLICATION TO AERIAL AND MARINE NAVIGATION. J. Robinson. (*Science Abstracts*, 23B, p. 220, Abstract No. 429, April, 1920—Abstract. *Technical Review*, 6, p. 302, March 30th, 1920—Abstract.)
See RADIO REVIEW, 1, pp. 213—219, February, 1920, and pp. 265—275, March, 1920, for original paper.

672. ON THE HISTORY OF DIRECTION FINDING AT THE DÖBERITZ AND LÄRZ AERODROMES. R. Baldus, E. Buchwald and R. Hase. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, pp. 99—101, February, 1920.)
See Abstract No. 673 which also deals with this article.

673. DIRECTIONAL WIRELESS ON AEROPLANES. E. Buchwald and R. Hase, (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, pp. 101 and 113. February, 1920. *Technical Review*, 6, p. 384, April 23rd, 1920—Abstract. See also RADIO REVIEW Abstract No. 672.)
A report of experiments carried out for the military authorities at Döberitz and Lärz. The aeroplane carried a trailing receiving aerial coupled to an antenna circuit containing a barretter inserted in one arm of a Wheatstone bridge. The aerial current was determined from the deflection of the galvanometer. Long dashes were sent from a fixed station with a wavelength of 250 metres. The exact position and direction of the aeroplane at the moment of reading was determined by taking a photograph of the ground immediately below by means of a camera fitted into the floor of the aeroplane. Curves are given showing the variation of received current as the aeroplane approached, passed over and receded from the transmitting station, and also showing the effect for a given distance of the rotation of the plane about a vertical axis.

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* RADIO REVIEW Abstract No. 670.
† RADIO REVIEW, 1, pp. 213—219, February, 1920, and pp. 265—275, March, 1920.

674. EXPERIMENTS WITH SCHELLER'S RADIO COURSE SETTER ON AEROPLANES. E. Buchwald. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, pp. 114—122, February, 1920. *Technical Review*, 6, pp. 384—385, April 27th, 1920—Abstract.)

German Patent No. 201496 of 1907 described two horizontal sending aerials enclosing an angle, connected alternately to the sending apparatus, which is sending a long dash. If one aerial sends out the letter A the other will send the inverse, viz., N. A receiving station which bisects the angle between the two sending aerials will hear a long dash, others will hear either A or N or both with different intensities. The present article describes experiments with aeroplane reception and compares the results with calculations made by Burstyn. The results are very complicated in view of the vertical angle subtended by the aeroplane at the sending station and by the varying direction of the receiving antenna which hung freely from the aeroplane.

675. THE ELECTROMAGNETIC PLANE-WAVE IN TWO MEDIA. K. Uller. (*Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, pp. 123—152, February, 1920. *Technical Review*, 6, p. 885, April 27th, 1920—Abstract.)

A highly mathematical investigation of the transmission of a plane wave along the boundary between two media. The author considers the terms "surface wave" and "space wave" introduced by Sommerfeld to be unfortunate and misleading. The author appears to favour reflection rather than refraction, but is not clear on this point.

676. ON THE ABSORPTION OF CORPUSCULAR RAYS PENETRATING THE TERRESTRIAL ATMOSPHERE AND FOLLOWING NON-RECTILINEAR PATHS. C. Störmer. (*Comptes Rendus*, 170, pp. 742—744, March 22nd, 1920.)

A mathematical treatment of the paths followed by ionised particles entering the earth's atmosphere under the influence of the earth's magnetic field, as affecting the ionisation produced in the upper atmosphere by these particles.

677. AN ION-PRODUCING EFFECT IN THE UPPER ATMOSPHERE. W. Hammer. (*Physikalische Zeitschrift*, 21, pp. 218—219, April 15th, 1920.)

The interplanetary space may contain a large number of molecules and the collisions between these and the earth's atmosphere due to the earth's orbital velocity may produce ionisation.

678. WIRELESS TELEGRAPHY AND TELEPHONY. W. H. Eccles. (*Electrician*, 84, p. 296, March 12th, 1920.)

Correspondence relative to the theoretical derivation of the Austin-Cohen transmission formula. The author points out that if as the distance between the stations increases the wavelength be varied so as always to produce the required signal intensity with the least possible value of the product Ih, then Ih must be proportional to the cube of the distance (I being the sending aerial current and h the sending aerial height); and also that the power required for signalling varies approximately as the sixth power of the range.

See also RADIO REVIEW Abstract No. 679.

679. WIRELESS TELEGRAPHY AND TELEPHONY. R. C. Colwell. (*Electrician*, 84, p. 526, May 7th, 1920.)

Further discussion * relative to the derivation of the transmission formula.

680. THE RANGE OF WIRELESS STATIONS. R. C. Trench. (*Jahrbuch der Drahtlosen Telegraphie*, 14, pp. 494—526, October, 1919. Article abstracted from *Electrician*, 79, pp. 102, 147 and 181, 1917.)

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* See RADIO REVIEW Abstract No. 678.

681. THE CONDITIONS FOR LONG RANGE IN WIRELESS. Professor Demanet. (*Union des Ingénieurs de Louvain*, 46, pp. 128—136, 1919.)

This paper presented before the Society in 1914 and only just published owing to wartime difficulties, summarises the chief factors influencing the range of wireless stations. The first part summarises the influence of the capacity, insulation, wavelength, etc., of the aerial, while the second briefly reviews the different means for the production of damped and undamped waves. The treatment given is based upon the following formula for the energy picked up by the receiving aerial at a distance D from the transmitter :—

$$W_2 = W_1 \left(\frac{3}{4}\right)^2 \left(\frac{\lambda^2}{2\pi}\right)^2 \frac{1}{D^2} \epsilon^{-2AD/\sqrt{\lambda}}$$

where W_1 = power of the transmitter, λ = the wavelength and A = absorption coefficient.

