THE
WIRELESS ENGINEER
AND
EXPERIMENTAL WIRELESS

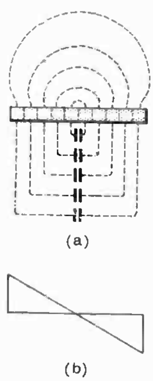
Vol. XII. | JUNE, 1935 | No. 141

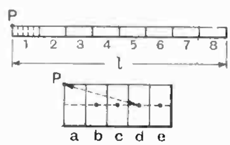
Editorial

The Behaviour of High Resistances at High Frequencies

THOSE who are experienced in making very accurate measurements involving the use of high resistances with alternating currents are familiar with the dangers which arise from capacity effects. These effects increase with the frequency, and now that many people are using frequencies of the order of 30 million in connection with short-wave work, it is no longer a matter of a small correction of a few parts in a thousand but a major effect which may, as we shall see, reduce the effective value of the resistance to a small fraction of its nominal value. The less experienced experimenter who finds his megohm behaving as if it had a resistance of 50,000 ohms may be forgiven for jumping to the conclusion that he is in the presence of some mysterious " effect " and proceeding to christen it.

We shall take as the basis of our calculations the simplest form of resistance—one which is very commonly employed—viz., a cylindrical rod, which may consist either of solid resistance material or of a rod or tube of glass, or other insulating material, coated with a thin film of metal. If a steady p.d. be applied to it the fall of potential along it will be linear (Fig. 1*b*) and an electrostatic field will be set up as shown in Fig. 1 (*a*). The capacitance of each unit of length is the quotient of the charge on it divided by the





(*Left*) Fig. 1.

(*Above*) Fig. 2.

p.d. between it and the oppositely charged element on which the electric lines of force terminate. Now, although the fall of potential along the resistance for a steady current will be linear, as shown in the figure, the distribution of charge will not be linear, but will be much more crowded towards the ends; it can be shown that although the potential is proportional to the distance from the centre, the density of the charge is more nearly proportional to the square of the distance. It follows from this that the capacitance per unit length will vary from point to point, but as this would make the problem almost impossible of mathematical solution, we shall adopt a simple approximation which will give us an average value of the capacitance per unit length. We assume that the charge is distributed linearly, that is, that the charge per unit length is proportional to the distance from the centre, as shown in Fig. 1 (b), and we calculate the resulting distribution of potential. This is much simpler than the converse problem. We take as a concrete example a rod with a length 20 times its diameter, and we divide it into 8 sections as shown in Fig. 2. If the length of the rod is l cm, each section has a length $l/8$, and if the charge per unit length is qx, where x is the distance from the centre, the charge on each section can be calculated. The potential at any point P on the rod can now be calculated by taking the charge on each section and dividing it by the distance of the midpoint of the section from the point P. This will be quite accurate enough for all sections except those adjacent to P, for which we adopt a different procedure. The charges, distances, and calculated potentials for the point P at the positive end of the rod are set out in Table I. The calculation of the potential due to Section 1 is set out in Table II and illustrated in the lower diagram in Fig. 2; the section has been further subdivided into five subsections, a, b, c, d and e, and the distances measured from P to the centre point of each. Even this would hardly be accurate enough for subsection a, on which P is situated, and the first line of Table II has therefore been calculated from the formula for the potential at a point on the edge of a narrow ring of width w and radius a with a charge σ per sq. cm of surface, viz. $V = 2\sigma w(\log_e \frac{8a}{w} + 1)$. This gives 0.4775 ql which is inserted in the first line of Table II, giving a total potential at P due to Section 1 of 1.0938 ql which is then entered in the first line of Table I. Adding all the positive potentials and subtracting the negative we get the final result of 1.2403 ql for the potential at P. Similar tables have been calculated for the potentials at the junction points of the various sections; these are not reproduced here, but the results are plotted in Fig. 3 for the positive half of the rod; for the other half the curve would be a replica below the base line. If as an approximation we assume this curve of

TABLE I.

Section No.	Charge on Section.	Distance from P.	Potential at P.			
	$ql^2/128$	$l/16$	$ql/8$	ql	ql	ql
1	7	—	—	1.0938	1.3947	1.2403
2	5	3	5/3	0.2080		
3	3	5	3/5	0.0750		
4	1	7	1/7	0.0179		
5	−1	9	−1/9	−0.0139	−0.1544	
6	−3	11	−3/11	−0.0341		
7	−5	13	−5/13	−0.0481		
8	−7	15	−7/15	−0.0583		

Note.—The factor at the top of each column is to be multiplied by the tabulated figures.

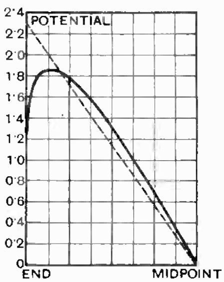


Fig. 3.

TABLE II.

Sub-section.	Charge per Unit Length.	Charge on Section.	Distance.	Potential at P.		
	$ql/80$	$ql^2/3200$	$l/8$	$ql/400$	ql	ql
a	39	39	—	—	0.4775	1.0938
b	37	37	0.36	37/0.36	0.2570	
c	35	35	0.54	35/0.54	0.1620	
d	33	33	0.73	33/0.73	0.1130	
e	31	31	0.92	31/0.92	0.0843	

potential distribution to be replaced by a straight line as shown dotted, we have a linear distribution of both charge and potential and therefore a constant capacitance per unit length. The potential at one end being 2.3 ql and that at the other end $-2.3\, ql$ the p.d. between the ends is 4.6 ql and the charge per unit length at the ends is $ql/2$. This gives a capacitance per unit length of $1/9.2 = 0.109$ electrostatic unit or 0.12 $\mu\mu$F. It should be noted that this is the capacitance per cm of length for any rod, no matter what its actual size may be, so long as the length is 20 times the diameter. We have not investigated the effect of a change in the ratio of length to diameter with any great accuracy, but an approximate calculation showed that if the ratio were reduced from 20 to 10, the capacitance per cm of length would be increased from 0.12 to 0.166 $\mu\mu$F, an increase of 38 per cent. This will enable anyone to form an approximate estimate of the capacitance for any shape occurring in practice.

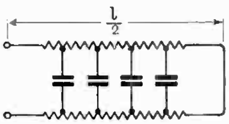


Fig. 4.

In Fig. 1 we have indicated how the capacitance may be represented by a number of condensers connected across the resistance, but it is better for our present purpose to picture the resistance broken at the middle and the two halves connected in series as shown in Fig. 4. The condensers will then be as shown and we see at once that we are dealing with a transmission line problem. If, to take a concrete case, we assume that the rod is 10 cm long and 5 mm diam. with a d.c. resistance of a megohm, each half will be 5 cm long and we have a transmission line 5 cm long with a resistance of 200,000 ohms per cm, and a capacitance of 0.12 $\mu\mu$F per cm. We can safely neglect the inductance. The line is short-circuited at the receiving end, and for this case the formula for the apparent impedance at the sending end is

$$Z = Z_0 \tanh al$$

where Z_0 is the characteristic impedance, *i.e.* the impedance which the line would appear to have if it were infinitely long. In the present case $Z_0 = \sqrt{\dfrac{r}{j\omega C}}$, $a = \sqrt{j\omega Cr}$

where r, the resistance per unit length of the line = 200,000 ohms.

C, the capacitance per unit length of the line = 0.12 $\mu\mu$F.

l, the length of the line = 5 cm

and $j = \sqrt{-1}$.

The formula may be written

$$Z = \sqrt{-j}\sqrt{\frac{r}{\omega C}} \tanh (\sqrt{j}\, l\sqrt{\omega Cr})$$

$$= \sqrt{\frac{r}{\omega C}}\,\underline{|-45^\circ}\, \tanh (l\sqrt{\omega Cr}\,\underline{|45^\circ})$$

As few readers will possess tables of the hyperbolic functions of complex quantities we have plotted in Fig. 5 the values of the necessary hyperbolic tangents, to enable anyone to calculate the impedance for any given resistance and frequency.

The formula can also be written thus

$$Z = lr\frac{\tanh \theta}{\theta} = R\frac{\tanh \theta}{\theta}$$

where $\theta = l\sqrt{\omega Cr}\,\underline{|45^\circ}$ and R is the d.c. resistance.

Readers who can consult Kennelly's "Tables of Complex Hyperbolic and Circular

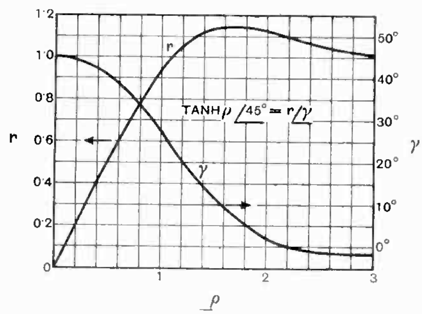


Fig. 5.

Functions" will find the values of $\dfrac{\tanh \theta}{\theta}$ tabulated on pages 26 to 31. This is a very convenient method.

We have tabulated in Table III the calculations for the above resistance at a number of frequencies from 100 cycles per second to 100 million.

Having thus obtained the magnitude and phase angle of the impedance $Z\,\underline{|\phi}$ it is a simple matter to express it as a resistance R'

in parallel with a condenser C', thus,

$$\frac{1}{Z\lvert\overline{\phi}} = \frac{1}{Z}\lvert\underline{\phi} = \frac{1}{R'} + j\omega C'$$

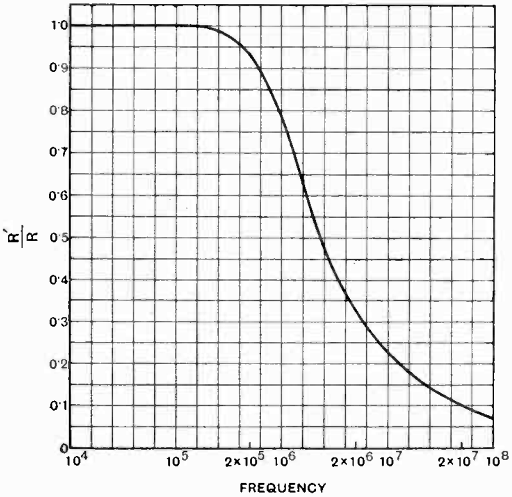


Fig. 6.

$$\therefore \quad \frac{1}{R'} = \frac{1}{Z}\cos\phi \text{ and } \omega C' = \frac{1}{Z}\sin\phi$$

$$\therefore \quad R' = \frac{Z}{\cos\phi} \text{ and } C' = \frac{\sin\phi}{\omega Z}$$

The last two columns in Table III have been calculated in this way and the results are plotted in Figs. 6 and 7. It is thus seen that owing to the unavoidable stray capacitance between the two ends of the rod the effective resistance of this megohm is reduced to 100,000 ohms at a wavelength of 6 metres, and to 73,000 ohms at a wavelength of 3 metres. From the formulae given above it is seen that the value of Z/R, and therefore also of R'/R and $\omega C'/R$, depends only on $\frac{\tanh\theta}{\theta}$ and therefore only on the value of $\theta = l\sqrt{\omega Cr} = \sqrt{\omega lCR}$. If Fig. 6 be plotted

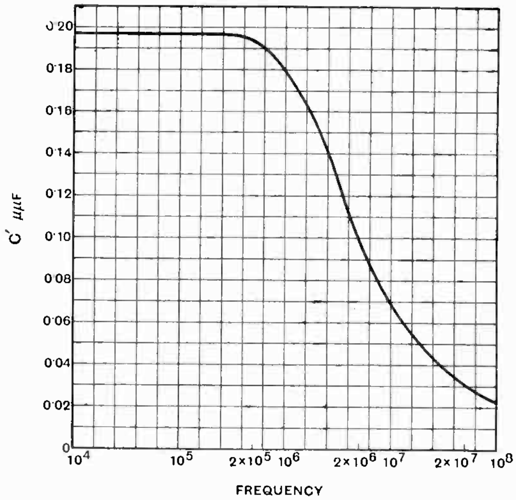


Fig. 7.

to a base of either $\sqrt{\omega lCR}$ or $flCR$ it will be applicable to any resistance by merely inserting the suitable values in this expression.

TABLE III.

	λ Metres.	$\sqrt{\frac{r}{\omega C}}$	$\theta = 5\sqrt{\omega Cr}$	Tanh θ $\underline{\lvert 45^\circ}$	Z Ohms.	R' Ohms.	$C'\mu\mu$F.
10^2	3×10^6	5.16×10^7	0.0194	0.0194 $\underline{\lvert 45^\circ}$	10^6	10^6	0.197
10^3	3×10^5	1.63×10^7	0.0614	0.0614 $\underline{\lvert 45^\circ}$	10^6	10^6	0.197
10^4	3×10^4	5.16×10^6	0.194	0.194 $\underline{\lvert 44.3^\circ}$	10^6 $\lvert\overline{0.7^\circ}$	10^6	0.197
10^5	3,000	1.63×10^6	0.614	0.61 $\underline{\lvert 38^\circ}$	9.94×10^5 $\lvert\overline{7^\circ}$	10^6	0.197
5×10^5	600	7.28×10^5	1.37	1.11 $\underline{\lvert 15^\circ}$	8.08×10^5 $\lvert\overline{30^\circ}$	9.33×10^5	0.194
10^6	300	5.16×10^5	1.94	1.13 $\underline{\lvert 3^\circ}$	5.83×10^5 $\lvert\overline{42^\circ}$	7.85×10^5	0.18
5×10^6	60	2.3×10^5	4.35	1.0 $\underline{\lvert 0^\circ}$	2.3×10^5 $\lvert\overline{45^\circ}$	3.26×10^5	0.098
10^7	30	1.63×10^5	6.14	1.0 $\underline{\lvert 0^\circ}$	1.63×10^5 $\lvert\overline{45^\circ}$	2.3×10^5	0.0691
5×10^7	6	7.28×10^4	13.72	1.0 $\underline{\lvert 0^\circ}$	7.28×10^4 $\lvert\overline{45^\circ}$	1.03×10^5	0.031
10^8	3	5.16×10^4	19.4	1.0 $\underline{\lvert 0^\circ}$	5.16×10^4 $\lvert\overline{45^\circ}$	7.31×10^4	0.022

This has been done in Fig. 8, which can therefore be used for any resistance.

If one takes as a criterion of the performance of a given resistance the frequency at which its effective value is reduced in a given ratio R'/R, this is equivalent to fixing the permissible value of $flCR$. We see then that the critical frequency will be inversely proportional to lCR; decreasing any one of these factors will raise the critical frequency. For a given value of the d.c. resistance R, one can decrease either l or C, the latter of which depends, as we have seen, only on the shape. Keeping the same ratio of length to diameter as we assumed in our example, viz. 20, reducing the length from 10 cm to 1 cm, and the diameter therefore from 5 mm to 0.5 mm, would multiply the critical frequency by 10, and the effective resistance at a frequency of 10^7 would be increased from 0.23 to 0.78 of its nominal value.

For use at very high frequencies such resistances should therefore be made with a very small ratio of diameter to length and the length should be as short as possible. We assume that the question of heating will not arise.

In conclusion, it should be emphasised that the above treatment of the problem is only approximate. At low frequencies, at which the fall of potential is approximately linear, the distribution of charge is far from linear, and the capacitance per unit length is therefore not constant. At the very high frequencies in which we are most interested, the distributions of both potential and charge are greatly modified, and an accurate solution of the problem would be very difficult.

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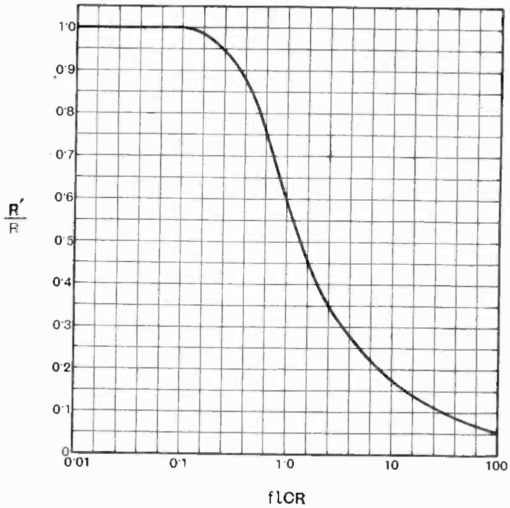
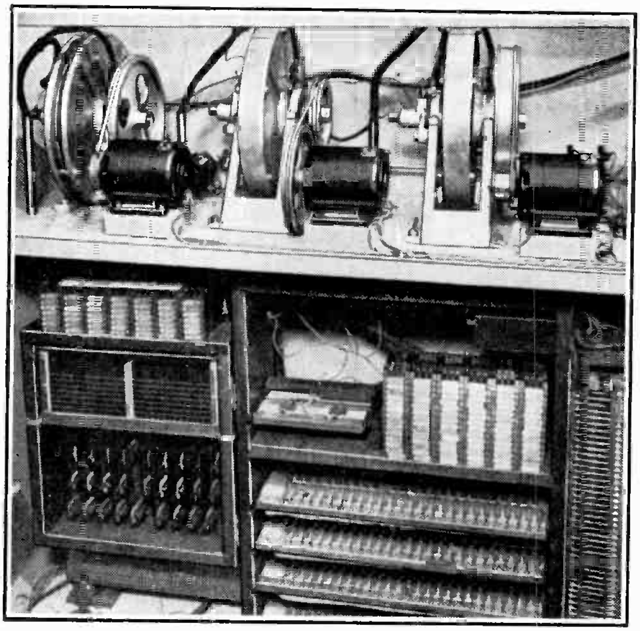


Fig. 8.

Electrical Organ Tones

LOUD speakers and a valve amplifier are used in an interesting instrument developed by the Compton Organ Company. This electrical organ avoids separate valve oscillators, photo-electric cells, etc., for building up the tones. Sine waves of various pitches corresponding to the usual range of fundamentals and harmonics in the musical scale are engraved concentrically on a fixed insulating disc. The grooves are filled in with conducting material and contacts are brought out from each ring. A second disc revolving at constant speed and spaced about a millimetre from the first carries an exploring electrode connected to the grid of the first valve of a power amplifier. The application of a constant D.C. potential to the sine wave conductors in the fixed disc induces an alternating voltage in the revolving electrode and by charging a group of rings simultaneously, any tonal quality can be built up.

In the picture the tone generating discs can be seen mounted above the keyboard and "stop" relays.



An Analysis of Class C Amplification *

By M. Reed, M.Sc., A.C.G.I., A.M.I.E.E.

SUMMARY.—On the assumption that the lumped characteristic of a valve can be represented by a straight line, a series of curves is obtained which enables the performance of a class C amplifier to be easily estimated. It is also shown that, when the ratio of the d.c. to the a.c. component of the lumped potential is less than 0.5, simple equations can be derived for the plate current, the load current and the efficiency of such an amplifier. The design of a class C amplifier from these equations and also from the curves is demonstrated.