682. WIRELESS IN SUBMARINES. (*La Nature*, 48, pp. 17—19, January 10th, 1920.)

A brief account of the use of loop aerials under water for reception on submerged submarines. Experiments with the arrangement described were commenced in 1917 by Lieut. de Broglie in French submarines. Two loop aerials are used mounted outside the submarine and fixed at an angle of 40° to one another, so that by connecting them in series or parallel or using them singly reception can be secured from any direction. A seven-valve amplifier was used. The American arrangement using a large single turn loop of which the submarine shell forms one side is also mentioned.

683. IMPROVEMENT IN VALVE MOUNTINGS. Gesellschaft für drahtlose Telegraphie. (*German Patent* 299776, May 3rd, 1917. Patent published September 29th, 1919. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, p. 257, March, 1920—Abstract.)

A scheme of preventing valve noises in which the movement of the filament is damped mechanically by springs.

684. NEW DETECTOR AND AMPLIFIER UNITS. (*Everyday Engineering Magazine*, 8, p. 235, January, 1920. *Radio Amateur News*, 1, p. 335, January, 1920.)

An illustrated description of a panel type valve detector and amplifier manufactured by the International Radio Co.

685. A SYSTEM FOR THE RECEPTION OF CONTINUOUS WAVES. J. Scott-Taggart. (*Telegraph and Telephone Age*, 39, pp. 62—64, February 1st, 1920. *Science Abstracts*, 23B, p. 168, Abstract No. 339, March, 1920—Abstract.)

Paper read before the Wireless Society of London. See RADIO REVIEW, 1, pp. 181—183, also RADIO REVIEW Abstract No. 434, June, 1920.

686. HETERODYNE RECEPTION. A. Meissner and E. Scheiffler. (*Zeitschrift für Fernmeldetechnik*, Nos. 2 and 3, 1920.)

An experimental study of heterodyne reception of both damped and undamped waves using both crystal and audion detectors. The audibility was determined with different values of local current for the same signal current, and also for different signal currents using always the optimum local current. The description is somewhat unsatisfactory owing to the absence of detailed explanation. The parallel-ohm method was employed, but what precautions were taken to avoid erroneous results are not stated. Up to a certain point the audibility was found to be roughly proportional to both the received and local currents, but the latter reached an optimum value beyond which the audibility was practically independent of the local current. It is stated that good tone and amplification due to heterodyne action can be obtained with quenched spark signals if proper adjustments are made.

687. WAVEMETER WITH CAPACITY BRIDGE. F. Kock. (*Physikalische Zeitschrift*, 21, pp. 214—216, April 15th, 1920.)

A description of a compact instrument for army field work, consisting of a wavemeter with buzzer carborundum detector and telephone, together with a set of ratio arm resistances, so that capacities of aerials, etc., can be measured by the bridge method. Range 60—8,000 metres and capacities of 50—200,000 cms.

688. THE OSCILLATORY VALVE RELAY: A THERMIONIC TRIGGER DEVICE. L. B. Turner. (*Journal of the Institution of Electrical Engineers*, 57, Supplement, pp. 50—65, April, 1920. *Technical Review*, 6, p. 548, June 22nd, 1920—Abstract.)

Paper read at a Wireless Sectional Meeting of the Institution of Electrical Engineers, June 30th, 1919. The principle of the relay is dealt with in RADIO REVIEW Abstract No. 196, February, 1920.* Various modifications for special purposes are described in the original paper, which also includes a report of the discussion.

689. DIFFERENTIAL VALVE RELAYS. L. B. Turner. (*British Patent* 142333, June 4th, 1919. Patent accepted, May 6th, 1920. *Engineer*, 129, p. 613, June 11th, 1920.)

The essential features of the arrangement described are indicated in Fig. 7. Two triode valves V_1 V_2 are connected up with the common filament battery V_1 and H.T. battery B_2 so that their plate circuits include the windings of the differential relay R. The plate currents traverse the winding R in opposite directions so that their resultant effect may be balanced

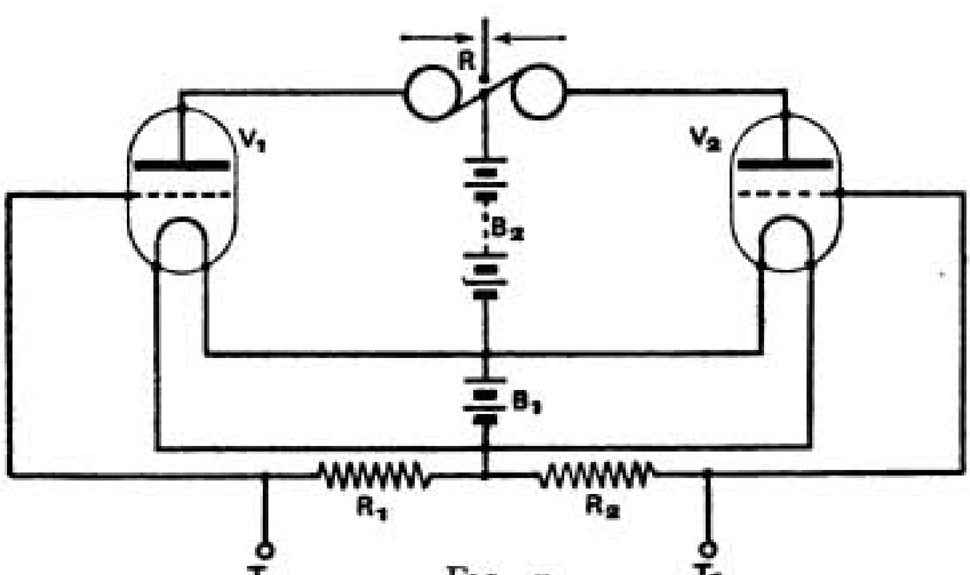

FIG. 7.

out in their normal condition. The grid circuits of the valves include resistances R_1, R_2 across which the incoming signal is applied by means of the terminals T_1, T_2. The passage of a current through the resistance R_1 R_2 upsets the balance of the valves and causes the relay to operate. Alternatively the resistance R_1 R_2 may be replaced by the secondary winding of a differential transformer through the primary of which the incoming signal is passed.

690. RECORDING OF EIFFEL TOWER TIME SIGNALS FOR DETERMINATION OF CLOCK ERROR. L. B. Turner. (*Electrical World*, 75, p. 687, March 20th, 1920—Abstract. *Science Abstracts*, 23A, p. 261, Abstract No. 666, May 31st, 1920—Abstract.)

See RADIO REVIEW Abstract No. 244, March, 1920.

691. THE PRINCIPLE OF THE ATMOSPHERIC ELIMINATOR. W. E. Cragor. (*Model Engineer*, 42, pp. 385—386, May 20th, 1920.)

A selective receiver is described to eliminate atmospherics and jamming. The apparatus

* See also RADIO REVIEW Abstracts No. 244, March, 1920, and No. 690, August, 1920.

depends upon acoustic tuning of diaphragms under the influence of an electromagnet through which the signals are passed.

692. A PORTABLE SET, AND SOME PROPERTIES OF C.W. SETS. R. C. Clinker. (*Wireless World*, 7, pp. 712—721, March, 1920. *Engineer*, 129, p. 394, April 16th, 1920—Abstract. *Everyday Science*, 2, p. 110, June, 1920—Abstract. *Technical Review*, 6, p. 385, April 27th, 1920—Abstract. *Electrical Review*, 86, p. 505, April 16th, 1920—Abstract. *Electrician*, 84, p. 406, April 9th, 1920—Abstract.)

An illustrated description of a compact portable wireless receiver manufactured by the British Thomson-Houston Co., Ltd., and described by R. C. Clinker at a meeting of the Wireless Society of London.*

693. THE PORTAPHONE. (*Scientific American*, 122, p. 571, May 22nd, 1920.)

A brief illustrated description of a portable receiver containing its own loop aerial inside the case.

694. THE WEAGANT GROUP FREQUENCY CIRCUIT. (*Wireless Age*, 7, pp. 16—20, November, 1919.)

In the circuit described a single valve is used with the telephones tuned to the group frequency.

695. THE PRACTICAL CONSTRUCTION OF WIRELESS RECEIVING STATIONS. P. Maurer. (*L'Électricien*, 50, pp. 6—10, January, 1920.)

This article deals with constructional details of the various parts of small receiving stations for experimental use.

696. CRYSTAL AND VACUUM TUBE DETECTORS. E. M. Sargent. (*Radio Amateur News*, 1, pp. 355—356, January, 1920.)

A comparison of the mode of operation of these detectors, by consideration of their characteristics.

697. STRAIGHT DETECTION *versus* THE OSCILLATING TUBE. (*Scientific American*, 122, p. 157, February 14th, 1920.)

Briefly refers to a report of a test carried out by the U.S. Naval Aircraft Radio Laboratory with a view to comparing simple detection plus amplification, with a receiver using an oscillating valve. The latter arrangement is favoured, particularly for radio-compass work, in spite of the loss of individuality in the case of spark signals.

698. AERIAL ARRANGEMENTS FOR WIRELESS SIGNALLING. F. A. Kolster. (*British Patent* 137073, December 24th, 1919. Convention date, November 27th, 1916. Patent not yet accepted but open to inspection.)

The essential feature of the radiating circuit described lies in the separation of the inductance and capacity of the aerial instead

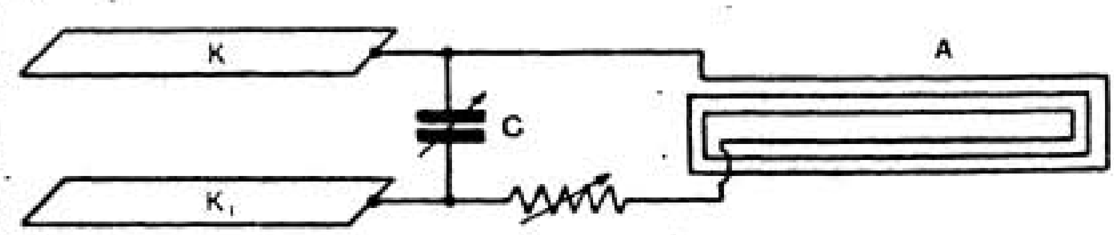

FIG. 8.

* See RADIO REVIEW, 1, pp. 292—293, March, 1920; also RADIO REVIEW Abstract No. 527, July, 1920.

of their being jointly distributed as in the ordinary arrangement. The arrangement described is practically an ordinary frame aerial with a variable condenser for tuning purposes and excited by a spark or arc transmitter. For directional purposes the aerial system may be arranged as in Fig. 8, in which the inductance takes the form of the elongated loop A and the capacity that of the elongated pair of capacity areas K K_1. An additional variable condenser C may be added for tuning purposes. Radiation is a maximum in the plane of the coil and plates.

699. DESIGNING AN AMATEUR TRANSMITTING ANTENNA. E. T. Jones. (*Radio Amateur News*, 1, p. 358, January, 1920.)

Curves of fundamental wavelength are given for aerials of various heights and spans.

700. NOTES ON RADIO ANTENNAS. (*Everyday Engineering Magazine*, 8, pp. 229—230, January, 1920.)

A brief summary of the chief properties of ordinary antennæ, loop aerials, and condenser aerials.