General Considerations

A CLASS C amplifier is defined as an amplifier in which the plate current flows for less than half a cycle of the input voltage, *i.e.*, one which is biased beyond cut-off. Since the a.c. voltages applied to the grid of such an amplifier are, in practice, quite large, it is found that a close approximation to the actual conditions, subject to a slight modification mentioned below, can be obtained by assuming that the lumped characteristic of the valve is a straight line of the form shown in Fig. 1a, where i_p is the total plate current,

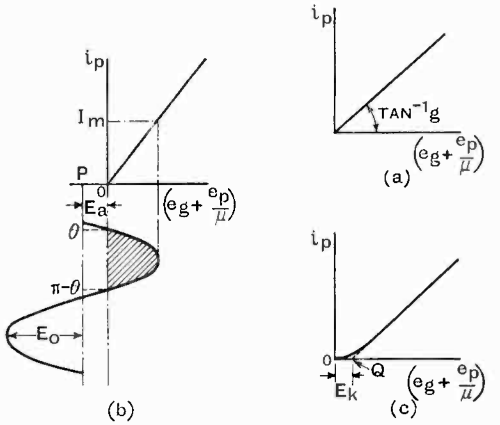


Fig. 1.

e_g the total grid voltage, e_p the total plate voltage and μ the amplification factor of the valve.† For such a curve the plate current is given by

$$i_p = g(e_g + e_p/\mu) \quad \ldots \quad \ldots \quad (1)$$

where, for purposes of approximation, g is assumed constant when $(e_g + e_p/\mu)$ is positive. For negative values of this quantity the current is zero. If R_p is the dynamic plate-filament resistance of the valve, g is given by μ/R_p.

Suppose now that the valve is biased at a value corresponding to P of Fig. 1b and that an a.c. voltage of amplitude E is introduced into the grid circuit, producing a lumped a.c. voltage of amplitude E_0. Plate current will begin to flow at an angle θ when $(e_g + e_p/\mu)$ becomes positive, and it will continue to do so until the angle becomes $(\pi - \theta)$.

The equation for the plate current which flows only between the limits θ and $\pi - \theta$ can be determined from equation (1), and it is given by

$$i_p = g\Big[E_0 \sin - E_a\Big]_{\theta}^{\pi - \theta} \quad \ldots \quad \ldots \quad (2)$$

where

$$E_a' = -E_a = \text{lumped d.c. voltage} = E_c' + E_b/\mu \ddagger \quad \ldots \quad (3)$$

$$E_0 = \text{lumped a.c. voltage} = E - IR_1/\mu \S \quad \ldots \quad (4)$$

E_b = d.c. plate voltage.

E_c' = d.c. grid bias.

R_1 = load impedance at the fundamental frequency.

I = amplitude of the fundamental component of the plate current.

$$\theta = \sin^{-1} E_a/E_0 \quad \ldots \quad \ldots \quad (5)$$

If equation (2) is expressed as a Fourier

* MS. accepted by the Editor, October, 1934.

† Bibliography (1).

‡ In a class C amplifier the lumped d.c. voltage is always negative, consequently, to avoid the complication of a negative sign for E_a, we write $E_a = -E_a'$.

§ Since the plate circuit is tuned to the fundamental frequency, the grid and plate a.c. voltages are 180° out of phase.

Series, the value of I can be evaluated from

$$I = \frac{gE_0}{\pi}\left(\frac{\pi}{2} - \theta - \frac{\sin 2\theta}{2}\right)^* \quad \ldots \quad \ldots (6)$$

Actually, the lumped characteristic generally takes the form shown in Fig. 1c, where the extension of the linear portion cuts the axis at some point Q. To allow for this, a voltage E_k given by the distance OQ is subtracted from E_c', so that equation (3) becomes

$$E_a = -(E_c' - E_k + E_b/\mu)$$
$$= -(E_c + E_b/\mu)$$
$$\text{(where } E_c = E_c' - E_k\text{)} \quad (7)$$

Another quantity of importance is the d.c. plate current. This is given by

$$I_b = \frac{1}{2\pi}\int_0^{2\pi} i_p \, . \, d\theta = \frac{g}{2\pi}\int_\theta^{\pi-\theta} (E_0 \sin\theta - E_a) \, . \, d\theta$$

$$= \frac{g}{\pi}\left\{E_0 \cos\theta - E_a\left(\frac{\pi}{2} - \theta\right)\right\}$$

Hence

$$\frac{I_b}{gE_a} = \frac{E_0}{E_a} \cdot \frac{\cos\theta}{\pi} - \frac{(\pi/2 - \theta)}{\pi} \quad (8)$$

Equations (4), (6), (7) and (8) provide the data necessary for the complete determination of the operation of a class C amplifier; although, in their present form, these equations do not lend themselves to simple computation. In the following, it is shown how the various quantities can be calculated rapidly by graphical methods and also how, given the condition $E_a/E_0 < 0.5$, the equations can be converted into fairly simple expressions for the fundamental component of the plate current, the d.c. plate current and the efficiency.

Fundamental Component of the Plate Current

If we put $K = \frac{1}{\pi}\left(\frac{\pi}{2} - \theta - \frac{\sin 2\theta}{2}\right)$, .. (9)

equation (6) can be written

$$I/gE_a = K.E_0/E_a \quad \ldots \quad \ldots (10)$$

* See Everitt, "Communication Engineering," page 381.

Now, K is a function of θ only which, in turn, is given by equation (5), consequently both θ and K can be plotted against E_a/E_0 as in Fig. 2. From the "K" curve and equation (10), I/gE_a and E_a/E_0 can be related in the way shown by the third curve of Fig. 2. This curve enables the fundamental component of the plate current to be

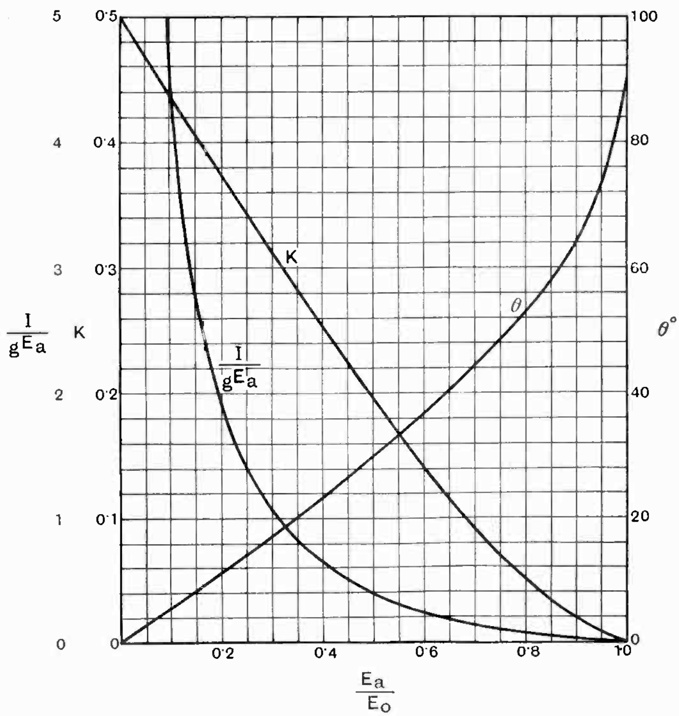


Fig. 2.

determined for any given values of E_0 and E_a. In practice, however, the applied grid voltage E rather than the lumped a.c. voltage is given, hence it is necessary to obtain the relationship between E_0 and E. Substituting the value of I obtained from equation (10) in equation (4), we obtain

$$\frac{E_a}{E} = \frac{E_a}{E_0} \cdot \frac{1}{1 + K \, . \, R_1/R_p}, \quad \ldots \quad (11)$$

from which the curves of Fig. 3 relating E_a/E with E_a/E_0 can be plotted. By utilising the curves of Figs. 2 and 3, it is possible to evaluate the fundamental component of the plate current for given values of E, E_a and R_1.

Fig. 2 shows that, for all practical purposes, the "K" curve can be regarded as linear for values of E_a/E_0 between 0 and 0.5. The equation for this portion of the curve is very closely

$$K = 0.5 - 0.61\, E_a/E_0 \quad \ldots \quad (12)$$

Substituting this value for K in equation (10), we obtain

$$I/gE_a = \frac{E_0}{E_a}(0.5 - 0.61\, E_a/E_0) \quad \ldots \quad (13)$$

and in equation (11), we obtain

$$\frac{E_0}{E_a} = \frac{\dfrac{E}{E_a} + 0.61\, R_1/R_p}{1 + R_1/2R_p} \quad \ldots \quad (14)$$

Combining equations (13) and (14) gives

$$I = \frac{g(E - 1.22E_a)}{2 + R_1/R_p} = \frac{\mu(E - 1.22E_a)}{R_1 + 2R_p} \quad \ldots \quad (15)$$

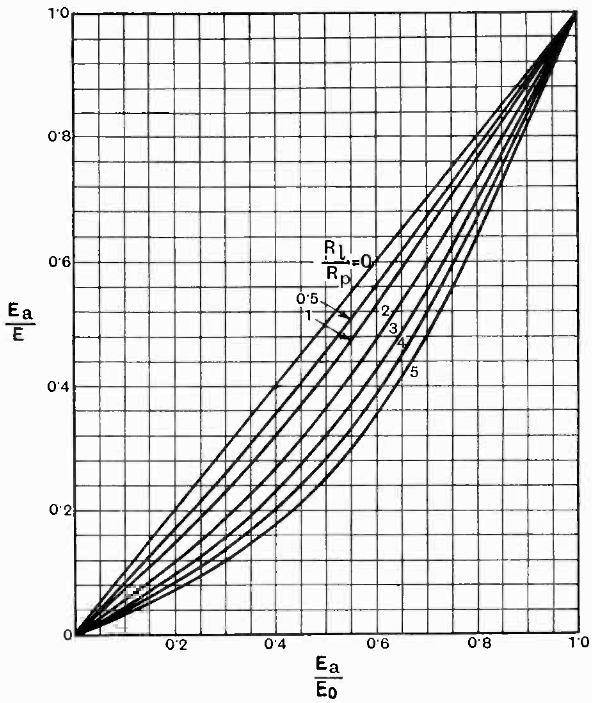


Fig. 3.

The minimum value of E/E_a for which this equation holds is obtained by putting $E_a/E_0 = 0.5$ in equation (14). This gives

$$(E/E_a)_{\text{min.}} = 2 + 0.39\, R_1/R_p \quad \ldots \quad (16)$$

Equation (15) shows that, provided $E_a/E_0 < 0.5$, a linear relationship is obtained between I and E (for a given value of E_a) and between I and E_a (for a given value of E). It therefore follows that the class C amplifier can be employed as a linear power amplifier and also as a linear plate modulator. In the case of the latter E_b is the only variable on the right-hand side of equation (15), whereas in the case of the former E is the only variable.

The equation for the I/gE_a curve for all values of E_a/E_0 can be obtained from equations (5) and (6). Putting $E_a/E_0 = x$, these equations give

$$I/gE_a = 1/\pi\{(\pi/2 - \sin^{-1}x - x(1 - x^2)^{\frac{1}{2}}\}$$

$$= 1/\pi\left\{\pi/2 - \left(x + \frac{x^3}{6} + \frac{3x^5}{40} + \frac{15x^7}{336} + \ldots\right) - \left(x - \frac{x^3}{2} - \frac{x^5}{8} - \frac{x^7}{16} + \ldots\right)\right\}$$

$$= 1/\pi\left(\pi/2 - 2x + \frac{x^3}{3} + \frac{x^5}{20} + \frac{x^7}{56} + \ldots\right)$$

which departs appreciably from linearity as x approaches unity.

D.C. Plate Current

From equations (5) and (8) the curve between I_b/gE_a and E_a/E_0 shown in Fig. 4 can be plotted. The equation of the portion of the curve which lies between the limits $E_a/E_0 = 0$ and 0.5 approximates very closely to

$$\frac{I_b}{gE_a} = 1/\pi\left(\frac{E_0}{E_a} - 1.40\right)$$

$$= \frac{E/E_a - 1.4 - 0.9\, R_1/R_p}{(1 + R_1/2R_p)} \quad \ldots \quad (17)$$

after substituting for E_0/E_a from equation (14).

As a rule R_1 does not differ greatly from R_p, therefore the expression for the d.c. plate current can be simplified to

$$I_b = \frac{\mu(E - 1.5\, E_a)}{\pi R_p(1 + R_1/2R_p)} \quad \ldots \quad (18)$$

The equation which fits the whole of the I_b/gE_a curve can be derived from equations (5) and (8). Putting $E_a/E_0 = x$, these equations give

$$\frac{I_b}{gE_a} = 1/\pi\left\{\frac{(1-x^2)^{\frac{1}{2}}}{x} - \frac{\pi}{2} + \sin^{-1} x\right\}$$

$$= 1/\pi\left\{\left(\frac{1}{x} - \frac{x}{2} - \frac{x^3}{8} - \frac{x^5}{16} + \ldots\right)\right.$$

$$\left. + \left(x + \frac{x^3}{6} + \frac{3x^5}{40} + \ldots\right) - \frac{\pi}{2}\right\}$$

$$= 1/\pi\left\{\left(\frac{1}{x} + \frac{x}{2} + \frac{x^3}{24} + \frac{x^5}{80} + \ldots\right) - \frac{\pi}{2}\right\}.$$

Peak D.C. Plate Current

Fig. 1b shows that the peak a.c. voltage is given by

$$E_m = E_0 - E_a,$$

which produces a peak d.c. plate current

$$I_m = g(E_0 - E_a),$$

or $$I_m/gE_a = E_0/E_a - 1 \quad \ldots \quad \ldots (19)$$

from which the curve of Fig. 4 relating I_m/gE_a and E_a/E_0 can be plotted.

When $E_a/E_0 < 0.5$, equations (14) and (19) give

$$\frac{I_m}{gE_a} = \frac{E/E_a - (1 - 0.11\,R_1/R_p)}{(1 + R_1/2R_p)}$$

Therefore

$$I_m = \mu\left\{\frac{E - (1 - 0.11\,R_1/R_p)E_a}{R_p(1 + R_1/2R_p)}\right\} \quad (20)$$

From equations (18) and (20)

$$\frac{I_m}{I_b} = \left\{\frac{E - (1 - 0.11\,R_1/R_p)E_a}{E - 1.5\,E_a}\right\}\pi \quad \ldots (21)$$

The Efficiency

The output is given by

$$P_0 = \frac{I^2R_1}{2} = \frac{g^2E_0{}^2K^2R_1}{2}$$

from equation (10), and the input is given by

$$P_i = E_bI_b = E_bgE_a\,.\,p,$$

where $$p = I_b/gE_a.$$

Therefore the efficiency is obtained from

$$\eta = \frac{g^2E_0{}^2K^2R_1}{2gE_bE_ap} = \frac{R_1}{2}\cdot\frac{g}{p}\cdot\frac{K^2}{E_b}\cdot\frac{E_0{}^2}{E_a},$$

or $$\frac{2R_p}{R_1}\cdot\frac{E_b}{\mu}\cdot\frac{\eta}{E_a} = \frac{K^2}{p}\left[\frac{E_0}{E_a}\right]^2 \quad \ldots (22)$$

For any given values of E_0/E_a, the value of K and p are known from Figs. 2 and 3 respectively, therefore a curve between the left-hand side of equation (22) and E_a/E_0 can be plotted. This curve is shown in Fig. 3.

When $E_a/E_0 < 0.5$, the efficiency can be obtained from equations (15) and (18). In this case

$$\eta = \frac{(E - 1.22\,E_a)^2}{E_b(E - 1.5\,E_a)}\cdot\frac{\mu\pi R_1}{8R_p(1 + R_1/2R_p)} \quad \ldots (23)$$

Determination of a Suitable Value for R_1/R_p

Equations (15) and (23) show that both the power output and the efficiency increase with E, consequently it is advisable to make this voltage as high as possible. On the other hand, the losses in the grid circuit also increase with E, particularly when the effective grid voltage exceeds the effective plate voltage. When the load is tuned the grid and plate voltages are 180° out of phase, therefore, to avoid excessive grid losses, we can employ as a basis for design the requirement that the maximum grid voltage should be equal to the minimum plate voltage. This condition is satisfied when

$$E + E_c = E_b - IR_1.$$

For $E_a/E_0 < 0.5$, we can substitute for I the value given by equation (15), and obtain

$$E = \frac{(E_b - E_c)(1 + y)}{1 + y(1 + \mu)} + \frac{1.22\,\mu yE_a}{1 + y(1 + \mu)} \quad \ldots (24)$$

where $y = R_1/2R_p$.

From equation (18) the input to the valve is given by

$$P_i = \frac{(E - 1.5\,E_a)\mu E_b}{\pi R_p(1 + y)},$$

which, after substitution of the value obtained for E from equation (24), reduces to

$$\frac{\pi R_pP_i}{\mu E_b} = \frac{E_b - E_c}{1 + y(1 + \mu)} + \frac{1.22\,E_ay}{(1 + y)\{1 + y(1 + \mu)\}} - \frac{1.5\,E_a}{1 + y} \quad \ldots \quad \ldots (25)$$

Writing $$t = \frac{\pi R_pP_i}{\mu E_b} \quad \ldots \quad \ldots (26)$$

enables equation (25) to be put in the form

$$y^2t(1 + \mu) + y\{t(2 + \mu) - E_c(0.5 + 0.28\mu) - E_b(1.28 + 1.5/\mu)\} + t - 0.5\,E_c - E_b(1 + 1.5/\mu) = 0 \quad \ldots \quad \ldots (27)$$

from which y can be obtained when the constants of the valve, the d.c. voltages and the input power are given. Of these quantities, the latter is generally unknown in the preliminary stages of the design, but an approximate value for t can be obtained by assuming

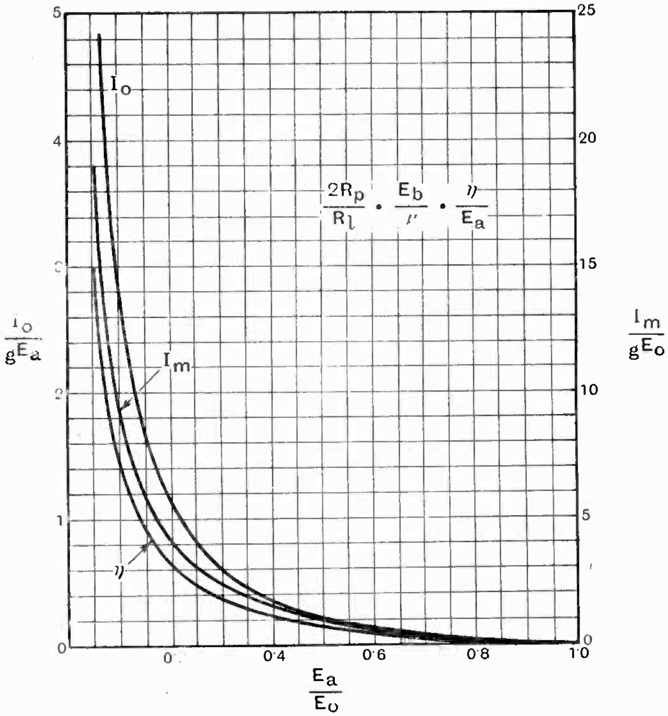


Fig. 4.

that the valve will be operated at the full plate dissipation W. In this case

$$P_i = \frac{W}{1 - \eta}, \text{ and } t = \frac{\pi R_p W}{\mu E_b(1 - \eta)} \quad .. \quad (28)$$

Further, an efficiency of the order of 70 per cent. (68.6 per cent. to be exact) can be taken as a reasonable working value, so that the value of t which can be employed in the preliminary design is given by

$$t = \frac{10 R_p W}{\mu E_b} \quad .. \quad .. \quad .. \quad (29)$$

The value of y can be then obtained from equations (27) and (29) when the constants of the valve and the d.c. voltages are given.

Design of a Class C Amplifier

When the above quantities are known, the amplifier can be designed by making use of the curves (for all values of E_a/E_0) or of the equations (when $E_a/E_0 < 0.5$). In the former case the procedure is as follows :—

(*a*) From the assumed value for the efficiency, the d.c. plate current is given by

$$P_i = W/1 - \eta, \text{ or } I_b = W/E_b (1 - \eta).$$

(*b*) Calculate I_b/gE_a, and find the corresponding values of E_a/E_0 and $\frac{2R_p}{R_1} \cdot \frac{E_b}{\mu} \cdot \frac{\eta}{E_a}$ from the curves of Fig. 4. The latter gives R_1/R_p, and hence the load resistance R_1.

(*c*) From the values of E_a/E_0 and R_1/R_p obtained above, the value of E_a/E (giving the peak value E of the grid input voltage) is found from Fig. 3.

(*d*) For the same value of E_a/E_0, I/gE_a (giving I the peak value of the fundamental plate current) is obtained from Fig. 2.

(*e*) Finally, the peak d.c. plate current I_m can be obtained from Fig. 4, and the ratio I_m/I_b calculated. For most valves, provided that I_m does not exceed the saturation value, this ratio should lie between 3 and 5.

When the equations are employed, the procedure is somewhat simpler, viz. :—

(*a*) Fix the efficiency as before, and determine t from equation (28).

(*b*) Obtain y, and hence R_1, from equation (27).

(*c*) E is given by equation (24), and I by equation (15).

(*d*) I_b and I_m are obtained from equations (18) and (20) respectively, and ratio I_m/I_b checked.

Additional information which can be derived from the equations is :

(1) The range of input voltages for which the valve will behave as a linear power amplifier. The upper value of this range is given by the value of E obtained from

equation (24), and the lower value is given by the value of E obtained from equation (16).

(2) The range of modulating voltages for which linear plate modulation can be produced. For given values of E and R_1, the range is obtained by determining the maximam value of E_a which satisfies the condition $E_a/E_0 < 0.5$

As a rule, the output and the efficiency desired from a class C amplifier are sufficiently high to require an input voltage to the grid which will enable the condition $E_a/E_0 < 0.5$ to be satisfied. Therefore, for all practical purposes, the design data and the operating conditions can be obtained from the equations alone.

Example

To illustrate the use of the equations, a valve having the following constants and applied d.c. voltages will be considered.

$\mu = 10$, $R_p = 5{,}000$ ohms, $W = 15$ watts, $E_k = 0$,

$E'_c = -120$ volts, $E_b = 600$ volts.

Therefore $E_c = E_c' + E_k = -120$.

and $E_a = -(E_c + E_b/\mu) = 60$.

If we assume that $\eta = 68.6$ per cent., then

$$t = 10 R_p W/\mu E_b = 125.$$

We have then

(*a*) From equation (27)

$$2.72\,y^2 + 2.035\,y - 1 = 0.$$

The positive root of this quadratic is $y = 0.339$, therefore $R_1 = 2R_p \cdot y = 3{,}390$ ohms.

(*b*) From equation (24), $E = 256.5$ volts.

(*c*) From equation (15), $I = 0.1375$ amps.

(*d*) From equation (18), $I_b = 0.0792$ amps; and from equation (20)

$I_m = 3.0$ amps;

therefore $I_m/I_b = 3.8$.

(*e*) From the above,

the output $= I^2R_1/2 = 32$ watts.

the input $= E_bI_b = 47.5$ watts.

and the efficiency $\eta = 32/47.5 = 67.4$ per cent. which is within 2 per cent. of the assumed value.

(*f*) For the assumed value of the efficiency, P_0, P_i and I_b can be checked in the following way.

Output $= W \,.\, \eta/(1-\eta) = 15 \times 2.19 = 32.8$ watts.

Input $= W/(1-\eta) = 15 \times 3.18 = 47.8$ watts.

$I_b = W/E_b(1-\eta) = 0.0796$ amps.

which are in good agreement with the values obtained from the equations.

(*g*) From equation (16), $(E/E_a)_{\text{min.}} = 2.265$, therefore $E_{\text{min.}} = 135.9$ volts. This means that the valve will operate as a linear power amplifier for all inputs whose peak values are between 135.9 and 256.5 volts.

(*h*) From $(E/E_a)_{\text{min.}} = 2.265$ and $E = 256.5$ volts, we obtain $(E_a)_{\text{max.}} = 113$ volts. For a negative grid bias of 120 volts this means that the corresponding plate voltage is 70 volts; consequently, given a normal plate voltage of 600 volts, linear plate modulation will be produced so long as the amplitude of the plate swing arising from the modulating signal does not exceed 530 volts.

Comparison between Calculated and Measured Quantities

To check the accuracy of the equations, the results obtained by calculation for the following case :—

$\mu = 10$, $R_p = 1{,}280$ ohms, $R_1 = 2{,}000$ ohms, $E_k = 70$ volts, $E_b = 3{,}000$ volts, $E'_c = -300$ and -350 volts.

were compared with those obtained by Fay by actual measurement.*

The first values to be checked were the peak input voltages at which the load current curve ceases to be linear.

For $E'_c = -300$, $E_a = 70$; therefore equation (16) gives

$$E_{\text{min.}} = 70 \times 2.61 = 182.7 \text{ volts.}$$

The value obtained by Fay is given by the point P_1 of Fig. 5 as 180 volts.

For $E_c' = -350$, $E_a = 120$; and $E_{\text{min.}} = 120 \times 2.61 = 313.2$ volts.

P_2 of Fig. 5 gives Fay's value as 300 volts; so that in both cases satisfactory agreement between the calculated and the measured values is obtained.

From the above, it follows that the equa-

* Bibliography (3), Table 1 and Fig. 2.

tions can be used when E exceeds 182.7 volts (for $E_c' = -300$ volts) and 313.2 volts (for $E_b' = -350$ volts).

Fig. 5 shows curves corresponding to the calculated and the observed values of I_m, I and η. Fay does not give an efficiency curve for $E'_c = -350$ volts. It is seen that the agreement between the I_m and the I curves is quite satisfactory, although the results obtained for the efficiency is not so good.

In addition to the above, equation (27) was checked by calculating the value of the load resistance for the following conditions, and then comparing the result with the value observed by Everitt (*).

$\mu = 8.3$, $R_p = 4.150$, $E_b = 600$, $E'_c = -146$,

$E_k = 5$, $W = 15$, $\eta = 66.5$,

$E_c = E_c' - E_k = -151$.

Substituting in equation (27), we obtain

$$2.11\, y^2 + 1.465\, y - 1 = 0.$$

The positive root of this quadratic is

$$y = 0.423.$$

Therefore $R_1 = 2R_p \,.\, y = 3{,}510$ ohms.

The value obtained by Everitt was 3,480 ohms, which gives satisfactory agreement between the calculated and observed resistances.

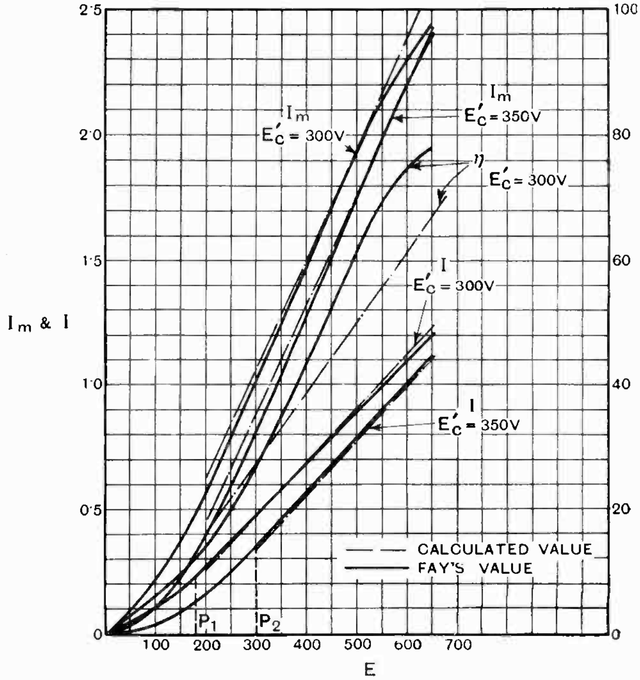


Fig. 5.

Conclusions

Given the constants of a valve and the d.c. voltages, the design data for the class C amplifier can be obtained from a few fairly simple equations. Comparison of the results obtained from these equations with the corresponding observed values shows that, in practice, the accuracy should prove sufficient in the preliminary stages of the design. Since the subsequent stages of the design will, in any case, be decided by measurement rather than by calculation, a greater degree of accuracy, although desirable, is not really essential.

* Bibliography (1) pages 173 and 174.

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The Behaviour of High Resistances at High Frequencies *

Observations on the Boella Effect

By O. S. Puckle, A.M.I.E.E.

HIGH resistances of the order of a megohm and over have a falling effective resistance-frequency characteristic which is independent of the stray capacity across the ends of the resistance and which varies with the form of construction and with the material of which the resistance is made. Such a characteristic, which is here discussed, may have a profound effect on the operating conditions of certain circuits in which the resistance may be placed, while, on the other hand, for many purposes the effect is of little or no importance.

Theoretical aspects of the causes of the additional H.F. losses are considered and the results of measurements made in this country, and in Italy, are quoted.

In the appendix the various formulæ used are proved.

General

1. Researches on the behaviour of high resistances at high frequencies have been carried out in this country by A. L. M. Sowerby and D. F. S. Marshall, working together, and in Italy by Professor Mario Boella, the latter of whom has published a full account of his work.† The two researches have been carried out in similar manner, using different measuring circuits, and are both of great interest, for they have focussed attention upon a source of high-frequency conductance, beyond that due to stray capacity, which is found to be due to the method of manufacture. The tests were carried out on various composition resistances and upon those in which the resistance material is deposited on glass or porcelain rods or tubes.

Methods of Measurement

2. The methods employed for measuring the characteristics of the resistances presuppose that the inductance is low compared with $\frac{R}{\omega}$; such a supposition is permissible, since the length of path is very short even in those resistances which are spiralised.

Sowerby and Marshall's circuit is shown in Fig. 1 and consists of a R.F. oscillator supplying energy to a tuned circuit, having a variable series resistance included, for the purpose of ascertaining the total effective series resistance of the tuned circuit.

The calibration of the circuit is carried out in the classical manner, by plotting the added series resistance against the reciprocal of the voltage across the tuned circuit at resonance, in the following way :—

The circuit is set up as in Fig. 1, the series reference resistances being inserted separately into a standard holder of good quality so arranged that contact resistance variations are eliminated. A useful range of reference resistance might consist of, say, nine units from 0.5 ohm to 100 ohms.

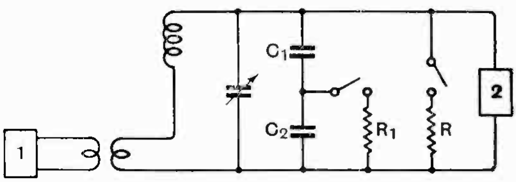


Fig. 1.—(1) *Radio-frequency oscillator.* (2) *Valve voltmeter.*

A reading is taken on the voltmeter with each of the reference resistances in circuit, the whole system being adjusted to resonance for each reading. From these readings the effective series resistance of the circuit is calculated for the frequency concerned.

The effective series resistance r of the circuit is equal to

$$r'\left(\frac{V_1}{V_0 - V_1}\right)$$

where V_0 = Voltmeter reading without any reference resistance,

* MS. accepted by the Editor, March, 1935.

† Sul comportamento alle alte frequenze di alcuni tipi di resistenze elevate in uso nei radio-circuiti. (On the behaviour, at high frequencies, of some types of high resistances in use in radio circuits.) Mario Boella, *Alta Frequenza*, Vol. III, No. 2, April, 1934.

V_1 = Voltmeter reading with the reference resistance (r') in circuit, and

r' = reference resistance (ohms).

A series of readings is taken with each of the reference resistances and the mean value is accepted as the true effective series resistance of the circuit.

After the circuit is calibrated it may be used to measure resistances by noting the increase in the effective resistance of the measuring circuit, for low values of test resistance placed in series, or for high values connected in shunt.

The additional effective series resistance r'', due to the shunt resistance R under test, is equal to

$$r\left(\frac{V_2 - V_3}{V_3}\right)$$

where V_2 is the voltage reading without R, and

V_3 is the voltage reading with R in circuit.

The additional effective series resistance r'' must then be converted to the shunt value. Here

$$R = \frac{\omega^2 L^2}{r''}$$

where L is in henries.

The pick-up coil consists of one or two turns and is, of course, included in the value of L. It is essential that the pick-up coil should be separated by at least one metre from the remainder of the measuring circuit in order to avoid stray coupling effects.

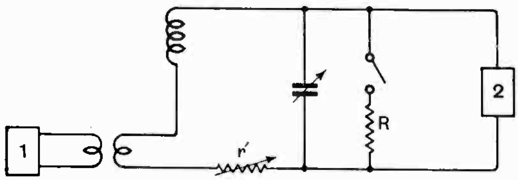


Fig. 2.—(1) *Radio-frequency oscillator.* (2) *Valve voltmeter.*

Boella's circuit, shown in Fig. 2, is similar to the former in that it makes use of a difference in the behaviour of high and low values of resistance, but its mode of operation is somewhat different. It consists of an oscillator supplying R.F. energy to a loosely coupled tuned circuit, across which is connected a capacity potential divider arranged so that an equality of voltage may be obtained, on a valve voltmeter connected thereto, under each of two conditions.

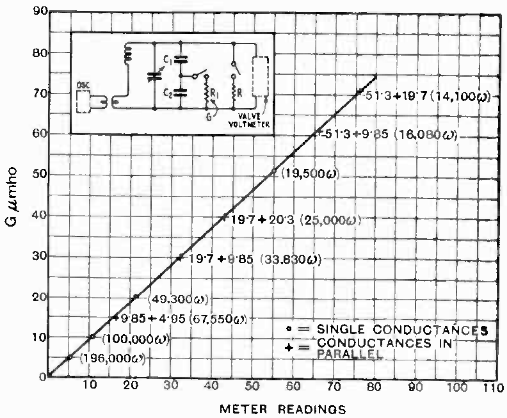


Fig. 3.—*Calibration curve for Boella's circuit at 6,000 kc/s.*

Condition (*a*) is that existing when the reference resistance of low value R_1 is connected across C_2, and condition (*b*) is that obtained when the resistance R, which is under test, is connected across the entire potential divider, R_1 being disconnected. The value of R is, of course, much greater than that of R_1.

The equation may be written

$$R = R_1\left(1 + \frac{C_2}{C_1}\right)^2 = KR_1, \text{ where } R_1 \gg \frac{1}{\omega C_2}.$$

The value of the constant $K = \left(1 + \frac{C_2}{C_1}\right)^2$ may be determined with an accuracy greater than 1 per cent. by measuring C_1 and C_2.

Since it is very unlikely that an exact balance will be obtained with fixed reference resistances, it is necessary to take several readings and to make interpolations.

It is found that, provided reference resistances of a sufficiently low value are used, the additional parallel conductance (apart from stray capacity) which is a feature of most high resistances, other than wire wound types, at high frequencies, is negligible; thus, two such equal resistances may be placed in parallel and the total conductance is exactly twice that of the single resistance. Moreover, for resistances of the same value no difference is detectable between those of different types.

Fig. 3 shows that the system is consistent and linear up to frequencies of 6,000 kc/s, since the errors obtained, either with single reference resistances or with two in parallel, are negligible.

It must be remembered that it is the added conductance at H.F. (Boella effect) which is to be measured, so that it is permissible to compensate for the stray capacity when testing with either circuit, and it is a feature of both methods that the tuning is adjusted to the optimum value in every case. It is, however, essential that the coupling should not be altered during any one test and also that it should be as weak as possible, to which end the main part of the inductance should be at least one metre away from the pick-up coil, as before stated.

In the case of Boella's circuit a possibility of error would occur if the inductive reactance of the condensers C_1 and C_2 were not negligible compared with the capacitive reactances, as this would alter the potential ratios across the condenser potentiometer. For this reason, also, the connecting leads to the condensers must be made as short as possible. In the researches described by Boella he used values as follows:—

$$C_1 = 186\ \mu\mu\text{F}. \qquad C_2 = 1{,}265\ \mu\mu\text{F}.$$

the condensers being mica insulated *in vacuo*. It is essential that good condensers be used, as small changes in the position of, or contact with, the laminations may cause serious errors and instability. However, with good condensers and short leads thereto the accuracy of the calculation of the constant K is sufficiently good. Boella prefers his circuit to that used by Sowerby and Marshall because of its greater ease in use and because of the fact that poor contact resistance is of less importance. On the other hand his reference resistances must be relatively independent of the temperature.

Resistances, Types and Values

3. For some years past there have been employed, in radio circuits, types of high resistance manufactured by depositing a thin conducting layer on porcelain rods or tubes. These resistance layers are then spiralised to adjust the total resistance to the value required, normally up to a maximum of 25 megohms. This form of resistance is manufactured by Siemens-Schuckert under the name of "Karbowid" and by other makers. The 1-watt resistances are 3 cms. long by 0.5 cm. diam., while the ½-watt resistances are 1.8 cms. long and 0.3 cm. diam.

Another form is that of Loewe, in which the deposit is on glass *in vacuo*, and in which the resistance is adjusted by thickness and length, no spiralising being resorted to. The Loewe resistances are about 1.2 cm. long by 0.3 cm. diam. in the ½-watt size.

Wire-wound resistances are also used, but normally these are of lower values of resistance, while in this country and America the solid rod form of resistance, made of carbon and employing a binding material is used. The latter is marketed under the name of Erie and measures 4.5 cms. by 0.7 cm. for the 1-watt size and 2.5 cms. by 0.7 cm. for the ½ watt size.

All these resistances have self-capacities of the same order.

TABLE 1.—Loewe resistances

No.	Nominal Value.	D.C.	Kilocycles. 9.2	19.3	40.3	100	226	516	1,000	2,020	6,000
		Resistance in Megohms.									
1	10*a*	8.21	8.33	8.2	8.15	7.96	8.06	7.19	6.48	6.4	4.74
2	10*b*	10.78	10.72	10.52	10.38	9.3	9.45	8.2	6.98	6.53	4.52
3	10*c*	9.38	9.355	9.355	9.27	8.79	7.69	6.37	5.41	4.91	4.12
4	5*a*	5.13	5.21	5.08	5.05	4.98	4.99	4.62	4.16	4.23	2.54
5	5*b*	8.8	7.86	8.0	8.06	7.26	7.4	6.53	5.55	5.37	3.63
6	5*c*	6.07	—	—	—	5.56	5.75	5.37	5.05	5.0	3.4
7	2*a*	2.36	—	—	—	2.385	2.41	2.315	2.239	2.23	1.78
8	2*b*	1.781	—	—	—	1.786	1.79	1.76	1.709	1.595	1.445
9	1*a*	1.009	—	—	—	1.217	1.189	1.18	1.11	1.074	.950
10	1*b*	.995	—	—	—	.991	.93	.988	.993	.916	.802
11	5*a*	.429	—	—	—	—	.439	.436	.425	.414	.365
12	5*b*	.525	—	—	—	—	.532	.53	.524	.527	.490

Results of Tests

4. Reference to the graphs giving the results obtained in this country and in Italy show that Boella's results make the Siemens' "Karbowid" resistances appear better than do the results by Sowerby and Marshall, while his measurements show Loewe resistances to be less good than do the measurements made in this country.