701. ANTENNÆ. J. Hettinger. (*French Patent* 498983, May 1st, 1917. Published January 28th, 1920.)

The invention consists in the use, as transmitting and receiving aerials for wireless telegraphy and telephony, of beams of ionised air, such as searchlight beams containing ultra-violet rays. It is also proposed to use such beams as electrically-conductive connections between fixed or movable stations. A single beam, projected by an arc or mercury-vapour lamp enclosed in a quartz vessel, is used as a transmitting aerial, and is connected through an electrode and spark gap to earth in the usual way, the aerial being coupled directly or inductively to the producing or receiving circuits. If desired two or more beams, either parallel or converging, may be employed, the two beams being produced by a single source by means of reflecting plates. The arc or spark gap in the oscillation circuit may be used as the source of ultra-violet rays. The electrode connecting the beam with the wire leads may be a grid lying across the beam or a series of spaced concentric cylinders with their axis along the beam, or a plurality of pointed spikes or projections with spaces between. Other forms are also described. The electrode for reflecting the beam consists of a metallic plate having a number of small reflecting surfaces, the surface facing away from the source of the beam being highly polished or covered with metal such as rubidium or an alloy of potassium and sodium which is highly sensitive to the photo-electric effect. The other face is covered with or formed of a metal which is only slightly sensitive, such as copper. The ionised beam may be combined with metallic aerials and may be partly or wholly saturated by direct current or alternating current of low frequency. The oscillations are then superimposed thereon.

For further particulars see British Patent 124833, also RADIO REVIEW Abstract No. 702.

702. A HIGH ANTENNA WITHOUT HIGH MASTS. J. Hettinger. (*Wireless Age*, 7, pp. 21—23, November, 1919. *Science Abstracts*, 23B, p. 170, Abstract No. 341, March, 1920—Abstract.)

The use of beams of ultra-violet light to ionise the air is suggested for obtaining a convenient elevated antenna.

703. A NEW FORM OF WIRELESS AERIAL. (*Electrical Review*, 86, p. 367, March 19th, 1920.)

Refers to some experiments at Scheveningen on a form of earth aerial.

704. WIND EFFECTS IN TOWER DESIGN. R. Fleming. (*Engineering News-Record*, 83, pp. 640—664, October 2nd, 1919. *Science Abstracts*, 23B, p. 17, Abstract No. 34, January 30th, 1920—Abstract.)

This paper summarises American practice with regard to the design of various towers to resist wind. The treatment includes towers for wireless aerials.

705. IMPERIAL WIRELESS COMMUNICATIONS. (*Electrical Review*, 86, p. 337, March 12th; pp. 377—379, March 19th, 1920. *Electrician*, 84, p. 283, March 12th, 1920. *Engineer*, 129, p. 280, March 12th, 1920. *Telegraphen- und Fernsprech-Technik*, 8, p. 217, March, 1920. *Jahrbuch Zeitschrift für drahtlose Telegraghie*, 15, pp. 515—516, June, 1920—Abstract. *L'Elettrotecnica*, 7, p. 170, April 5th, 1920. *Journal of the Franklin Institute*, 189, p. 606, May, 1920. *Technical Review*, 6, p. 385, April 27th, 1920—Abstract. *Science Abstracts*, 23B, pp. 278—279, Abstract No. 549, May 31st, 1920—Abstract.) See also PROPOSED IMPERIAL WIRELESS SYSTEM. (*Wireless World*, 8, pp. 41—43, April 17th, 1920. *Technical Review*, 6, p. 459, June 22nd, 1920—Abstract.)

Marconi's Wireless Telegraph Co., Ltd., have put forward to the Government their proposal for an Empire-wide wireless network. The proposed routes and branches are as follows:—

(1) England to India, and thence to Singapore, Australia and New Zealand, with a branch from Singapore to Hong Kong.
(2) England to Egypt, and thence to East Africa and South Africa.
(2A) England to Egypt, and thence to India, Singapore, etc.
(3) England to West Africa, and thence to South Africa; with a branch from West Africa to South America.
(4) England to West Indies.
(5) England to Montreal, and thence to Vancouver.
(6) Australia to Vancouver (only night service to begin with).

The use of C.W. transmission is recommended. Apparatus is already being assembled capable of dealing efficiently with an output of 100 kW. giving an aerial power of 75 kW. An aerial current of upwards of 300 amperes is expected.

The proposed aerial system for reception is that due to Franklin, an important characteristic of which is the absence of long horizontal aerial wires, which enables the various receiving systems to cross one another. The scheme of communications outlined depends fundamentally upon the adoption of the Franklin aerial.*

706. REVIEW OF TELEGRAPHY IN 1919. (*Journal Télégraphique*, 44, pp. 1—3, January 25th, 1920.)

Includes a list of recently opened routes of radiocommunication, and references to radiotelephone tests.

707. NOTES ON THE TELEFUNKEN SYSTEM. W. D. Owen. (*Radiograph*, 1, pp. 135—137, May, 1920.)

A brief illustrated description with circuit diagrams and particulars of various parts of a Telefunken installation captured during the war.

708. THE PRIESS LOOP SET: II. TRANSMITTER.† W. J. Henry. (*Radio Amateur News*, 1, p. 334, January, 1920.)

The set is excited from a 500 cycle power transformer operated from a 10 volt battery. The three turns of the transmitting loop are connected in parallel in order to obtain a low resistance. The article includes a wiring diagram and illustrations of the parts of the set.

709. A LIGHT-WEIGHT AIRPLANE TRANSMITTER. (*Everyday Engineering Magazine*, 8, pp. 228—229, January, 1920.)

An illustrated description of a ½ kW. set manufactured by the E. J. Simon Co.

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* See also pp. 543—544 of this issue.
† See also RADIO REVIEW Abstract No. 530, July, 1920.