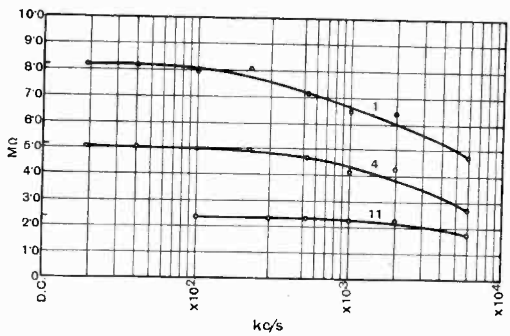


Fig. 4—*Loewe resistances.*

The cause of these discrepancies is, unfortunately, not definitely known and probably could not be ascertained without the shipment of large numbers of sample resistances to and fro between England and Italy.

The following possible causes of error in the measurement exist :—

1. Error in the calibration of coils and/or condensers.
2. Stray couplings.
3. Error in the calibration of the reference resistances at high frequency.
4. Stray leaks.
5. Tuning errors, *i.e.*, incorrect condenser settings.

For either method there is a possibility of reading inaccuracies, but these are reduced in Sowerby and Marshall's method because, since a large number of readings are required, the reading errors tend to balance out. On the other hand, the resistances used in this measurement must be very carefully made if they are to give accurate results, although the presence of a small inductance, inherent in the resistance, will usually be of negligible importance.

The measurements made by Sowerby and Marshall were for the purpose of investigating particular resistances at specific frequencies, and not with the idea of making a general investigation of the behaviour of high resistances at high frequencies, so that their results are not so complete as those of Prof. Boella.

Table 1 gives some values obtained by Boella when measuring Loewe resistances at high frequencies. Some of these figures are also shown in the form of a graph in Fig. 4. The letters refer to different samples of the same nominal value. It is not known why the figures at 226 kc/s appear higher than would be expected ; possibly the resistances resonate slightly at this frequency.

TABLE 2.—Loewe resistances

No.	Nom. Value.	Kilocycles. 30	100	300	1,000	3,000
		Resistance in Megohms.				
1	10	10.17	10.01	9.66	9.08	7.55
2	7.5	8.28	7.57	6.83	6.12	4.80
3	5.0	5.36	4.89	4.78	4.58	4.04
4	4.0	4.26	3.89	3.69	3.9	3.27
5	3.0	3.13	3.14	2.58	2.38	2.07
6	2.0	1.92	1.88	1.72	1.86	1.67
7	1.0	.986	.968	.89	.959	.917
8	.5	.487	.455	.445	.339	.46
9	.25	.244	.228	.230	.238	.234
10	.1	.106	.103	.107	.079	.092

Table 2 shows some results obtained by Sowerby and Marshall with Loewe resistances, which are also shown in graphical form in Fig. 5. Although some errors in measurement exist, it would appear that the Boella effect in Loewe resistances is rather inconsistent.

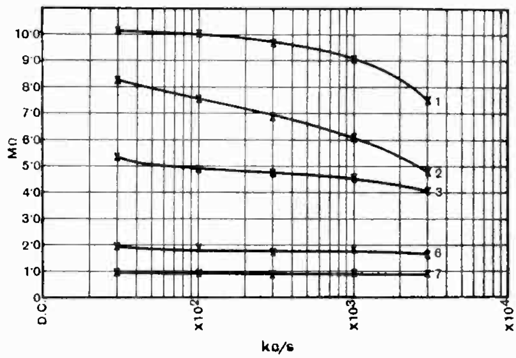


Fig. 5.—*Loewe resistances.*

TABLE 3.—Siemens " Karbowid " resistances

No.	Nominal Value.	D.C.	Kilocycles. 9.2	19.3	40.3	100	226	516	1,000	2,020	6,000
		Resistance in Megohms.									
1	4*a*	3.95	4.0	4.02	3.922	3.91	3.895	3.445	3.32	2.94	2.39
2	4*b*	3.98	4.03	4.02	3.95	3.942	3.845	3.61	3.358	2.962	2.318
3	2*a*	1.995	—	—	—	1.972	1.968	1.91	1.752	1.581	1.37
4	2*b*	1.985	—	—	—	1.967	1.96	1.891	1.71	1.533	1.258
5	1*a*	.994	—	—	—	.993	1.02	.983	.939	.89	.777
6	1*b*	.973	—	—	—	.966	.911	.966	.939	.898	.886
7	.5*a*	.508	—	—	—	—	—	.509	.503	.489	.438
8	.5*b*	.508	—	—	—	—	—	.509	.504	.491	.438

Table 3 shows the results of some measurements made by Boella on Siemens " Karbowid " resistances, and Fig. 6 shows these results in graph form.

Table 4 shows results obtained with Siemens " Karbowid " resistances by Sowerby and Marshall. Of these latter resistances four samples were sent to Italy for comparison measurements to be made, and Boella's figures are given in Table 5, while the two sets of results are shown together in Fig. 7.

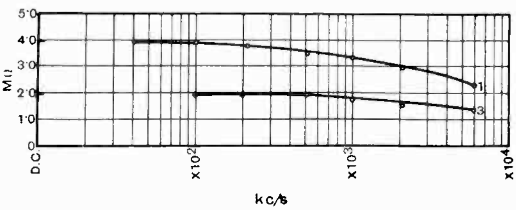


Fig. 6.—*Siemens " Karbowid " resistances.*

Boella remarks that the difference between the results at 99 kc/s and the values for direct current, for the first two resistances, are definitely due to the calibration of the condenser potentiometer. The larger difference between these values for the fourth resistance is perhaps due to the fact that the measuring installation is actually arranged for the measurement of higher resistances, and that it gives less certain results for the lower values of resistance, for which reason also he was unable to measure the 250,000-ohm resistance which was sent to him.

The resistances of which the results are shown in Tables 4 and 5 are the only samples which were actually measured both in Italy and in England.

Table 6 shows results obtained in England on two Erie resistances connected in series. This type has not been investigated in Italy; presumably they are not easily obtainable in that country.

TABLE 4.

Siemens " Karbowid " resistances

No.	Watts.	Nominal.	D.C.	1,600 kc/s.
		Resistance in Megohms.		
1*	1.0	2	2.02	1.34
2*	.25	2	1.9	1.34
3	.5	1	1.04	.74
4*	.5	1	1.01	.75
5	.25	.5	.519	.434
6*	1.0	.25	.250	.21
7	1.0	.25	.253	.21

* Sent to Italy (see Table 5).

Probable Causes of the Effect

5. It is considered that the change of resistance at high frequencies is due to the fact that the molecules of which the resistance

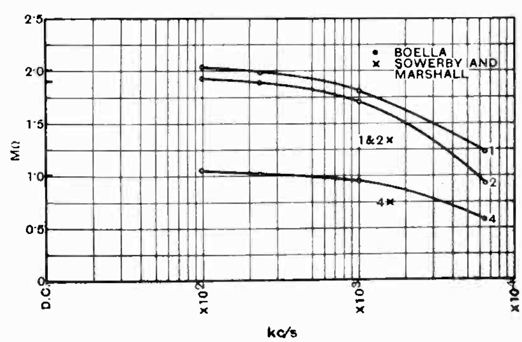


Fig. 7.—*Siemens " Karbowid " resistances.*

is composed are separated by minute condensers. In the case of the Erie resistances, which are believed to be made of a mixture of carbon, fine sand and a binding material, the sand separates the carbon particles, thus producing the capacities mentioned above. but this has not been verified in practice. Where the deposit is on porcelain or glass rods the circuit as shown in Fig. 8 will explain the cause, and in the opinion of the author such an explanation is an entirely feasible one.

TABLE 5.—Siemens "Karbowid" resistances

No.	Watts.	Nominal.	D.C.	Kilocycles. 99	233	1,000	6,450
		Resistance in Megohms.					
1	1.0	2	2.020	2.044	1.992	1.812	1.227
2	.25	2	1.900	1.927	1.882	1.713	0.922
4	.5	1	1.011	1.051	1.021	0.953	0.578

The equivalent circuit is probably somewhat as shown in Fig. 8, in which case the change of effective resistance, due to the Boella effect, should reach a finite value at some definite frequency, the curve being an asymptotic one.

With regard to the resistances produced by a deposit on porcelain tubes, the added conductance at the higher frequencies is probably attributable partly to the presence of a similar deposit on the inside of the tube, which may be disconnected from that on the outside. In such a case the inner deposit will be effective only at the higher frequencies. In all probability the effect is also partly due to the same cause as is described above for Erie resistances.

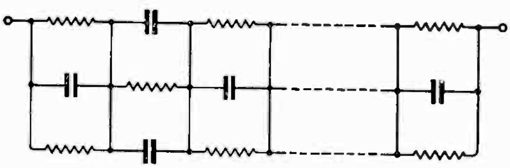


Fig. 8.

Certain resistances which show the Boella effect to a more marked degree than others may possibly have a thicker internal deposit,

Conclusions

6. In certain cases the Boella effect may be of great moment, but for the majority of purposes the effect is of little or no importance, since only a relatively small frequency range is normally covered. In the manufacture of broadcast receivers the effect is negligible except, perhaps, for those receivers which also operate on the short wave-band (10 to 100 metres). It is, however, only necessary to remember that a one-megohm resistance may be actually 0.5 megohm, or even less in practice, but the use of higher values of resistance, where necessary, obviates this difficulty. For high-definition television receivers the effect should be borne in mind. The wide-frequency bands used in television necessitate the use of low values of anode resistance, and, since the grid resistances are effectively in parallel with the anode resistances, the behaviour of the latter at high frequencies is unimportant.

The experiments here described have shown that certain of the cheap and easily obtainable resistances, as used in broadcast receivers, are suitable for purposes of a more delicate nature, such as those which present themselves in measuring technique, provided they are wisely used. The problem

TABLE 6.—Erie resistances

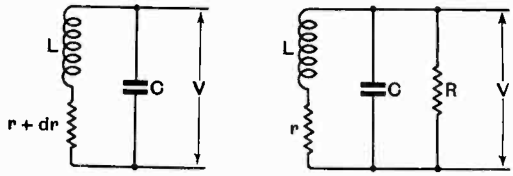
No.	Watts.	Nominal.	D.C.	Kilocycles. 27.5	50	100	300	1,000	3,000
		Resistance in Megohms.							
1	$\frac{1}{2}+\frac{1}{2}$	$6 = (2 \times 3)$	5	4.61	3.76	3.08	2.1	1.42	.84

of obtaining a wide range of resistances for use over an extended frequency scale with zero phase angle is, however, still unsolved.

The writer's thanks are due to Prof. Boella and to Messrs. Sowerby and Marshall for much valuable information, and for assistance by the making of measurements in connection with this paper, and also to Mr. L. H. Bedford for assistance and advice.

Appendix

Sowerby and Marshall's Formula



The proof of the equality of the two conditions used by Sowerby and Marshall, and depicted above, is as follows :—

Data $R >> dr$

r = the effective series resistance of the circuit, and dr = the added effective series resistance resulting from the addition of R.

Writing the impedances, we have,

$$\frac{L}{C(r+dr)} \qquad \frac{\left(\frac{L}{Cr}\right)R}{R+\frac{L}{Cr}}$$

Since $\frac{1}{C} = \omega^2 L$ we have,

$$\frac{\omega^2L^2}{r+dr} \qquad \frac{R\left(\frac{\omega^2L^2}{r}\right)}{R+\frac{\omega^2L^2}{r}}$$

$$\frac{1}{r+dr} \qquad \frac{\frac{R}{r}}{R+\frac{\omega^2L^2}{r}}$$

Equating the two conditions and solving for R gives,

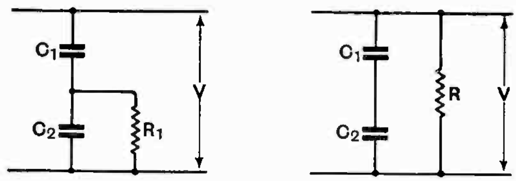
$$R = \frac{Rr+\omega^2L^2}{r+dr}$$

$$= \frac{R+\frac{\omega^2L^2}{r}}{1+\frac{dr}{r}}$$

$$1+\frac{dr}{r} = 1+\frac{\omega^2L^2}{Rr}$$

$$R = \frac{\omega^2L^2}{dr}$$

Boella's Formula



The proof of the equality of the two conditions used by Boella, and shown above, is as follows :—

$$\text{Data } R_1 >> \frac{1}{\omega C_2}$$

$$R >> R_1$$

Writing the impedances, we have :—

$$\frac{1}{jpC_2+K_1}+\frac{1}{jpC_1} \qquad \frac{1}{\frac{1}{R}+\frac{1}{\frac{1}{jpC_1}+\frac{1}{jpC_2}}}$$

where $K_1 = \frac{1}{R_1}$

$$1+\frac{jpC_1}{jpC_2+K_1} \qquad \frac{1}{\frac{1}{jpC_1R}+\frac{1}{1+\frac{C_1}{C_2}}}$$

Writing the admittances

$$\frac{\frac{1}{R_1}+jpC_2}{\frac{1}{R_1}+jp(C_1+C_2)} \qquad \frac{1}{1+\frac{C_1}{C_2}}+\frac{1}{jpC_1R}$$

$$\frac{1+jpC_2R_1}{1+jp(C_1+C_2)R_1}$$

Rationalising

$$\frac{1+jp(C_2R_1-[C_1+C_2]R_1)+p^2C_2R_1\overline{C_1+C_2}R_1}{1+p^2\overline{C_1+C_2}^2R_1^2}$$

Equating the real parts

$$\frac{1+p^2C_2R_1\overline{C_1+C_2}R_1}{1+p^2\overline{C_1+C_2}^2R_1^2} = \frac{C_2}{C_1+C_2}$$

1 is negligible compared with the remainder both in the numerator and in the denominator, so that with this exception the above is an identity.

Equating the imaginary parts, we have,

$$\frac{-pC_1R_1}{1+p^2\overline{C_1+C_2}^2R_1^2} = -\frac{1}{pC_1R}$$

1 is again negligible compared with the remainder, so that,

$$R = R_1\left(\frac{C_1+C_2}{C_1}\right)^2$$

$$= R_1\left(1+\frac{C_2}{C_1}\right)^2$$

The Time of Flight of Electrons in a Cylindrical Diode

Case when the Current is Limited by Space Charge

By Prof. C. L. Fortescue

THE generation of oscillations of frequencies corresponding to wavelengths of one metre or less is related to the time of flight of the electrons between cylindrical cathodes and anodes which thus becomes a matter of practical importance. In the case of a cylindrical diode, a graphical method has been given by McPetrie* and an alternative method has been proposed by Benham†. This latter alternative may be combined with Langmuir's‡ solution of this problem to enable the time of flight to be calculated comparatively easily.

(1) The potential distribution is given by the well-known equation :—

$$r\frac{d^2V}{dr^2}+\frac{dV}{dr}=2I\left(\frac{2e}{m}\right)^{-\frac{1}{2}}V^{-\frac{1}{2}} \quad .. \quad (1.1)$$

which is satisfied by

$$I=A\frac{V^{\frac{3}{2}}}{r\beta^2}$$

when A is given the value $\frac{2}{9}\left(\frac{2e}{m}\right)^{\frac{1}{2}}$

and β^2 is evaluated directly or indirectly from the series

$$\beta=y-\frac{2}{5}y^2+\frac{11}{120}y^3-\frac{47}{3{,}300}y^4+\frac{31033}{1{,}848{,}000}y^5\ldots$$

in which $y=\mathrm{Log}_e\frac{r}{r_c}$.

Throughout these equations the units are the ordinary electrostatic units, V is the potential relative to the cathode which is assumed to be at zero potential, I is the current per cm. axial length, r_c is the radius of the cathode and r is any radius greater than r_c up to the radius of the anode, r_a.

Benham has pointed out that if the substitution

$$I=A\frac{V^{\frac{3}{2}}}{\phi}\text{, where }\phi=r\beta^2,$$

is made in equation (1.1), then :—

$$r\frac{d^2\phi}{dr^2}-\frac{1}{3}\frac{r}{\phi}\left(\frac{d\phi}{dr}\right)^2+\frac{d\phi}{dr}=\frac{2}{3}$$

and consequently

$$\frac{d}{dr}\left(\frac{3}{2}r\phi^{\frac{1}{3}}\frac{d\phi}{dr}\right)=\phi^{-\frac{1}{3}} \quad .. \quad (1.2)$$

But from the fact that under conditions of constant V and I,

$$u=\left(\frac{2e}{m}\right)^{\frac{1}{2}}V^{\frac{1}{2}}=\left(\frac{2e}{m}\right)^{\frac{1}{2}}\left(\frac{I}{A}\right)^{\frac{1}{3}}\phi^{\frac{1}{3}}$$

where u is the velocity of an electron at radius r, it follows with the aid of (1.2), that if T is the time of flight from cathode to radius r

$$\frac{dT}{dr}=\left(\frac{2e}{m}\right)^{-\frac{1}{2}}\left(\frac{I}{A}\right)^{-\frac{1}{3}}\frac{d}{dr}\left\{\frac{3}{2}r\phi^{-\frac{1}{3}}\frac{d\phi}{dr}\right\}$$

At the cathode when $r=r_c$, $T=0$ and $\phi^{-\frac{1}{3}}\frac{d\phi}{dr}$ is zero. Consequently

$$T=\left(\frac{2e}{m}\right)^{-\frac{1}{2}}\left(\frac{I}{A}\right)^{-\frac{1}{3}}\frac{3}{2}r\phi^{-\frac{1}{3}}\frac{d\phi}{dr} \quad .. \quad (1.3)$$

Substituting $\left(\frac{I}{A}\right)^{-\frac{1}{3}}=V_a^{-\frac{1}{2}}\phi_a^{\frac{1}{3}}$ in (1.3) gives :

$$T=\frac{3}{2}\left(\frac{2e}{m}\right)^{-\frac{1}{2}}\phi_a^{\frac{1}{3}}V_a^{-\frac{1}{2}}\,.\,r\phi^{-\frac{1}{3}}\frac{d\phi}{dr} \quad .. \quad (1.4)$$

so giving the time of flight to any radius r in terms of the applied potential and the electrode dimensions. Actually it is the time of flight from cathode to anode that is generally required. For $r=r_a$ (1.4) becomes

$$T_a=\left\{\frac{3}{2}\left(\frac{2e}{m}\right)^{-\frac{1}{2}}\left(\frac{d\phi}{dr}\right)_a\right\}V_a^{-\frac{1}{2}}r_a \quad .. \quad (1.5)$$

* *Phil. Mag.*, 16, 284, 1931.
† *Phil. Mag.*, Supp. 11, 457, 1931.
‡ *Phys. Rev.*, xxii, 347, 1923.

Now

$$\frac{d\phi}{dr} = \frac{d}{dr}(r\beta^2) = \beta^2 + 2r\beta\frac{d\beta}{dr} = \beta^2 + 2\beta\frac{d\beta}{dy},$$

and so if β^2, β and $\frac{d\beta}{dy}$ can be found, $\frac{d\phi}{dr}$ can be obtained and the time of flight calculated without recourse to graphical methods such as those proposed by McPetrie.

Langmuir tabulates the value of β^2 in his 1923 paper for all values of r/r_c from 1.00 to ∞. In addition, he gives the values of $\frac{d\beta}{dy}$ for values of y from 3.0 to 10.5; *i.e.*, for values of r/r_c from about 20 to about 20,000. For higher values of y, $\frac{d\beta}{dy}$ is negligible. For values of y below 3.0 the values of $\frac{d\beta}{dy}$ are derivable from the coefficients given in Table 1 of Langmuir's paper.