710. RADIO TELEGRAPH AND COMPASS SERVICE ON THE COAST IN THE NEIGHBOURHOOD OF NEW YORK HARBOUR. (*Telegraph and Telephone Age*, 38, pp. 17—18, January, 1920. *Aire, Mar y Tierra*, 2, pp. 43—44, January, 1920.)

Deals with the radio traffic control arrangements near New York (see RADIO REVIEW Abstract No. 203, February 1920).

711. RADIOTELEPHONY ON MOUNT HOOD. C. M. Allen. (*Radio Amateur News*, 1, p. 336, January, 1920.)

Describes an installation used in connection with the Forest Protective Service.

712. CHRISTIANIA WIRELESS STATION. (*Teknisk Ukeblad*, January 16th, 1920. *Technical Review*, 6, p. 177, February 17th, 1920—Abstract.)

A note to the effect that this station was officially opened on January 10th last. The installation works on the Arco system and is to be used exclusively for European messages, while the Stavanger station is reserved for American traffic.

713. WIRELESS TELEGRAPHY IN CABA JUBY. (*Aire Mar y Tierra*, 2, pp. 17—21, January, 1920.)

A general description of the station.

714. WIRELESS COMMUNICATION ON THE LACKAWANNA RAILROAD. (*Telegraph and Telephone Age*, 38, pp. 67—68, February 1st, 1920.)

A brief note relative to the resumption of radio work and experiments on the use of wireless on the trains of the Lackawanna Railroad Company. A number of illustrations of the installations are included.

715. WIRELESS AND EVERYDAY BUSINESS. B. F. Miessner. (*Scientific American*, 122, p. 182, February 21st, 1920.)

The applications of radiotelephony on the Lackawanna Railroad and elsewhere are dealt with.

716. DEVELOPMENT OF WIRELESS TELEGRAPHY. (*Aire Mar y Tierra*, 2, pp. 55—56, January, 1920.)

717. THE WIRELESS ERA. (*N.P.L. Review*, 1, pp. 10—14, March, 1920.)

A general article describing briefly the triode valve and some of its applications.

718. PROGRESS IN THE ART OF COMMUNICATION. B. Gherardi and F. B. Jewett. (*Electrical World*, 75, pp. 202—204, January 24th, 1920.)

Includes a very brief *resumé* of radio developments during 1919, in the three chief branches of Radiotelegraphy, Radiotelephony, and Radiogoniometry.

719. AN INTERESTING AUDION CONTROL BOX. M. B. Sleeper. (*Everyday Engineering Magazine*, 8, pp. 316—317, February, 1920.)

An illustrated description of a valve receiver manufactured by the Wireless Improvement Company (New York).

720. THE ANNUAL PHYSICAL SOCIETY AND OPTICAL SOCIETY EXHIBITION. (*Electrician*, 84, pp. 63—65, January 6th, 1920; pp. 117—119, January 30th, 1920; pp. 146—147, February 6th, 1920.)

Contains detailed descriptions of the electrical and wireless exhibits.*

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* See also RADIO REVIEW, 1, p. 240, February, 1920.

721. STANDARDISATION OF ELECTRICAL INDICATING INSTRUMENTS FOR USE WITH RADIO APPARATUS. G. Y. Allen. (*Electrical Journal*, 16, pp. 494—500, November, 1919. *Science Abstracts*, 23B, p. 33, Abstract No. 65, January 30th, 1920.)

This paper describes with numerous illustrations the work carried out by the U.S. Navy in co-operation with various instrument-making firms towards standardising ammeters, voltmeters, etc., both for direct and alternating currents, and for high and low frequencies. The data includes constructional details of a special radio frequency ammeter with a bulb type of thermo-couple.

722. A 500,000-VOLT CONDENSER FOR TESTING PURPOSES. (*Electrical World*, 74, pp. 404—405, August 23rd, 1919. *Science Abstracts*, 23B, p. 33, Abstract No. 66, January 30th, 1920.)

This condenser has been designed for testing insulators for radio work. It is built for frequencies up to 60,000 cycles and is used in conjunction with a Poulsen arc. It is housed in a special hut outdoors.

723. ELECTRICAL WARNING SIGNALS FOR RAILWAY TRAINS. (*L'Électricien*, 50, pp. 145—149, April 15th, 1920.)

The Augereau system* of wireless communication with moving trains is described, together with a brief *resumé* of other experiments including wireless telephone communication tests with American trains, one of the latter installations being illustrated.

724. SOME DETAILS OF A NEW CONDENSER. M. B. Sleeper. (*Everyday Engineering Magazine*, 8, pp. 314—315, February, 1920.)

An illustrated description of a special form of vane type variable condenser designed to have great mechanical rigidity.

725. TEN-STEP VARIABLE INDUCTOR. (*Electrical World*, 75, p. 761, March 27th, 1920.)

A short note describing and illustrating a new variable inductance for H.F. circuits manufactured by the Clapp-Eastham Manufacturing Co.

726. THE WESTERN ELECTRIC CO.'S LOUD-SPEAKING TELEPHONE. (*Electrician*, 84, p. 300, March 12th, 1920. *Science Abstracts*, 23B, p. 224, Abstract No. 440, Abstract.)

Describes the constructional details of this new telephone and its use with amplifying valves.

727. MANUFACTURING DETAILS OF THE "B" BATTERY. (*Everyday Engineering Magazine*, 8, pp. 226—227, January, 1920.)

728. NEW APPARATUS FOR LIGHT TELEPHONY. H. Thirring. (*Physikalische Zeitschrift*, 21, pp. 67—73, February 1st, 1920.)

A description of improved apparatus developed in Germany during the war but too late to be employed at the front. The transmitter consisted of a searchlight upon the current of which is superposed the microphone current; the receiver consisted of a camera in which the beam is focussed on an improved selenium cell operating a telephone receiver through a four-stage amplifier. The difficulties arising in connection with various types of selenium cells and the troubles due to the self-excitation of the amplifiers are discussed. Even with a four-stage amplifier and a 35 cm. searchlight the range is only 8—9 km. The author entirely discredit's Ruhmer's claim to a range of 15 km.

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* RADIO REVIEW Abstract No. 566, July, 1920.

729. TELEGRAPHY AND TELEPHONY BY LIGHT RAYS. T. W. Case. (*French Patent* 499912, September 24th, 1918. Published February 26th, 1920.)

This specification describes a method of and apparatus for signalling by radiant energy. Light waves are utilised to vary a local current in accordance with a variation in the light waves produced at the sending station.

For further particulars, see British Patent 132341.*

730. PUTTING INFRA-RED RAYS TO WORK. G. Gaulois. (*Scientific American*, 122, p. 248, March 6th, 1920.)

A description of a photophone signalling arrangement using infra-red rays used during the war. A six-valve amplifier was used in conjunction with the receiver. Particulars of the filters for cutting out the visible rays from the transmitting searchlight are also given.

731. TELEPHONING BY LIGHT. A. O. Rankine. (*Nature*, 104, pp. 604—606, February 5th, 1920.)

A summary of early work, together with a description of the arrangements due to the author.†

732. THE TRANSMISSION OF SPEECH BY LIGHT. A. O. Rankine. (*Science Abstracts*, 23A, p. 52, January 30th, 1920—Abstract.)

See RADIO REVIEW Abstract No. 178, January, 1920.

733. GERMAN AIRCRAFT RADIOTELEGRAPHY. E. Niemann. (*Jahrbuch der Drahtlosen Telegraphie*, 14, pp. 69—89, and 190—206, May and July, 1919. *Electrical World*, 75, p. 687, March 20th, 1920—Abstract.)

The article gives a description of a number of airplane stations for various purposes, and deals in detail with many practical questions.

734. FLYING OVER CLOUDS IN RELATION TO COMMERCIAL AERONAUTICS. M. Jones. (*Aeronautical Journal*, 24, pp. 220—249, May, 1920.)

The use of wireless telephony is discussed in connection with cloud flying in commercial aviation.

735. USE OF WIRELESS FOR PRESS PURPOSES. H. Bredow. (*Elektrotechnische Zeitschrift*, 41, pp. 75—76, January 22nd, 1920.)

A discussion from many points of view of the relative advantages and disadvantages of wireless and wire telegraphy for the distribution of news.

736. SOME DEVELOPMENTS IN THE ELECTRICAL INDUSTRY DURING 1919. J. Liston. (*General Electric Review*, 23, pp. 4—56, January, 1920.)

A short section on radio communication is included in this *resumé*. The 200 kW. Alexanderson alternator is dealt with particularly and the special regulator for maintaining constant speed is described. The high-frequency alternators are usually driven by 60 cycle induction motors fed from public power lines. One or more choke coils may be inserted in the supply line to the induction motor and the direct current saturation of these chokes controlled by means of a vibrating regulator of the ordinary power station type. The operation of the regulator is controlled by rectified current derived from a tuned high frequency circuit fed from the H.F. alternator.

737. A NEW POWERFUL WIRELESS COMPANY. (*Wireless Age*, 7, pp. 10—12, November, 1919. See also *Telegraphen- und Fernsprech-Technik*, 8, p. 33, May, 1920.)

Deals with the formation of the Radio Corporation of America.

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* RADIO REVIEW Abstract No. 320, April, 1920.

† See RADIO REVIEW Abstracts No. 178, January, 1920, No. 255, March, 1920, and No. 732.

738. RADIOTELEGRAPHIC STATISTICS FOR 1918. (*Journal Télégraphique*, 44, pp. 22—28, February 25th, 1920.)

Gives numerous particulars (number of stations of various classes, number of messages, receipts, etc.) classified under the various countries of the world.

739. LOCATING UNDERGROUND PIPES AND CABLES WITH WIRELESS APPARATUS. M. Dieckmann. (*Elektrotechnische Zeitschrift*, 41, pp. 435—436, June 3rd, 1920.)

A quenched spark transmitter connected to a frame aerial and a detector and telephone receiver connected to another frame aerial are used as transmitter and receiver. The signals will be strongest when the two coils are over the pipe or cable.

740. WIRELESS SIGNALS ON LOCOMOTIVES. J. Trevieres. (*Le Génie Civil*, 76, pp. 391—394, April 24th, 1920.)

A description of a system under trial in France in which the movement of the signal closes a circuit and operates a wireless apparatus (Ruhmkorff coil and spark-gap) connected to an aerial alongside the track. The locomotive carries a receiving aerial and coherer by means of which a steam whistle is controlled.*

741. A RADIO RESEARCH BOARD. (*Nature*, 104, p. 638, February 12th, 1920. *Electrical Review*, 86, p. 209, February 13th, 1920.)

A list is given of the members of this Board which was recently established by the Department of Scientific and Industrial Research.

742. THE CONTROL OF WIRELESS TELEGRAPHY IN ENGLAND. (*Revue Générale de l'Électricite*, 7, p. 4B, January 3rd, 1920.)

Discusses the question of the undesirability of restricting "amateur" wireless activities.

743. X-RAY PHOTOGRAPHS OF RADIO APPARATUS. P. C. Rouls. (*Radio Amateur News*, 1, p. 688, June, 1920.)

The author refers to the use of X-ray photographs for rendering visible the arrangement of the wiring in the interior of radio apparatus. The method is particularly useful when the wiring is bedded in the interior of insulating panels.

744. USE OF RADIO BY TRANSMISSION COMPANIES. G. A. Iler. (*Electrical World*, 75, pp. 376—377, February 14th, 1920. *Science Abstracts*, 23B, p. 220, Abstract No. 430, April, 1920, Abstract.)