The equation (1.5) may therefore be written

$$T_a = f_1(r_a, r_c)\, r_a V_a^{-\frac{1}{2}}$$

and the function f_1 may be calculated and either tabulated or plotted directly in terms of r_a/r_c or r_c/r_a. The figures in the second column of the Table below have been worked out in this way:

TABLE

r_a/r_c	$f_1(r_a, r_c)$	$f_2(r_c, r_a)$
1.00	$10^{-9} \times 0.00$	$10^{-9} \times 0.00$
1.10	0.26	0.28
1.20	0.47	0.51
1.40	0.77	0.89
1.60	1.00	1.20
2.00	1.26	1.88
2.50	1.44	2.10
3.00	1.56	2.43
4.00	1.67	2.71
6.00	1.73	3.43
10.00	1.73	4.20
18.0	1.68	4.64
30.0	1.62	5.13
50.0	1.58	
100.0	1.55	
500.	1.50	
1,000	1.48	
10,000	1.46	
	1.46	

(2) The cylindrical diode with the cathode outside and the anode inside.

The equation (1.1) is still applicable and the solution

$$I = A\frac{V^{\frac{3}{2}}}{r\beta^2}$$

may still be used. It is convenient in this case to put

$$y_1 = \mathrm{Log}_e \frac{r_c}{r}$$

which is a positive quantity, rather than to follow Langmuir in continuing to use $y = \mathrm{Log}_e \frac{r}{r_c}$. Expressed in terms of y_1

$$\beta = y_1 + \frac{2}{5}y_1^2 + \frac{11}{120}y_1^3 + \frac{47}{3{,}300}y_1^4 + \frac{31033}{1{,}848{,}000}y_1^5 \ldots$$

in which all the coefficients have the same values as in the previous expression for β in terms of y, but are all of the same sign. The time of flight is found as before from

$$-\frac{dT}{dr} = \left(\frac{2e}{m}\right)^{-\frac{1}{2}}\left(\frac{I}{A}\right)^{-\frac{1}{3}}\frac{d}{dr}\left\{\frac{3}{2}r\phi^{-\frac{1}{2}}\frac{d\phi}{dr}\right\}$$

and since when $T = 0$; $r = r_c$, $y_1 = 0$ and $\phi^{-\frac{1}{2}}\frac{d\phi}{dr} = 0$

$$T_a = -\left\{\frac{3}{2}\left(\frac{2e}{m}\right)^{-\frac{1}{2}}\left(\frac{d\phi}{dr}\right)_a\right\} r_a V_a^{-\frac{1}{2}}.$$

In this case

$$\frac{d\phi}{dr} = \beta^2 - 2\beta\frac{d\beta}{dy_1} \text{ since } \frac{d\beta}{dr} = -\frac{1}{r}\frac{d\beta}{dy_1},$$

and so, expressing the time of flight in terms of the greater radius r_c:—

$$T_a = f_2(r_c, r_a) r_c V_a^{-\frac{1}{2}}$$

where $f_2(r_c, r_a)$ can easily be computed. Approximate values are given in the third column of the Table.

(3) When a positive grid triode is used for the generation of centimetre-wave oscillations, the time of flight from cathode to positive grid is found from paragraph 1, and the time of flight either from grid to virtual cathode or *vice-versa* is found from paragraph 2. The whole time of flight from cathode to virtual cathode and back to grid is thus easily found. The time of flight of electrons passing the grid a second or a fourth time can be similarly determined.

Incremental Magnetisation

Experiments upon Stalloy

By L. G. A. Sims, Ph.D., M.I.E.E., and D. L. Clay, B.Sc., Hons.

(*Concluded from page* 245 *of last issue.*)

In the first part of this paper, the development and checking of a technique of measurement which deals comprehensively with incremental magnetisation were detailed. In the present section the results of measurement are discussed.

Test Results

The following information was obtained from each series of results :

(1) The "elliptic incremental permeability"* derived from the fundamental component of the current.

(2) The elliptic incremental permeability derived from the R.M.S. value of the alternating current.

(3) The true incremental permeability obtained from the full amplitude of the complex A.C. wave by Joubert disc (includes eddy-current effects).

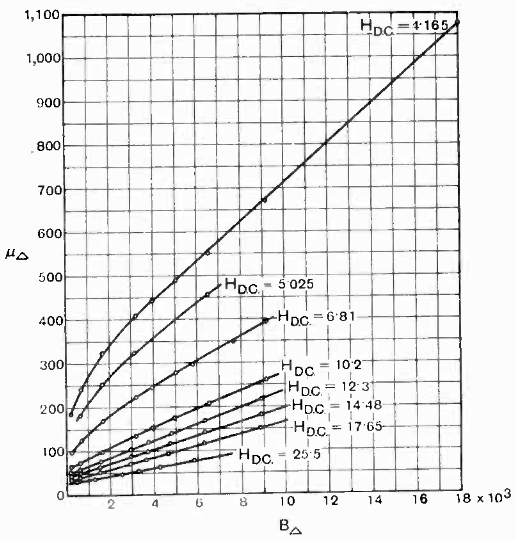


Fig. 9.—*Elliptic* μ_Δ *from current fundamental.*

(4) The current waveform.

(5) The iron losses.

(6) Ballistic measurements.

(7) The current harmonics.

These will be taken in order and complete graphical results given where they may prove of value to designers.

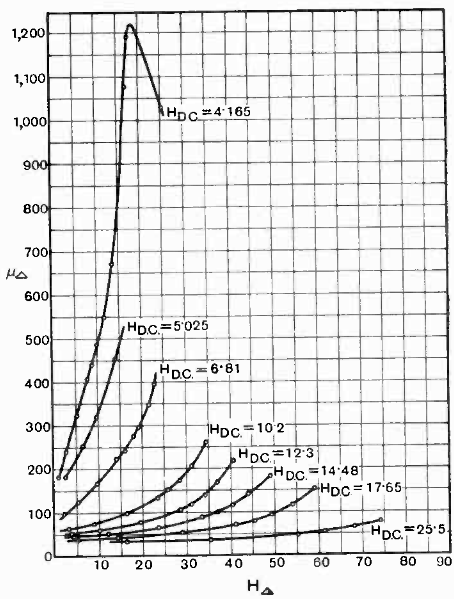


Fig. 10.—*Elliptic* μ_Δ *from current fundamental.*

(1) *Elliptic Incremental Permeability from Current Fundamental.*

The values are derived from the co-ordinate potentiometer readings of A.C. voltage and current. As the latter does not include harmonics, the true hysteresis loop is replaced by an ellipse with a reduced amplitude in H. (The area of the ellipse equals that of the loop if the voltage is a sinusoid).

* See Gall and Sims, *J.I.E.E., loc. cit.*

The values of μ_Δ so obtained are plotted in terms of B_Δ in Fig. 9 and in terms of H_Δ (as given by the potentiometer) in Fig. 10.

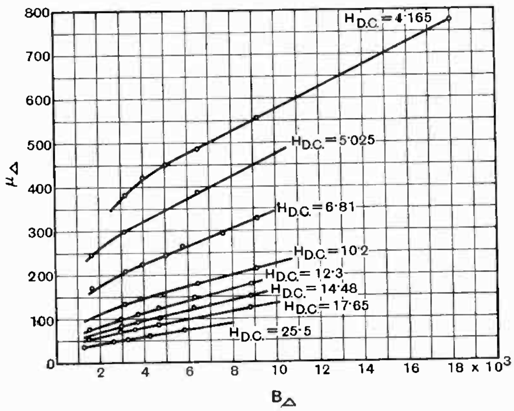


Fig. 11.—*R.M.S. values of* μ_Δ.

It should be pointed out that in this, and following sets of similar curves, the values of B_Δ *and* H_Δ *are for full amplitude, i.e., from positive maximum to negative maximum* and not for half amplitude as is customary, for example, in plotting reversals curves such as that of Fig. 4. This does not affect the values of μ_Δ but does show itself in the values of the independent variables, namely, B_Δ or H_Δ.

(2) *Elliptic Permeability from R.M.S. Value of Current.*

The D.C. component of current was measured by the potentiometer and the R.M.S. value of the combined A.C. and D.C. by dynamometer. The R.M.S. value of the A.C. was then obtained by calculation, the chief inaccuracy being that entailed in the observation of the dynamometer. This limited readings to those cases where the A.C. and D.C. were comparable in amplitude.

The value of B_Δ was obtained from the potentiometer reading of search coil voltage.

Figs. 11 and 12 give the curves of μ_Δ (R.M.S. value) against B_Δ and against H_Δ.

As indicated in the introduction, the accuracy of these curves is necessarily of a lower order than that obtained by potentiometer alone or by Joubert disc and potentiometer.

(3) *True Incremental Permeability by Joubert Disc and Potentiometer.*

Refer to Fig. 8. The Joubert contact is adjusted in phase to give the maximum and minimum of the current wave. It therefore gives the true amplitude of H as shown in Fig. 7, and since the readings of voltage at the contact are made by potentiometer the accuracy is high.

Incremental permeability values obtained thus must agree closely with the values which would be given from a ballistic test with excitation conditions arranged if possible to resemble those of the dynamic test. (Symmetrical cycles of B, unsymmetrical cycles of H in the present case).

But the Joubert disc used as described is superior to the ballistic test since it includes eddy current effects.

In Fig. 13 are plotted curves of μ_Δ against B_Δ and in Fig. 14 the same values of μ_Δ are plotted against the full amplitude of the complex H_Δ.

It is a lengthy matter requiring care and some skill to obtain the A.C. balances and the Joubert readings whilst at the same time maintaining direct current, A.C. exciting voltage and frequency constant to potentiometer order of accuracy for each reading.

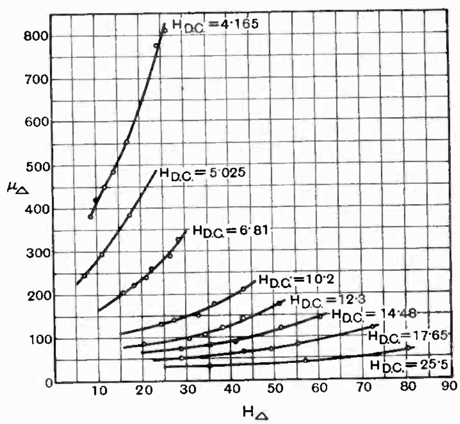


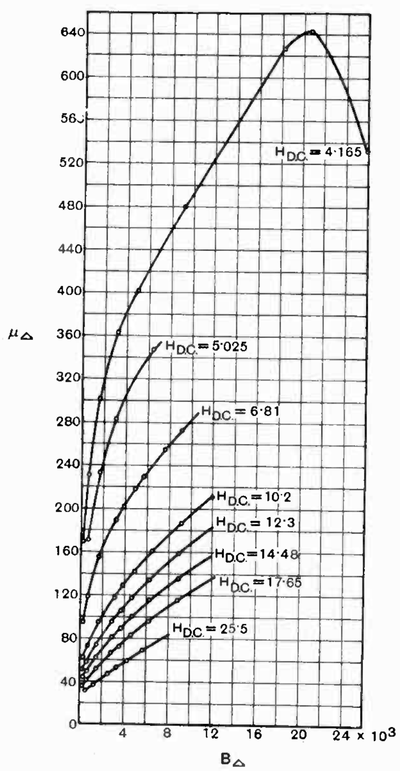
Fig. 12.—*R.M.S. values of* μ_Δ *in terms of* H_Δ *(R.M.S.).*

The change of A.C. excitation needed for each fresh point upon the curves involved from time to time, re-adjustment of circuit resistance following necessary changes in instrument ranges, and so on. This is mentioned in order to justify the range of measurement shown, for example, in Fig. 14. Here only one curve (namely, that for D.C. $H = 4.165$) was taken to the point where μ_Δ began to fall in value. All the curves would show similar maxima however and the whole family would fall within the reversals permeability curve (Fig. 5, 1) as an envelope.

If reference be made to Figs. 4 and 5 the following points will be noted :

(i) The range of *D.C. excitations* taken by the authors in their experiments, referred to the reversals curve of Fig. 4, extended downwards only to about the knee of the curve.

(ii) Under this condition the maximum incremental permeability obtainable is about 650 as against the maximum reversals value of about 5 000 (Fig. 5).



(*Above*) Fig. 13.—*μ_Δ from complex current (by Joubert) in terms of B_Δ.*

(*Right*) Fig. 15.—*Positive and negative peak values of H_Δ.*

(iii) The reversals maximum value of 5 000 will be approached as the D.C. excitation is further reduced.

Extension of the range of measurement may be undertaken later.

(4) *The Current Waveform.*

The Joubert readings also enable graphs to be plotted from which the assymmetry of the A.C. component of exciting current can be read. These are shown in Fig. 15. The use of these curves will best be demonstrated by an example. Thus, taking the case of a steady polarising D.C. giving $H = 4.165$, an A.C. induction of $\pm$ 5 000 ($B_\Delta = 10\,000$) requires an A.C. component of exciting current whose positive peak increases H by 15.5 and whose negative peak reduces H by 4.5.

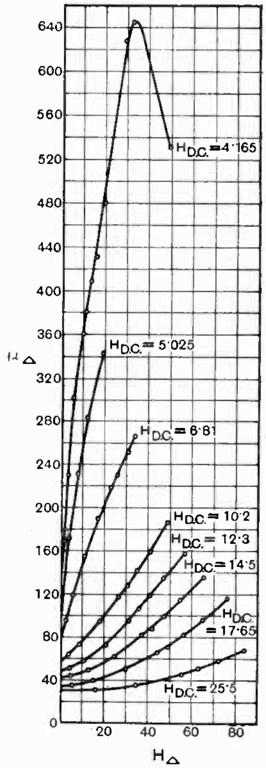
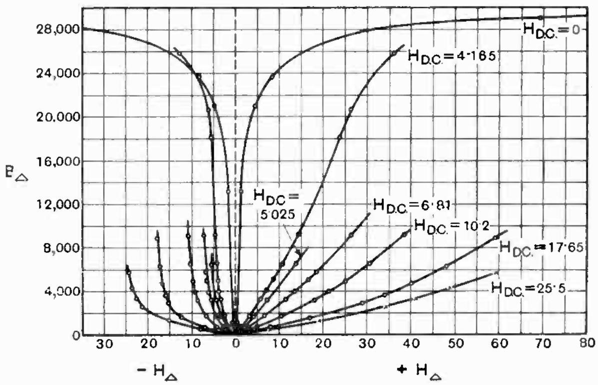


Fig. 14.—*μ_Δ from complex current (by Joubert) in terms of H_Δ.*



It is of interest to note in passing that the time mean value of H, which is the value due to the D.C. excitation, is in no way the same quantity as the amplitude mean. The latter has no physical importance in the measurement, though it has a bearing upon ballistic results described later.

From the curve for $H_{D.C.} = 0$ (Fig. 15) it can be clearly seen that current waveform symmetry applies in this case, only odd harmonics then being present in the exciting current. In all other cases even harmonics are present with corresponding assymmetry but, when the D.C. polarisation is great as in the case of $H_{D.C.} = 25.5$, symmetry is nearly obtained again for small A.C. induction amplitudes.

(5) *Iron Losses.*

For small A.C. induction amplitudes the losses are greater when the iron is in a polarised condition, but the difference is reduced and probably reversed for large A.C. amplitudes.* The general tendency is illustrated by Fig. 16 where it is seen that,

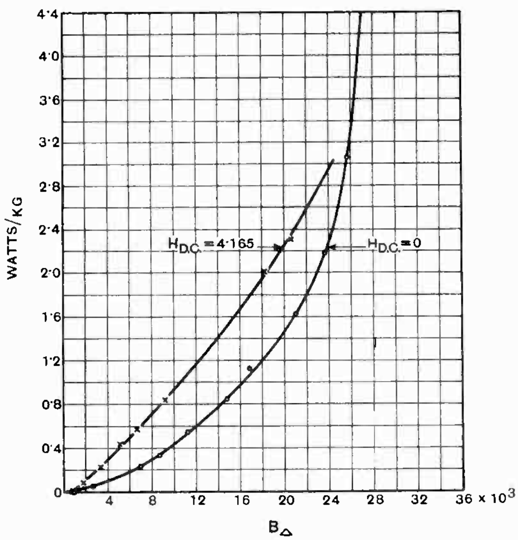


Fig. 16.

with a polarisation of $H_{D.C.} = 4.165$ the iron losses are greater than in the pure A.C. case, at any rate up to $B_\Delta = 26\,000$ approximately. (It will be recalled that B_Δ is the full A.C. induction amplitude, peak to peak).

Fig. 17 shows a selection of curves plotted

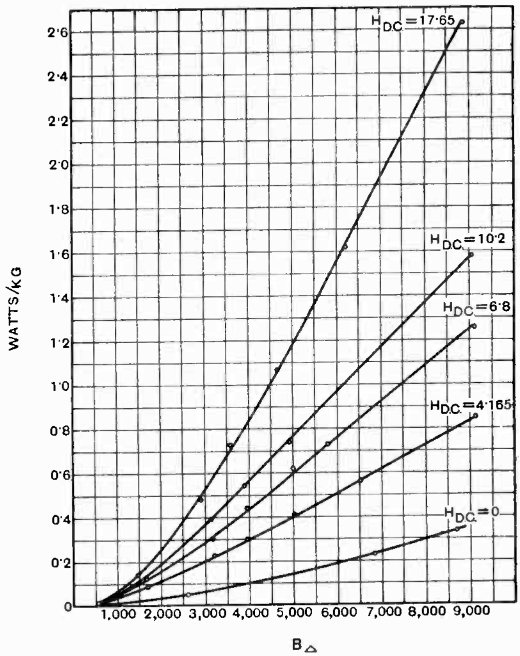


Fig. 17.

for amplitudes of A.C. excitation up to $B_\Delta = 9\,000$.

In the authors' experiments attention was paid particularly to the measurement of incremental permeabilities, the loss measurements taking second place in the tests. For this reason no steps were taken to relate the incremental loss curves with the pure A.C. loss curve except in the single case shown in Fig. 16. The above results are therefore advanced as auxiliary to the main line of investigation.

(6) *Ballistic Measurements.*

As the ballistic method of measurement has a firmly established position in the field of magnetic measurements, it was important to apply it in the present investigation.

It has been demonstrated experimentally† that, where symmetrical magnetisation is

* *Cf.* Edgar, " Silicon Steel with A.C. and D.C. Excitation," *Electrical Engineering*, Feb., 1934.

† See Gall and Sims, *J.I.E.E.*, *loc. cit.*

concerned (*i.e.*, magnetisation without superposed steady polarisation) the results of ballistic and A.C. methods of measurement can be closely correlated.

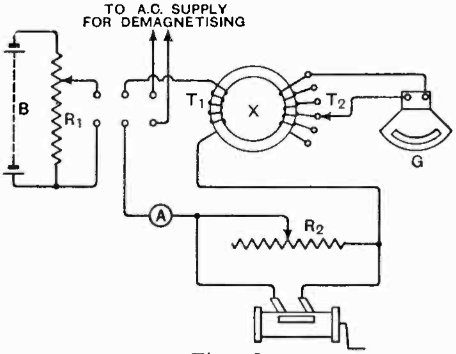


Fig. 18.

The A.C. test may be carried out with sinusoidal voltage, distorted current, or vice versa. The condition will not cause difficulty for the absence of even harmonics leads to a symmetrical distortion in which the time mean and the amplitude mean of the distorted quantity or quantities are identical. There is therefore no difficulty in simulating the excitation cycle in a ballistic test.