Illustrates the apparatus used by the Georgia Railway and Power Co. at their central and other stations. No trouble was experienced from the H.T. lines provided the aerials were arranged symmetrically with respect to the lines. The possible future use of wireless telephony is also discussed.†

745. TWO PHENOMENA DISCOVERED BY MEANS OF AMPLIFIERS. H. Barkhausen. (*Physikalische Zeitschrift*, 20, p. 401, September, 1919. *Elektrotechnische Zeitschrift*, 41, p. 379, May 13th, 1920—Abstract. *Wireless World*, 7, pp. 691—692, March, 1920—Abstract. *Technical Review*, 6, p. 342, April 13th, 1920—Abstract.)

If thin well-annealed iron is subjected to a steadily changing magnetising force, the E.M.F. induced in a coil gives noises in an amplifier, indicating sudden molecular movements. Peculiar sounds heard with amplifiers connected to earth wires are also mentioned.

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* See also RADIO REVIEW, 1, Abstracts No. 566, July, 1920, and No. 723.
† See also RADIO REVIEW Abstract No. 414, June, 1920.

746. ALTERNATING CURRENT AMPLIFIER. H. Könemann. (*German Patent* 303932, December 5th, 1916.)

An amplifier of alternating current consisting of a direct current arc with parallel oscillating circuits of different frequencies (Fig. 9). Sufficient resistance is included to bring the circuits to the verge of self-excitation in which case any impressed current oscillation may be amplified.

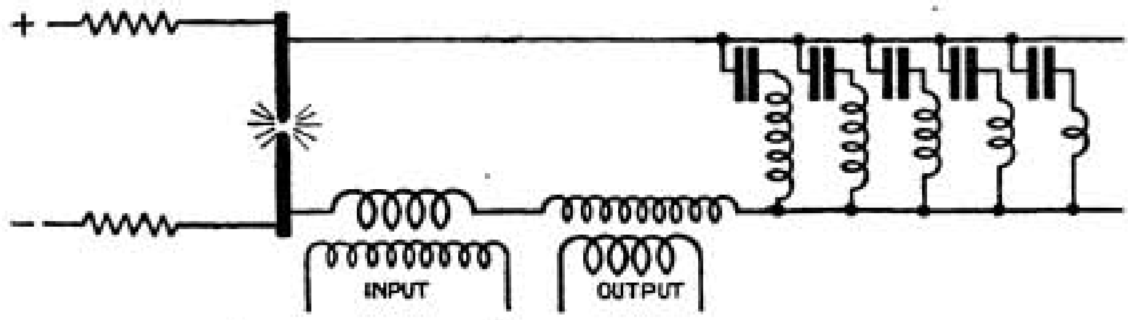

FIG. 9.

747. CATHODE RAY TUBES. Gesellschaft für drahtlose Telegraphie. (*German Patent* 299103, March 21st, 1915. Patent published, September 11th, 1919. Addition to German Patent 298460. *Jahrbuch Zeitschrift für drahtlose Telegraphie*, 15, p. 645, November, 1919—Abstract.)

A cathode ray tube for the amplification or generation of high-frequency oscillations in which the hot cathode of large surface consists of several parallel evenly spaced filaments which are connected electrically in parallel. The cathode and its connections lie in a plane which cuts the grid perpendicularly.

2. Books.

RADIO ENGINEERING PRINCIPLES. By H. Lauer, B.S., and H. L. Brown, B.E.E. (New York: *McGraw-Hill Book Co., Inc.* London: *Hill Publishing Co., Ltd.* 1920. Pp. xv. + 300. Price 21*s.* net.)

This book is written by two former officers of the Signal Corps of the United States Army whose duties were "the preparation of training literature on radio theory and equipment." It contains, no doubt, the gist of a good deal of the literature thus prepared and is now published presumably for the consumption of the purely practical radio expert.

The whole field of modern wireless is covered in a descriptive manner with at intervals little outcrops of mathematics and extracts from recent papers and patent specifications.

According to the title page, the qualifications of the authors are unimpeachable, but after reading the book the conclusion is unavoidable that they do not understand the underlying principles of their subject. The book is full of statements which are either incorrect or misleading. These statements are distributed throughout the whole book and occur as frequently in the description of the action of specific pieces of apparatus as in the discussion of general principles. In many places, too, mere statements of facts are paraded in the guise of logical arguments.

To take the individual chapters in order, the first is a refreshing attempt to break away from the usual dull *résumé* of electromagnetic theory found in the opening chapters of the majority of similar books. But it is disappointing to find it neither a logical statement of the modern electron theory nor a pleasantly readable account of the modern views of electricity.

Chapter II. deals with single and coupled oscillating circuits, and is perhaps a little more satisfactory than the first chapter. In Chapter III., the suspicion that arose when reading Chapter I., viz. that the authors do not understand the generally accepted theory of electromagnetic waves, becomes a certainty. Nor are they much happier in their description of the oscillations in an open earthed aerial.

Chapter IV. is the first chapter dealing with the application, and consists of a very passable account of the older damped-wave telegraphy, both transmitting and receiving. The usual methods are described and the advantages of loose-coupled receivers are well accentuated. Chapter V. corresponds to Chapter IV. but deals with the continuous-wave systems other than the valves. The essential features of the alternators and arcs are well described and heterodyne reception is dealt with fairly completely.

Chapter VI. contains a good general account of the three-electrode valve. The amplification factor of the valve is discussed at some length and its relation to the slopes of the characteristics worked out—albeit a little inconsistently at one or two points. Chapter VII. deals with the use of the valve for detecting. As in the majority of text books the detecting action with the grid insulating condenser is badly described. Chapter VIII. deals with amplifiers and on the whole is good. All the amplifier circuits of Figs. 147 and 148, 150, 152 and 153 have the anode battery shown on the valve side of the anode circuit. In practice the leakage and earth capacity of the battery would reduce the high-frequency amplification to a negligible amount with this arrangement. Also, separate batteries are shown for each valve. All this may be intentional, with a view to simplifying the explanations. But it is not stated that this is the case and the reader is led to suppose that this is the usual procedure. The claim for an amplification of 10^{14} for a seven-valve Signal Corps amplifier must surely be a record !

The ninth chapter deals with the valve as an oscillator, and is again quite good up to a point. It is noticeable that nothing—or practically nothing—is said of the limitations of output from a tube and the conditions prescribing these limits. Many circuits are described, but not at all from the practical point of view.

Radiotelephony, Chapter X., is quite well done. Here the authors are evidently more at home, but the following statement on the top of p. 254 gives one food for thought :—" During the travel of the waves through the æther from the transmitting to the receiving station, voice modulations of high frequency or pitch are absorbed to a greater extent than those of lower frequency."

Chapter XI. deals with direction finding and but for the now well-established impression that the authors do not understand the electromagnetic wave theory, might be very good indeed.

The last chapter gives a very short account of the application of wireless apparatus to special purposes such as aircraft, submarines, laboratory work, etc.

In spite of all these criticisms, this book has however one saving grace. Except in a few cases where very recent and untested apparatus is discussed (as for example on pp. 256 and 257) the perspective is essentially practical and up-to-date. Only those points are stressed which are of importance, and side issues are in general avoided. This is a merit not to be found in all books and will act as a counterpoise to some at any rate, of the defects mentioned. To the operator or amateur whose interests are purely practical and who does not desire the niceties of scientific accuracy this book may be recommended.

The printing and reproduction are in keeping with the usual high standard of the McGraw-Hill Co., and the number of mere printer's errors is no more than is to be expected in a first edition.

C. L. FORTESCUE.

TREATMENT OF HARMONICS IN ALTERNATING CURRENT THEORY BY MEANS OF A HARMONIC ALGEBRA. By A. Press. (Berkeley, U.S.A.: *The University of California Press*. 1919. Pp. 66. Price $1.00.)

The object of this pamphlet is to give a mathematical discussion of the problem of wave-form in iron-cored inductances when an alternating current is applied to them. It is well known that owing to the saturation and hysteresis of such iron cores various higher harmonics appear in the current and flux wave-forms depending on the actual conditions. If it is assumed that the magnetising force, and therefore the magnetising current, is a pure sine wave the problem presents no difficulty; but unfortunately this is not the case which usually occurs. Generally the problem appears in the reverse form. The wave-form of the applied voltage and therefore of the resultant flux is known and it is required to deduce from this the current wave-form. In this form the problem has so far defied solution by mathematical means.

Mathematically this means that in the equation $B=\mu H$, μ is not a constant but a two-valued function of B.

The basis of the author's method is to introduce an operator function Q_m such that Q_m operating on $\sin pt$ produces $\sin mpt$. An operator calculus is thus derived by means of which this inverse operation is effected. The successive coefficients in the Fourier expansion of H are evaluated term by term, the algebra being fairly simple except in a few special cases. The method is applied to verify some results given by Hague and Neville in the *Electrician*, October 13th, 1916, but the discrepancies are rather large.

The special calculus is also applied to various other problems which arise in alternating current engineering such as the distribution of flux density in a mass of iron subjected to an alternating E.M.F. and formulæ are deduced for the power lost in such cases.

The work is not, of course, of special interest to the radio engineer whose use of iron cores is strictly limited; even when used they are worked at extremely low densities. It might, however, possibly come in in the design of control chokes for radiotelephony in connection with speech distortion.

J. HOLLINGWORTH.

LA TELEFONIA SENZA FILO. By Umberto Bianchi. (Milan: *Ulrico Hoepli*. 1920. Pp. viii. + 296. Price L. 10.)

A very unpretentious account of the development and present state of radiotelephony. No mathematical expression or symbol occurs in the whole volume and the book is evidently intended for a non-technical reader. It contains many inaccuracies, however, and one would hesitate to recommend it to such a reader. In addition to misleading descriptions of phenomena, one comes across such things as the following:—" un' energia primaria di 900 volts e una energia radiata di 300 watts," neither volts nor watts being units of energy. The book is profusely illustrated, but many of the photographs are very poorly reproduced.

G. W. O. H.

Books Received.

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

THE HOW AND WHY OF RADIO APPARATUS. By H. W. Secor. (New York: *Experimenter Publishing Co. Inc.* 1920. Pp. 160. Price $1.75.)

ETUDE DE QUELQUES PROBLEMES DE RADIOTÉLÉGRAPHIE. By H. de Bellescize. (Paris: *Gauthier-Villar et Cie.* 1920. Pp. 174. Price 16 fr.)

ÉLÉMENTS DE TÉLÉGRAPHIE SANS FIL PRATIQUE. By F. Duroquier. (Paris: *H. Dunod*. Second Edition. 1920. Pp. 130. Price 6 fr. 75.)

RADIOTÉLÉGRAPHIE PRATIQUE ET RADIOTÉLÉPHONIE. By P. Maurer. (Paris: *H. Dunod*. 1920. Pp. 386. Price 21 fr.)

A New French Radio Journal.

The first issue of a new French journal *Radioélectricité* has recently been published in Paris under the auspices of the *Revue Générale de l'Électricité*. This new monthly publication is addressed to all classes of radio workers and is to include technical and theoretical articles as well as more practical ones addressed to the experimenter and amateur. Special sections will be devoted to maritime and commercial information including matter of interest to ship wireless operators. A review of books and current periodicals is also to be included.

The Administrative Committee, under the presidency of M. J. Carpentier, includes the following engineers: MM. Brenot, Brylinsky, Dupont, Girardeau, de Valbreuze and Lezaud.