But when polarisation is present the matter is more difficult. As already pointed out under (4) above the "time mean" and the "amplitude mean" of the distorted quantity are not the same, whilst the latter is also continually changing.

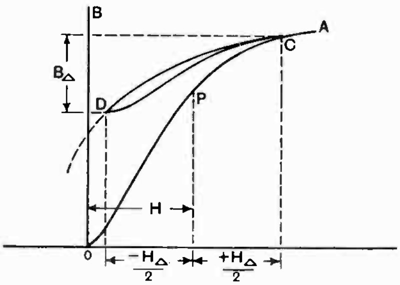


Fig. 19.

The circuit used was that shown in Fig. 18. It corresponds with that used independently by Elenbaas.* It will be clear that the upper limit of excitation can be set by means of the resistance R_1, the commutator short-circuiting R_2 during this part of the adjustment. Rotation of the commutator having brought R_2 in series the current can be adjusted by R_2 to a lower limit of excitation and thereafter continued rotation of the commutator swings the excitation repeatedly between these limits the mean excitation, corresponding to a constant polarisation.

It will be clear that, presuming an initial condition of demagnetisation, the sequence of events above outlined will produce the magnetic cycle shown in Fig. 19. It will also be clear that there is a fundamental difference between this simulated cycle and an actual A.C. + D.C. cycle as indicated, for example, in Fig. 7. But the cycle so simulated is likely to be that adopted by experimenters desiring information upon incremental magnetisation†.

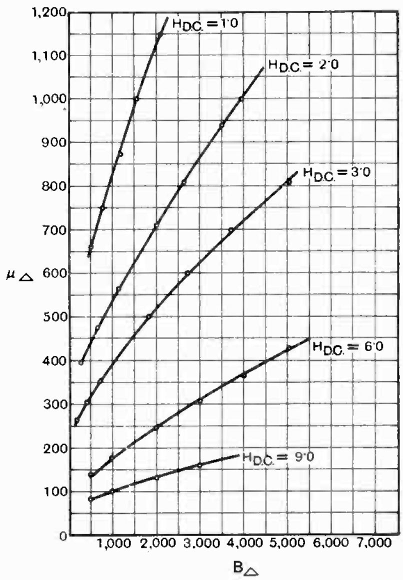


Fig. 20.—*Ballistic* $\mu_\Delta - B_\Delta$.

The authors carried out a series of measurements by this means, using the same sample of Stalloy with the same exciting turns as used in the main tests but with search coils adapted to the needs of the calibrated Grassot fluxmeter.

Figs. 20 and 21 show the results in terms

* See "De Effectieve Permeabiliteit bij Groote Amplituden," W. Elenbaas, publication of the Philips Lamp Factory, Eindhoven, *Physica*, II, 209–214, Sept., 1931.

† For example, see Elenbaas, *loc. cit.*

of B_Δ and H_Δ respectively (full amplitude in both cases).

Comparison of Results

By the foregoing measurements, results had been obtained giving the incremental permeability of Stalloy on four different bases, any one of which might reasonably be advanced and accepted as suitable for defining the quantity concerned.

It was part of the authors' investigation to compare these results, their contention being that incremental permeability values with large excitation amplitudes have little or no practical value unless the method of measurement is

(*a*) Completely specified.

(*b*) Carefully controlled.

The truth of this contention is adequately demonstrated by the curves of Figs. 22 and 23. The families of curves marked *A* are plotted in terms of H_Δ, those marked *B* in terms of B_Δ. Fig. 22 relates to the

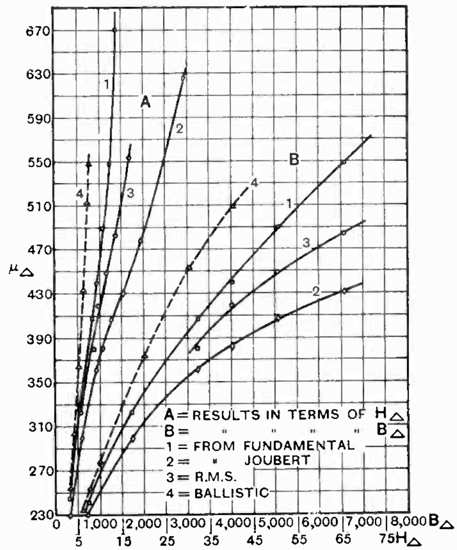


Fig. 22.

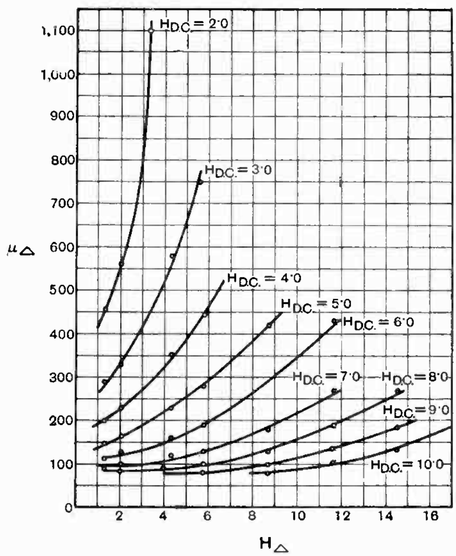


Fig. 21.—*Ballistic* $\mu_\Delta - H_\Delta$.

smallest D.C. polarisation employed, namely, $H_{D.C.} = 4.165$. Fig. 23 relates to $H_{D.C.} = 6.81$.

The numbers marked upon the curves have the following meanings :

(1) Incremental permeability calculated from potentiometer reading of A.C. exciting current component, *i.e.*, the elliptic incremental permeability based upon the fundamental of the distorted exciting current.

(2) Incremental permeability calculated from the R.M.S. value of the distorted A.C. exciting component, *i.e.*, the elliptic incremental permeability based upon an equivalent sine current of R.M.S. value equal to that of the actual distorted current.

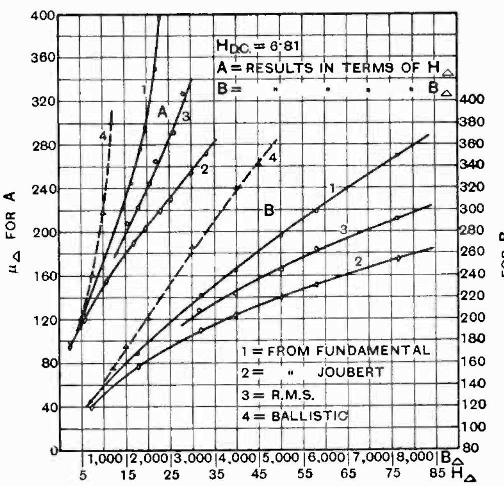


Fig. 23.

(3) True incremental permeability (including eddy current effects) as calculated from the full A.C. exciting component amplitude measured by Joubert contact.

(4) Incremental permeability as calculated from ballistic measurements.

The differences between the curves are so great that some stress needs to be laid upon them.

It may be sufficient to emphasise the danger of drawing conclusions from comparisons between results obtained by different investigators, unless the effect of waveform is taken carefully into account. The present authors do not assert that misinterpretations have already occurred from an insufficient appreciation of this matter, but it is at least certain that they could arise.

If incremental measurements were made with a sinusoidal alternating component it is likely that the ballistic results shown in this paper would correlate closely with such A.C. measurements, so long as the latter took into account the full amplitude of the distorted induction cycle. As stated earlier, in the introduction, it seems necessary to employ a special design of commutator for such work.*

It is undoubtedly of academic interest to attempt this correlation, but the more practical comparison is that shown in the present paper, and here no correlation between the ballistic results and any of the A.C. measurements can be expected.

Before leaving this section it should be stated that Fig. 24 is included as showing conditions applying to a large polarisation. It is otherwise comparable with Figs. 22 and 23 with the exception that it does not include ballistic curves, which were not obtained in this case.

It is important to note that the large polarisation leads to fairly close agreement between the curves so long as the A.C. excitation amplitude is small. This result has already been shown in different manner in the waveform curves of Fig. 15.

Current Harmonics

It was stated that the investigation included an attempt to obtain some information upon the harmonics of incremental magnetisation. Though this part of the work led to the determination of a revised technique of harmonic measurement and to developments in the design of the analyser (which need not be included in the present paper) it is perhaps desirable to indicate some of the difficulties which are the direct result of incremental, as distinct from A.C., magnetisation.

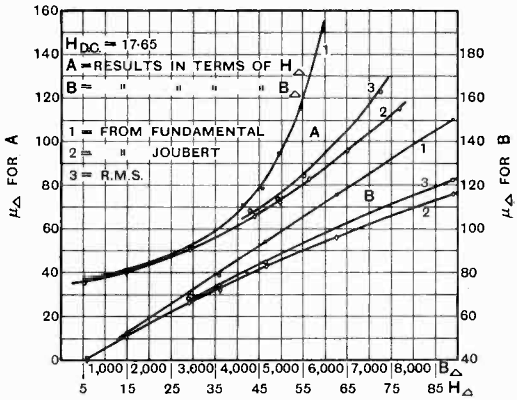


Fig. 24.

Theoretically, it is possible by means of the synchronous disc already described, to measure harmonic amplitudes and phases up to approximately the fifteenth harmonic. Whilst this is possible, with due care, when only A.C. is present, the addition of D.C. in the circuit increases the practical difficulties in the following ways.

(*a*) *Harmonic Amplitudes.*

The steady voltage across the measuring shunt due to the D.C. is very much greater than the harmonic voltages and the latter must be read as differences. Even with considerable waveform distortion the accuracy of observation was found to be poor for harmonics above the fifth.

(*b*) *Harmonic Phases.*

For similar reasons the determination of phase becomes unduly difficult since the percentage change in voltage in passing the harmonic peak is enormously reduced by the presence of the large steady component.

The remedies for the above are probably

* A Joubert disc applied to the measurement of the voltage wave would not suffice since the voltage is the derivative of the induction.

to neutralise the D.C. drop by a backing D.C. voltage supplied from the quadrature element of the co-ordinate potentiometer, and to eliminate all fluctuations of voltage due to the rubbing contact between the synchronous disc and its brush.

The former needs no comment: the latter introduces problems of a nature and extent which fall outside the scope of our discussion. But it is perhaps well to recall that the disc runs at 3,000 r.p.m. and must be continuously in service for weeks or perhaps months. It is easy to total some millions of revolutions during such a period and brush and disc life and contact under such conditions present major problems.

But very interesting data were forthcoming upon these matters when numerous measurements of the amplitude of the lower harmonics were made. As examples of some of the results recorded Figs. 25 and 26 are presented for general interest.

It has been pointed out earlier that the analyser disc concerned had contact segment lengths which were designed for A.C. rather than for incremental work and the even harmonics occurring in the latter must therefore have produced some error in the readings (correction for which is only possible if many terms of the harmonic series are known). In view of this fact and the difficulties of accurate observation mentioned above, it is possible that the harmonic curves presented may need some correction

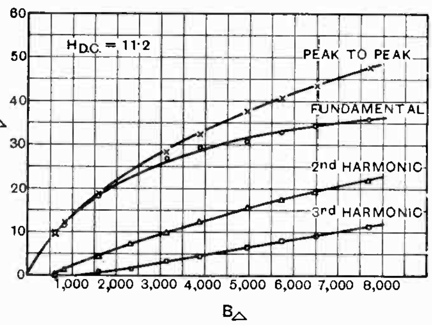


Fig. 25.

later, following further work. At the same time, it is felt that the accuracy is of a sufficiently high order to justify their inclusion in this description of pioneer experiments in a difficult realm of measurement.

Conclusions

Certain conclusions can be drawn from the work.

(*a*) The main object was to apply to incremental measurements an arrangement of precision apparatus capable of providing full and accurate information concerning the behaviour of a ferromagnetic sample excited

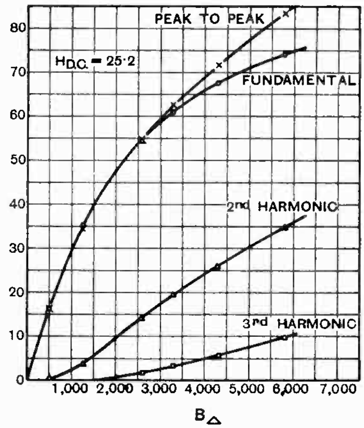


Fig. 26.

by D.C. and A.C. simultaneously. The investigation showed that this is not only possible but that an accurately controlled method of measurement is particularly necessary with this form of excitation, due to the asymmetrical waveform distortion.

(*b*) Further it is shown that (unlike the case of excitation by A.C. alone) ballistic measurements will not in general be reliable as a guide to the behaviour of the sample when magnetised incrementally (using a sine wave of voltage).

(*c*) The superposition of A.C. and D.C. electrically in a single exciting circuit (rather than the superposition of their magnetic effects through the joint action of two separate electrical circuits) is shown to be satisfactory, in that the two quantities can be isolated for accurate measurement by suitable potentiometry.

(*d*) The Joubert disc forms a valuable aid to measurement in this class of work.

The above are general conclusions which can be deduced from the paper as presented.

Others drawn from the authors' experience are included for the interest of other investigators.

Voltage Waveform

It has been explained that the best possible precautions were taken to ensure a sine wave of voltage at the terminals of the test ring during all tests. But the very low inductances of the test coil under heavy D.C. polarisations make this problem excessively difficult, the circuit resistance becoming comparable with the coil reactance from time to time despite many precautions.

The remedies appear to be still more stringent reductions of circuit resistance together with the use of a larger iron sample. In an endeavour to meet the former, the authors have acquired a heavier feed transformer whose rating is greatly in excess of the power required for the tests. This transformer has lower winding resistances than those employed in the present tests and will be used in all future work. Lower resistance ammeters and a lower resistance shunt may also be necessary.

Demagnetisation of Sample

The authors found that a careful routine of demagnetisation is particularly desirable in incremental measurements if special accuracy in the measurements of loss is desired. The dual excitation complicates this matter appreciably, but it can probably be met by a specially planned routine.

Measurement of Harmonics and their Phases

The difficulties at present are due to the attempt to make the harmonic analyser as reliable and accurate as the potentiometer with which the authors used it. This demand is abnormal in view of the high speed of the analyser disc, the long life required and the speed at which readings are required.

It would be premature to say more than that there are grounds to expect that the difficulties can be overcome.

In conclusion, the authors wish to acknowledge their debt to Professor William Cramp, D.Sc., without whose practical interest the work could not have been carried out.

The Industry

A PORTABLE "transceiver" (combined transmitter and receiver) operating on about 5 metres, is being produced by the Ideal Radio and Gramophone Co., Ltd., of 444, Ewell Road, Surbiton. Satisfactory two-way communication has been demonstrated between moving cars and between a moving aeroplane and the ground. Without batteries the Hermes transceiver unit weighs only 5 lb. Mr. E. H. Shaughnessy, late Assistant Chief Engineer of the G.P.O., is associated with the company producing the sets.

By arrangement between Philips and Chrysler Motors, Ltd., a special type of aerial is to be fitted to Chrysler cars. The aerial has been specially designed for use in conjunction with the Philips Motoradio car set, and sparking plug suppressors, which are undesirable with a high-performance engine of the Chrysler type, will not be needed.

"Modern Service Methods," a booklet issued by Everett, Edgcumbe and Co., Ltd., of Colindale Works, Hendon, London, N.W.9, in connection with the Radiolab Set Analyser and Valve Tester, has now been completely rewritten and brought up-to-date. Copies of this new edition can be obtained direct from the firm for 7½d., post free.

La Théorie d'Einstein dementie par l'expérience
By E. Carvallo. pp. 55. E. Chiron, Paris. 6 frcs.

The title page of this attack on the theory of relativity bears a quotation from Einstein dated 1925: "If Dr. Miller's results were confirmed, the theory of relativity would be at fault." Dr. Miller is a disciple of Michelson, who has continued and elaborated the classical experimental work of the latter, in the attempt to detect an effect of the earth's velocity on the velocity of light. In this booklet the author, who does not dissemble his dislike of relativity, maintains that the experimental results of Miller and of other experimenters definitely disprove the theory of relativity. We must confess, however, that we do not find M. Carvallo very convincing. His accounts and discussions of the various experiments are too short and superficial. When he defines an *absolute* velocity as a velocity relative to nothing except a postulated fixed ether, we find it impossible to attach a meaning to his words, although we must also confess that the answer given by the relativitist to the question as to what it is, with respect to which the velocity of light is 3×10^{10} cm per second, is also difficult of conception.

It appears that Dr. Miller's results do not exactly agree with M. Carvallo's expectations, but this he thinks is probably due to the electromotive forces induced in the silvering on the mirrors (which are stationary), due to the magneto field of the earth, and he blames Faraday for putting this idea into his head.

The book did not provide the entertainment which the title led us to expect.

G. W. O. H.

Asymmetric Side-Band Broadcast Transmission

Paper by P. P. Eckersley, M.I.E.E., read before the Wireless Section, I.E.E., on May 1st, 1935

Abstract

BROADCASTING technique is hampered because of the scarcity of channels and the multiplicity of transmitting stations. The spectra of frequencies radiated by stations occupying contiguous frequency channels overlap, and the audio-frequency output from a receiver designed for ordinary domestic reception must be limited to meet the existing conditions of transmission. It is improbable that European nations will agree to limit either the existing power or the number of working stations. If, however, it were possible to modify transmitters so that the spectrum of frequencies radiated contained the carrier and only one set of side-bands, spectrum overlap could be avoided or minimised.

After discussing the phase-modulation or phase-distortion effect when only one side-band is sent out the author proceeds to discuss a system which permits full modulation while using a small "vestigial" value of the nearly suppressed side-band to eliminate or minimise phase distortion. This is explained in relation to Fig. 2,* which shows an idealised amplitude/frequency characteristic of a band-pass filter. The filter is supposed to be arranged so that it attenuates currents of the carrier frequency f_c to exactly one-half of their value. If this carrier is modulated 100 per cent. at 500 cycles the resultant could be expressed as a carrier of 2 units with an upper frequency side-band and a lower-frequency side-band each of 1 unit. If this is applied to a filter of the idealised response shown, the carrier is reduced to 1 unit (attenuated by half), and (on the sloping wall of the characteristic), the upper side-band = 0.75 and the lower side-band = 0.25 unit. The carrier is thus still modulated 100 per cent. although the power in the spectrum is reduced to one-quarter of its original value. It is also clear that whatever frequency of modulation within the range $\triangle f'_m$ is applied to the carrier before the filter, the output still represents 100 per cent. modulation because the sum of the side-band amplitudes is always equal to 1.

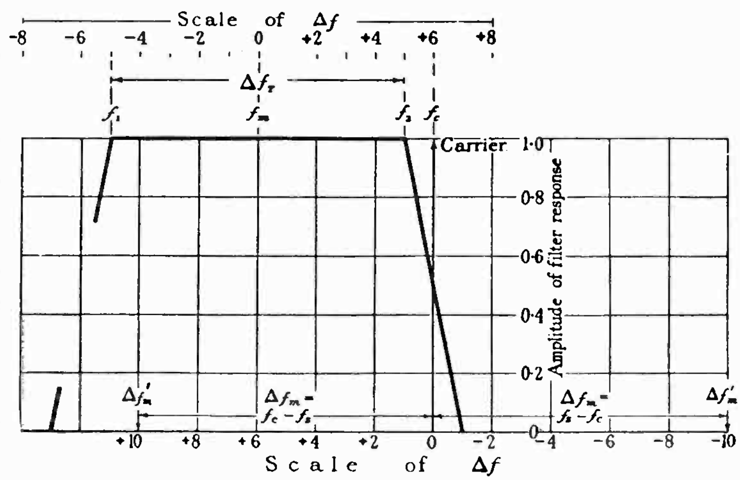


Fig. 2.

In the case of a transmitter working on the system of low-power modulation, it will not require a serious alteration to increase the high-frequency amplification of the stages which follow the output from the filter. For example, a 1-valve stage would suffice in practice and its consumption would not be comparable with the power required to operate the whole station. In contradistinction, no amount of amplification would restore the missing side-bands and give 100 per cent. modulation if the filter completely cut off one set of side-bands, unless the carrier were separately attenuated.

The method could not be used in the case of high power modulation because of the serious loss of power involved, which could only be restored at great capital and maintenance expense. A method applicable in this case is shown in Fig. 3, where in A is shown the same idealised characteristic as in Fig. 2, but with the carrier now located at $(f_2 - 1{,}500)$ kilocycles. There is theoretically no loss of power either of the carrier currents or of the modulated carrier currents over the range 0–1,500 cycles. At modulating frequencies beyond this value, however, the maximum possible percentage modulation gradually falls as one side-band is removed until, at a frequency of 3,500 cycles it is only 50 per cent. (although, of course, the original currents are 100 per cent. modulated before being applied to the filter). This results in a transmitter modulation/audio-frequency characteristic such as that of Fig. 3B. The interposition of equalisers in the audio-frequency circuits of the transmitter could, however, be made to straighten the frequency

* The author's original figure numbers are adhered to throughout this abstract.

characteristic of Fig. 3B. This would at first sight appear to result in a reduction of the modulation to 50 per cent. over the whole band, because the equaliser would have to reduce the modulation intensity by half over a frequency range of 0–1,500

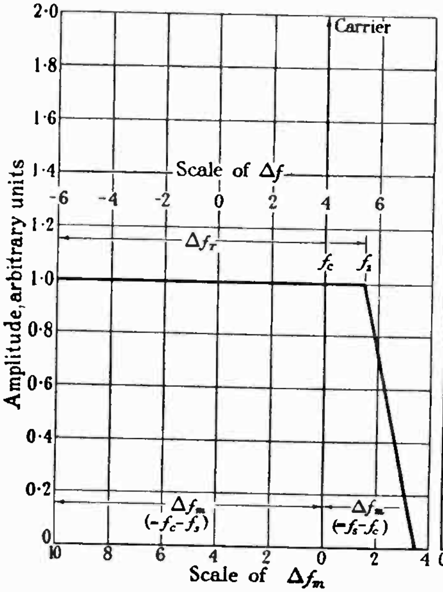


Fig. 3A.

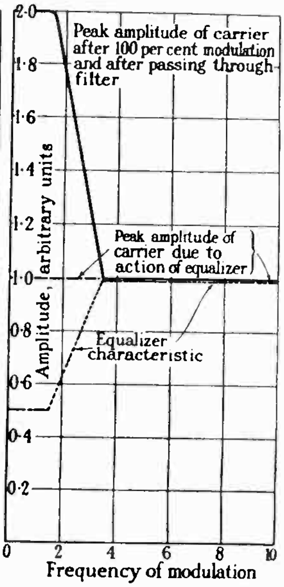


Fig. 3B.

cycles. Thereafter, as the frequency increased, the equalisers would gradually allow greater and greater modulation, reaching a maximum at a frequency of 3,500 cycles. In practice, however, the audio spectrum has intensities which attain their maxima in the region of 500–1,500 cycles, and, in fact, 100 per cent. modulation is practically ever demanded for over audio frequencies above 1,500 cycles. We can, therefore, safely increase the audio-frequency input until the carrier currents are modulated 100 per cent., it being assumed that this will not result in over-modulation at treble and top frequencies.

An experiment is described in the paper to test, under practical conditions of asymmetric side-band broadcasting, whether, in fact, phase-modulation distortion was noticeable with even a high-fidelity receiver. This was done by means of a practical filter having the characteristics shown in Fig. 4, and with the carrier of the London Regional station located as shown. Details of the receiver are given in the paper, and the author states the conclusions that (1) phase-modulation distortion is a second order effect; (2) if it exists it gives no offence even to a critical ear; (3) if it can be detected when the carrier and only one set of side-bands are used, the introduction of the vestigials over the noisy band of frequencies so minimises the effect as to make it negligible.

The author then discusses spectrum overlap with asymmetric side-band broadcasting and shows, typically, that in the case of a very strong unwanted station a weak wanted station could be obtained on the "ideal" receiver with a clear reception of a band of wanted frequencies 6 kilocycles wide and 40 decibels deep.

In relation to modifications of receiver design it is pointed out that if asymmetric side-band transmission were put into practice no existing receiver would remark any change for the worse. The power of stations would remain apparently the same and spectrum overlap would still be noticed. It would be more marked on "straight" sets, embracing symmetrical band-widths on either side of the wanted carrier, to which it is tuned, than on a superheterodyne receiver. In some cases where the wanted station had, as frequency neighbours, one powerful and one weak station, there would be a noticeable improvement even with a straight receiver, provided the powerful station was of lower frequency than the wanted (according to the technique set out in the paper). The superheterodyne type of receiver would benefit by the introduction of the scheme. The

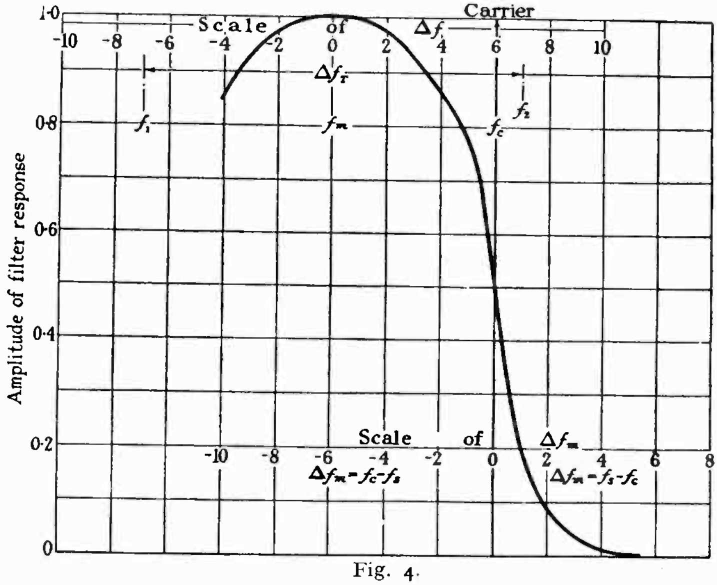


Fig. 4.

typical "visual tuning" indicator would not be beneficial but in time the user would be able to obtain sets for foolproof operation. It is probable that intermediate-frequency filter design would have to be studied so that the response was flatter over the passed band and the rate of change of attenuation with frequency was greater than it need be to-day. These questions must wait for fuller discussion but meantime the author emphasises that no hardships would be imposed by the introduction of the scheme.

An appendix to the paper discusses the design of filters for asymmetric side-band transmission as regards (*a*) low power modulation, (*b*) high-power modulation, (*c*) frequency stability.

Discussion

In opening the discussion, Mr. Noel Ashbridge thought that broadcasting authorities would not raise objections to improvements in the direction of single side-band transmission. Difficulties which existed were to be found in the continental point of view which favoured deep modulation without regard to quality. The author's suggestions were not new, and the subject had been under discussion for at least three years by the U.I.R. and, more lately, by the C.C.I.R. Experiments by the B.B.C. both on transmitters and receivers, on the lines of the author's suggestions had shown that 40 per cent. modulation gave hardly tolerable quality and that modulation had to be 30 per cent. or less for acceptable quality. International discussions had revealed similar results in other places. The C.C.I.R. had the matter under discussion from the point of view of partial or complete carrier suppression.

Col. A. S. Angwin pointed out that broadcasting was not ruled by technicians. More stations were needed in certain parts of Europe, and the ultimate use of single side-band operation seemed imperative. The final aim should be single-side-band without carrier. In the interests of receiver design it might be desirable to have an intermediate stage of partial carrier, used, at the receiver, as a regenerative source for adequate carrier replacement, with the ultimate view of the complete carrier replacement. The author's suggestions represented a temporary expedient in this direction.

Dr. J. Robinson referred to the fact that the author had used the single side-band receiver and asked was not this the correct solution of the problem? Why not use a quartz crystal for the purpose? He agreed that single-side-band operation would be essential.

Mr. H. L. Kirke referred to several points of detail, including phase modulation, and the phase-displacement effect which was known to exist through the passed band of a filter. He compared the modulated envelope with double and single side-band, and stated that the harmonics in the latter case were due to combination tones. He also amplified the information on the B.B.C. experiments already given by Mr. Ashbridge.

Mr. P. K. Turner referred to practical difficulties of receiver design. As an example of the effect of the loss of modulation he quoted that 100 per cent. double-side-band modulation became equal, on single-side-band working, to 45 per cent. modulation of the fundamental with 10 per cent. distortion.

Correspondence

Letters of technical interest are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

Mixing Valves

To the Editor, The Wireless Engineer

Sir,—With reference to the operating characteristics and constants of the frequency changers 41 M.P.G. and F.C.4 given in my previous letter, and with some of which Dr. Strutt cannot entirely agree, I would like to say that these values were obtained by calculation from the makers' published curves (current in August, 1934) and hence may be taken as representative of average valves, *used under the conditions for which my formulae were derived*, i.e. with oscillator grid self-biased by means of grid condenser and leak, so that the maximum instantaneous grid potential is practically equal to the cathode potential. This point was made clear in "Heptode Frequency Changers," *W.E. & E.W.*, December, 1934.

With regard to the discrepancy between the makers' figures for the 2A7 and those which I have given, these latter were obtained by measurement on one particular valve, the purpose of the investigation being, of course, to verify my formulae, not to obtain average characteristics. The specimen used may have differed considerably from the average as now manufactured, owing to manufacturing tolerances and to the fact that it was obtained soon after the 2A7 was available in this country. This, combined, perhaps, with different methods of measurement and a certain amount of Transatlantic optimism in presenting the results, may conceivably account for the makers' figures being considerably different from those which I obtained.

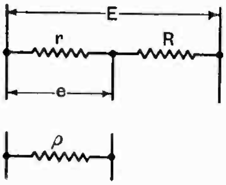
Dr. Strutt, I hope, will now be no longer in doubt as to the method of obtaining the figures which I have quoted.

London, W.13. R. J. Wey.

Anode Potential Measurements

To the Editor, The Wireless Engineer

Sir,—Inventions are in the air and here is a proof of it. I was very interested to read the letter by Mr. C. R. Cosens in the February issue of the *Wireless Engineer*, for I, myself, solved the same problem some months ago; however, in a more general way, as follows :—



R and r are two resistances in series, ρ being the voltmeter-resistance; the total voltage to be measured will be E and the true p.d. across r is e. By inserting the voltmeter across r and R the readings will be $e_{,}$ and $e_{,,}$ respectively.

The following equations are easily to be found :

$$e = \frac{r}{r+R}E \text{ and } \frac{1}{e} = \frac{r+R}{r}\,\frac{1}{E} = \left(1 + \frac{R}{r}\right)\frac{1}{E}$$

and

$$\frac{1}{e_{,}} = \frac{\frac{r\rho}{r+\rho} + R}{\frac{r\rho}{r+\rho}}\,\frac{1}{E} = \frac{1}{e} + \frac{R}{\rho E}$$

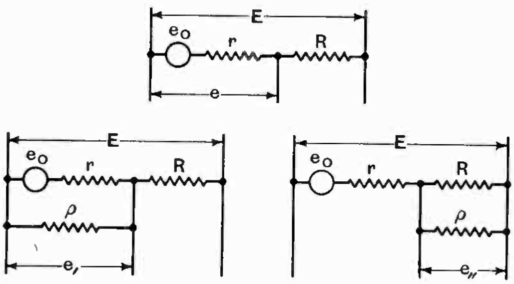
after some operations.

$$\frac{1}{e_{,,}} = \frac{r+R}{R}\,\frac{1}{E} + \frac{r}{\rho E} \text{ and } \frac{R}{re_{,,}} = \frac{1}{e} + \frac{R}{\rho E} = \frac{1}{e_{,}}$$

$$\therefore \frac{R}{r} = \frac{e_{,,}}{e_{,}} - \frac{1}{e} = \left(1 + \frac{e_{,,}}{e_{,}}\right)\frac{1}{E} - \frac{E}{e} = 1 + \frac{e_{,,}}{e_{,}}$$

$$\therefore e = \frac{e_{,}}{e_{,} + e_{,,}}E \left(\text{i.e. } e = \frac{V_{xz}}{V_{xr} + V_{rz}}V_{rz}\right)$$

A thermionic valve can be replaced by an e.m.f. $= e_0$ and a resistance $= r$ in series, so far as the valve characteristics are straight over the relevant portions (condition β of Mr. Cosens). So there are the following diagrams and equations :



$$e = \frac{r}{r+R}(E - e_0) + e_0 = \frac{rE + Re_0}{r+R}$$

$$e_{,} = \frac{\frac{r\rho}{r+\rho}}{\frac{r\rho}{r+\rho} + R}E + \frac{\frac{\rho R}{\rho+R}}{\frac{\rho R}{\rho+R} + r}e_0 = \rho\frac{rE + Re_0}{R\rho + Rr + r\rho}$$

$$e_{,,} = \frac{\frac{\rho R}{\rho+R}}{\frac{\rho R}{\rho+R} + r}(E - e_0) = \rho\frac{RE - Re_0}{R\rho + Rr + r\rho}$$

$$e_{,} + e_{,,} = \rho\frac{(r+R)E}{R\rho + Rr + r\rho}$$

$$\frac{e_{,}}{e_{,} + e_{,,}} = \frac{rE + Re_0}{(r+R)E} = \frac{e}{E}$$

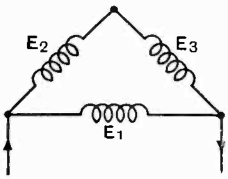
$$\therefore \quad e = \frac{e_{,}}{e_{,} + e_{,,}}E.$$

$e_{,}$ — Regarding E—r and ρ are parallel and in series with R; regarding e_0—R and ρ are parallel and in series with r.

$e_{,,}$—Regarding $(E - e_0)$—R and ρ are parallel and in series with r.

Yet there are other ways to solve this problem, by applying Ohm's and Kirchhoff's laws.

There will be many other applications to this formula. For instance, the H.T. source can be regarded in the same manner, R being the load, r = the internal resistance, e_0 = unloaded tension = e.m.f.



To conclude, I will give this measuring device a name: *The three voltmeter method for d.c.* As already known, the three voltmeter method for a.c. has an identical diagram and serves to find the phase-shift of three p.d. in triangle (see diagram, the arrows giving the direction of the energy).

Krabbenbosweg 29, Hengelo (o), Holland. B. VAN DAM.

Rigour and Nomenclature in Mathematics

To the Editor, The Wireless Engineer

SIR,—Several interesting points are raised by Dr. McLachlan in his letter in your May issue. One feels that rigour (or the lack of it) in mathematical work should be relative to the relevant circumstances. Whilst the efforts of mathematical purists to place their subject on sound foundations is appreciated, physicists and engineers are concerned with practical applications of mathematics. Cannot they then take the rigour more or less for granted? If this view is accepted, the degree of rigour attained in physical and engineering analysis may permissibly fall short of the standard insisted upon by purists.

What is needed in the mathematical training of engineers is not more rigour, but extended knowledge. Having mastered the elements of a mathematical subject, the engineer may proceed to apply it with confidence. That such mastery is not so difficult as is commonly supposed is shown by "Bessel Functions for Engineers." Useful results from the higher branches of the subject, the derivation of which often entails much soul searching, may be taken as read, and applied *ad hoc*. This is true not only of Bessel functions, but of vector analysis, theory of complex functions, operational calculus, and other subjects, the elementary parts of which could advantageously be included in an engineering course.

Purists seem sometimes to forget that most mathematics begins with a stage of experimental development; it is only later that rigorous proofs become possible. The Heaviside operational calculus is a good example of this. Another is Dr. McLachlan's assertion that $2 + 2 = 4$. To whatever extent the latter "theorem" rested originally on an empirical basis, an acquaintance with the work of B. A. W. Russell and A. N. Whitehead shows that it is now decidedly not without proof! But even those logicians have to start somewhere with undefined concepts. Nobody ever really proves anything. All that is possible is to show that certain conclusions logically follow from certain premises.

The names "surd," "irrational" and "imaginary number" bear witness to the hesitancy with which these concepts were experimentally introduced into mathematical theory. They also illustrate Dr. McLachlan's contention that mathematical nomenclature is occasionally surprisingly inept. In spite of this laxity, however, purists are quick to take exception to terms used by engineers. For instance, they do not like "vector" applied to the directed quantities (impedances, etc.) of alternating theory; although, personally, I cannot agree that these quantities are not two-dimensional vectors.

Many of the above arguments were strongly advocated, *inter alia*, by Heaviside; and a perusal of the opening sections of vol. 2 of his "Electromagnetic Theory" may be recommended to purists. Is it not curious, by the way, considering the immense amount of experimental research Heaviside did in asymptotic and divergent series, that he is never mentioned by purists dealing with this subject? There are still plenty of nuts in Heaviside for purists to crack. Is it too much to hope that the subsequent distribution of manna will include the kernels of new results as well as the hard shells of rigour?

London. A. L. MEYERS.

Book Review

"Fernseh Empfang" (Television Reception).

BY MANFRED VON ARDENNE: Weidmannsche Buchhandlung, Berlin, S.W.8: 117 pp. with 80 illustrations.

This little book, with the sub-title "Construction and Use of an equipment for the reception of ultra-short-wave television broadcasting with a cathode-ray tube," appears opportunely at a moment which the author rightly describes as the turning point in the history of television. Moreover, the author is known to readers of *The Wireless Engineer* as one of the most able pioneers of cathode-ray television. The book, therefore, should be of the utmost interest to those who can read German—even haltingly, for the matter is given with a commendable economy in words.

The author is no reckless optimist as to the prospects of an immediate "boom" in television among the German populace. The fundamental problems have been solved, it is true, at any rate in principle; receivers can actually be turned out on a commercial scale. But for popular success he considers two problems remain to be solved—the receivers must be made easier to work and, above all, cheaper to buy. He also considers that transmitters do not at present (he is writing in December, 1934) display the full desirable stability. While these remaining difficulties are being overcome, he looks for a great extension of activity among the "amateurs"; the main object of this book is to give a vigorous impulse to an intensive activity in experimental work. No attempt is made to describe a complete commercial receiver; the book, apart from the first part which deals with the Berlin transmitter, is really a dissertation on the experimental equipment which he himself has put together and used for the reception of the Berlin ultra-short-wave picture-and-sound transmissions; the equipment, in fact, which was employed for taking the instantaneous photographs of received images which are distributed through the book, and which illustrate the results of good and bad receiver design and adjustment. Some of these have appeared in an article in our sister journal, *The Wireless World*, for 15th March, 1935. The whole equipment is, of course, designed for these Berlin (Witzleben) transmissions of 180 lines and 25 pictures per second.

For those who have followed the author's work in the past, when he did so much to develop the cathode-ray tube with gas-focusing, for television and other uses, it is of great interest to read his verdict on the comparative merits, for the purpose in view, of the high-vacuum and gas-focused types of tube. On p. 28 he writes "In television in the future only the high-vacuum type will be used. Only for special purposes, where extreme brightness of spot is required, will types with more or less strong compensation of electron space-charge by means of residual gas perhaps find an application."

Another moot point—the comparative merits of electrostatic and magnetic deflecting methods—is decided in favour of a combination of the two, magnetic deflection being used for the 25 per sec. vertical motion (at which frequency only a reasonable amount of power is demanded) and electrostatic for the horizontal line-scanning. The advantages of this compromise are discussed on pp. 33–35. The question of the choice between independent "kipp" (time-base) circuits, synchronised by pull-in signals from the transmitter, and "kipp" circuits controlled entirely from the transmitting end, is discussed on pp. 61–62. The decision is in favour of the former, as being—at any rate at present—easier to manage and less susceptible to interference: a point of importance except where the received field strengths are very great.

In his survey of the results obtained with this equipment (all parts of which are illustrated by circuit diagrams and lists of German components, with their electrical values) the author points out that all the instantaneous photographs were taken before the recent improvement of the frequency curve of the Berlin transmitter, and most of them (at any rate) at a time when these transmissions did not give perfectly superposed pictures, displacements of two or three line-thicknesses being sometimes found. A particularly interesting photograph is that of Fig. 80, two images taken with single-sideband reception.

Abstracts and References

Compiled by the Radio Research Board and reproduced by arrangement with the Department of Scientific and Industrial Research.

PROPAGATION OF WAVES

1727. The Propagation of Medium Radio Waves in the Ionosphere [Gradient of E Region: Value of Collisional Frequency There].—D. F. Martyn. (*Proc. Phys. Soc.*, 1st March, 1935, Vol. 47, Part 2, No. 259, pp. 323–339.)

Author's abstract :—All the available measurements of sky-wave intensities at medium frequencies are collated and expressed as field-strength/distance curves for six typical wavelengths and for distances from 25 to 1000 km. It is shown how this material may be used for the determination of the non-fading radii of broadcasting emitters over country of any effective conductivity. From the observational material an empirical expression for the reflection coefficient of the lower E layer of the ionosphere is derived. It is shown that the observations are incompatible with the existence of a linear or parabolic gradient of ionisation in this layer. The incompatibility is not removed by the assumption of an absorbing or D region below the E layer, or by consideration of the variation with height of the collision frequency ν of an electron with the air molecules in the E layer. It is found that the observations can be fully explained if the gradient of ionisation is given by the exponential form $N = \epsilon^h$, where h is the height in km above the region where ionisation first becomes appreciable. This gradient also gives rise to equivalent heights which are in agreement with experience. It is found that ν has a value of 10^6 collisions per sec. at a height of 90 km, in close agreement with Chapman's recent estimate. It is shown that the conclusions reached are not affected by the use of the ray methods of geometrical optics or by neglect of the influence of the earth's magnetic field.

1728. Long-Distance Observations of Radio Waves of Medium Frequencies.—D. F. Martyn, R. O. Cherry and A. L. Green. (*Proc. Phys. Soc.*, 1st March, 1935, Vol. 47, Part 2, No. 259, pp. 340–351.)

Downcoming waves from a distant transmitter were analysed by the frequency-change method: simultaneous observations were made at distances of 25 and 700 km from the emitter. Several downcoming waves were present at the more distant station. The equivalent heights of both E and F regions were relatively stable over the 700 km path and did not vary appreciably with the angle of incidence. The equivalent height of F region showed a minimum at about 3 a.m. The rate of propagation of the minimum height in the horizontal direction appeared to be slower than the rate of sunset propagation in the same direction. Estimates were made of the ionisation density in E region. The intermediate layer was regularly observed. It is concluded from the experiments that the gradient of ionisation at the lower boundary of E region is sharp.

1729. Collision Frequency and Molecular Density in the F_1 Layer of the Ionosphere [from Measurements of Reflection Coefficient and Equivalent Height].—T. L. Eckersley. (*Nature*, 16th March, 1935, Vol. 135, p. 435.)

There should be a linear relation between the logarithm of the intensity of the reflected wave and the equivalent height; the slope of the line should give the collision frequency at the height at which reflection occurs. Experimental graphs of this are shown.

1730. Ionisation Charts of the Upper Atmosphere, Part II.—G. Millington. (*Proc. Phys. Soc.*, 1st March, 1935, Vol. 47, Part 2, No. 259, pp. 263–276.) For Part I *see* 1933 Abstracts, p. 32. An envelope correction to the previous charts is given, and the new charts are presented on a circular projection to help in the study of conditions in the polar regions.

1731. The Fraction of the Radiation from a Vertical Dipole absorbed by the Earth [Practical Formulae and Calculations].—K. F. Niessen. (*Ann. der Physik*, Series 5, No. 2, Vol. 22, 1935, pp. 162–188.)

General formulae are first found for the Hertzian potentials, field components and energy radiated upwards and downwards from a vertical dipole at a height h above a plane earth. Bessel function formulae already given by van der Pol and the writer (1932 Abstracts, pp. 87 and 300) are used to transform the integrals in the general formulae. Special cases are then considered: (§ 2) the atmosphere is non-conducting, (§3) the atmosphere is non-conducting and the earth a good conductor, (§4) the wavelength and earth constants are connected by Sommerfeld's relation, in which the refractive index $n \gg 1$; formulae are found in each case for the amount of radiation absorbed by the earth and emitted into the atmosphere. §5 transforms the expression for the total energy radiated, with the Zenneck-Sommerfeld assumptions and limited dipole height [it is assumed that $(h/\lambda) \leq (n/8)$]. §6 gives a practical formula (38) and calculations for the fraction absorbed in the earth, and Fig. 8 shows the results graphically for different values (represented in Figs. 5, 6, 7) of the earth constants. Variation of dipole height (excluding short-wave emitters and aeroplane aerials) is found to have little effect on the proportion of energy absorbed by the earth.

1732. ELECTROMAGNETIC WAVE-INDUCTION IN MEDIA AT REST AND THE NECESSARY CONDITION THEREFOR [Occurrence of Surface Waves: Propagation along Surface of Earth and Kennelly-Heaviside Layer].—K. Uller. (*Hochf:tech. u. Elek:akus.*, March, 1935, Vol. 45, No. 3, pp. 87–91.)

This paper extends previous work by the writer (*see* 1929 Abstracts, p. 203; also 1932, p. 158 and back ref.) on the possibility of a plane wave being transformed into a surface wave when it meets a plane boundary surface (no reflected or refracted waves being produced); the phenomenon known as Faraday induction was found to be the necessary condition for the production of this surface wave. Here the theory is extended (without details of the mathematics) to an arbitrary wave incident on an arbitrary surface: the same general conclusions are found to hold. Transmission of radio waves to great distances is thought by the writer to be due to passage of waves along the surface of the earth and Kennelly-Heaviside layer, rather than to optical reflection between these surfaces.

1733. CONCERNING THE IONOSPHERE [Seasonal, Diurnal and Latitude Variations of F Region Ionisation].—E. O. Hulburt. (*Phys. Review*, 1st March, 1935, Series 2, Vol. 47, No. 5, p. 422.) *See* Appleton, 941 of April.

1734. IONOSPHERE STUDIES [Seasonal Variation of Virtual Height of F_2 Region].—E. B. Judson. (*Phys. Review*, 15th March, 1935, Series 2, Vol. 47, No. 6, p. 509.)

1735. THREE-FOLD MAGNETO-IONIC SPLITTING OF THE RADIO ECHOES REFLECTED FROM THE IONOSPHERE [observed occasionally after Sunset].—G. R. Toshniwal. (*Nature*, 23rd March, 1935, Vol. 135, pp. 471–472.)

1736. THE IONISING EFFECTS OF METEORS [Comprehensive Survey].—A. M. Skellett. (*Proc. Inst. Rad. Eng.*, February, 1935, Vol. 23, No. 2, pp. 132–149.)

The two principal sections deal with the evidence of the ionising effect of meteors from meteoric data and from radio data. The difference between Nagaoka's "clean-up" theory (suggesting a decrease in ionisation) and the writer's ideas is stressed. Many literature references are given, including a few not included in these Abstracts. In the writer's previous paper (1933 Abstracts, p. 207) correlation as regards the E region only was claimed. In Part IV of the present paper reasons are given for concluding that showers of average-sized meteors, at random times, might occur in the F region which would be unobservable by ordinary visual means. Such showers would furnish a possible cause of the unexplained disturbances in short-wave transmission referred to in Part III. The paper ends with a discussion of the size of meteors and the recombination coefficient at the height of the E region.

1737. ELECTRONIC TIDES IN IONOSPHERE CAUSED BY MOON.—Stetson. (*Sci. News Letter*, 23rd Feb. 1935, Vol. 27, No. 724, pp. 115–116.)

1738. PHASE OF THE DIURNAL COMPONENT OF THE GRADIENT OF TERRESTRIAL ELECTRICAL POTENTIAL [and the Possible Connection with Ionosphere Layer Heights].—R. Guizonnier. (*Comptes Rendus*, 4th March, 1935, Vol. 200, No. 10, pp. 852–853.) For the paper by Brown referred to, *see* 1341 of May.

1739. THE BEHAVIOUR OF ELECTRONS IN CHLORINE [Application to Collisions of Electrons in Ionosphere: Non-Formation of Negative Ions by Attachment].—V. A. Bailey and R. H. Healey. (*Phil. Mag.*, April, 1935, Series 7, Vol. 19, No. 128, pp. 725–746.)

1740. ON THE ORIGIN OF THE RADIATIONS EMITTED BY THE NIGHT SKY IN THE SPECTRAL REGION 5000–8000 Å.—J. Cabannes. (*Journ. de Phys. et le Rad.*, December, 1934, Series 7, Vol. 5, No. 12, pp. 601–613.) Development of the results referred to in 1934 Abstracts, p. 492. *See* also 24 of January.

1741. THE ABSORPTION SPECTRUM OF OZONE AT LOW TEMPERATURE.—Lucie Lefebvre. (*Comptes Rendus*, 18th Feb. 1935, Vol. 200, No. 8, pp. 653–654.)

1742. EFFECT OF THE TEMPERATURE OF THE STRATOSPHERE ON THE SPECTRUM OF OZONE.—Barbier, Chalonge and Vassy. (*Comptes Rendus*, 18th March, 1935, Vol. 200, No. 12, pp. 1063–1066.) With comments by Fabry.

1743. THE VERTICAL DISTRIBUTION OF ATMOSPHERIC OZONE IN HIGH LATITUDES.—A. R. Meetham and G. M. B. Dobson. (*Proc. Roy. Soc.*, Series A, 15th Feb. 1935, Vol. 148, No. 865, pp. 598–603.)

Observations similar to those recently made at Arosa (Abstracts, 1934, p. 553: *also* 1933, p. 560) were carried out at Tromsö in May and June, 1934. The average height of the ozone was found to be very slightly lower at the higher latitude; the ozone at Tromsö was more concentrated in a region centred at a height of 21 km above sea-level, whereas at Arosa it was more uniformly distributed through the lower 30 km.

1744. CONTRIBUTION TO THE STUDY OF IONISED GASES.—Th. V. Jonescu. (*Journ. de Phys. et le Rad.*, November, 1934, Series 7, Vol. 5, No. 11, pp. 578–584.)

Calculation of the coefficient of self-induction of ionised gases: of their capacity: of their natural frequency of vibration. The behaviour of valves containing ionised gases, with positive grids (B.-K. formula deduced from the natural period of the gas): propagation velocity of electrical energy in tubes containing ionised gas. Experimental section:—Variation of propagation velocity produced by variation of the capacity of the tube by bringing up a metal plate: propagation of energy inside metallic tubes: variation of propagation velocity with the tube diameter.

1745. On the Dielectric Constant and the Conductivity of Ionised Gases [Survey of Past Work].—Th. V. Jonescu and C. Mihul. (*Journ. de Phys. et le Rad.*, January, 1935, Series 7, Vol. 6, No. 1, pp. 35–48.) Various *Comptes Rendus* Notes on these researches have been dealt with previously.

1746. Considerations on the Propagation of Ultra-Short and Micro-Waves [Rome/Sardinia and Rocca di Papa Results: Inadequacy of Diffracted Field to account for Ranges Obtained: Preponderance of Refractive Effects in Lower Atmosphere, due to Various Degrees of Ionisation from Radioactive Emanations, Vapours, etc.].—G. Pession. (*Rassegna delle Poste dei Teleg. e dei Telef.*, April, 1933, Vol. 5, No. 4, pp. 232–238.)

1747. Hartford/Boston Link established on 2.5 Metres [90-Mile Indirect Path with Directive Aerial: Certain Lower-Atmospheric Conditions more favourable than to 5-Metre Waves: etc.].—R. A. Hull. (*QST*, March, 1935, Vol. 19, No. 3, pp. 16 and 98, 99.) For previous reports *see* 931 of April and 1440 of May.

1748. A Simple Photographic Recorder for the Experimenter [as used for Recording Hartford/Boston Ultra-Short-Wave Signal Variations].—R. A. Hull. (*QST*, March, 1935, Vol. 19, No. 3, pp. 27–28 and 100, 102.)

1749. Propagation of Light in the Atmosphere [Quantitative Study of Variations in Intensity (up to 1 : 10 even in Calm Air) at Points some Centimetres apart, from Light Source 8 Kilometres away].—J. Duclaux. (*Journ. de Phys. et le Rad.*, February, 1935, Series 7, Vol. 6, No. 2, pp. 49–51.)

1750. New Researches on the Penetration of Fog by Light.—M. Wolff. (*E.T.Z.*, 14th March, 1935, Vol. 56, No. 11, pp. 319–320.)

1751. The Penetration of the Red, Green and Violet Components of Daylight into Atlantic Waters [and the Differential Effects of Dissolved and Suspended Substances].—R. H. Oster and G. L. Clarke. (*Journ. Opt. Soc. Am.*, March, 1935, Vol. 25, No. 3, pp. 84–91.)

1752. Equation of Waves in Media with Velocity Varying with Time.—P. I. Wold. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 333: abstract only.)

1753. Analytical Investigation of Wave Propagation Phenomena in a Medium whose Constants are Functions of Time, Space, and the Surge Itself [using Modified Form of Laplace's Transformation].—S. Hayashi. (*Journ. I.E.E. Japan*, February, 1935, Vol. 55 [No. 2], No. 559, pp. 110–114: English summary p. 19.)

1754. Simultaneous Travel of a Surge of Stress and a Group of High-Frequency Waves of Stress in a Steel Wire.—D. O. Sproule. (*Nature*, 6th April, 1935, Vol. 135, p. 547.) Discussion of letter by Wall (955 of April).

1755. Viscous Fluids and Waves which can be Propagated therein.—G. De Backer. (*Comptes Rendus*, 11th March, 1935, Vol. 200, No. 11, pp. 899–901.)

1756. Underground Wireless—Recent Experiments in Signalling through the Earth.—C. H. Roddis. (*Electrician*, 8th Feb. 1935, Vol. 114, No. 2958, p. 178.)

Summary only. "Considering that the results so far experienced point towards working upon the possibilities of utilising the magnetic field to more advantage, and watching the success recently experienced in a cross-Channel telephone by the aid of the magnetic field, there is ample reason for confidence that the experiments are worth proceeding with."

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

1757. Study of the Diurnal Variation of Atmospherics at Shanghai.—P. Lejay. (*Comptes Rendus*, 25th Feb. 1935, Vol. 200, No. 9, pp. 768–770.)

1758. The New Phenomena discovered by Schonland and Collens in the Path of a Lightning Flash [Main Earth-Cloud Discharge due to Flow of Electricity induced on Earth below Cloud: General Discussion of Lightning Phenomena].—B. Walter. (*Ann. der Physik*, March, 1935, Series 5, Vol. 22, No. 4, pp. 421–424.) *See* 1934 Abstracts, p. 555, and back references.

1759. "Multiple Lightning Strokes": Discussion.—McEachron. (*Elec. Engineering*, March and April, 1935, Vol. 54, Nos. 3 and 4, pp. 332–333 and 444–445.) *See* 670 of March.

1760. Surge Currents in Protective Devices [Analysis of Data relating to Magnitude and Probable Frequency of Occurrence].—A. M. Opsahl. (*Elec. Engineering*, February, 1935, Vol. 54, No. 2, pp. 200–204.)

1761. Discussion on "Cathode-Ray Oscillographic Studies of Surge Phenomena."—Allibone, Hawley and Perry. (*Journ. I.E.E.*, February, 1935, Vol. 76, No. 458, pp. 236–238.) *See* 42 of January.

1762. Thunderstorm Disturbances of a South African 132 kV Two-Wire System from 1926 to 1933.—H. Neuhaus. (*E.T.Z.*, 14th March, 1935, Vol. 56, No. 11, pp. 313–316.)

1763. Discussions of Papers on Lightning Investigations on Transmission Lines.—(*Elec. Engineering*, February, 1935, Vol. 54, No. 2, pp. 218–233.) Discussions on papers which have been referred to in past Abstracts.

1764. Lightning and the Washington Monument.—Nat. Bureau of Stds. (*Journ. Franklin Inst.*, March, 1935, Vol. 219, No. 3, pp. 373–374.)

1765. The Protection of Houses against Lightning [Official Appendix].—(*L'Elettrotec.*, 15th Nov. 1934, Vol. 21, No. 32, pp. 749–752.)

1766. The Potential Acquired in the Natural Electric Field by a Vertical Rod Standing on the Ground, Insulated at the Bottom and Carrying a Collector at the Top [Theoretical Investigation].—L. H. G. Dines. (*Proc. Phys. Soc.*, 1st March, 1935, Vol. 47, Part 2, No. 259, pp. 218–234.)

1767. Corona Effect with D.C. Potentials.—G. de Fassi. (*L'Elettrotec.*, 10th March, 1935, Vol. 22, No. 5, pp. 163–172.)

1768. Explosive Distances [in Air].—G. Rebora. (*L'Elettrotec.*, 25th March, 1935, Vol. 22, No. 6, pp. 202–206.)

1769. Testing with High Impulse Currents [Experiments with High-Current Impulse Generator with Open-Circuit Potential of 150 kV].—McEachron and Thomason. (*Gen. Elec. Review*, March, 1935, Vol. 38, No. 3, pp. 126–131.)

1770. "Electrical Figures on Plates in Air": Discussion [Difference in Rates of Growth of Positive and Negative Figures, etc.].—Pleasants. (*Elec. Engineering*, February, 1935, Vol. 54, No. 2, p. 234.) *See* 1934 Abstracts, p. 262.

1771. Direct Measurement of Surge Currents [by Surge-Crest Ammeter].—Foust and Henderson. (*Elec. Engineering*, April, 1935, Vol. 54, No. 4, pp. 373–378.) For previous papers on this instrument *see* 1934 Abstracts, p. 555.

1772. Meteorological Radio Soundings [Survey of Exploring Balloon Methods, especially those of the Trappes Observatory and of Moltchanoff].—R. Bureau. (*L'Onde Élec.*, January and February, 1935, Vol. 14, Nos. 157 and 158, pp. 10–26 and 87–96.)

1773. Phase of the Diurnal Component of the Gradient of Terrestrial Electrical Potential.—Guizonnier. (*See* 1738.)

1774. Simultaneous Measurements of Various Elements of Atmospheric Electricity.—Odette Thellier. (*Comptes Rendus*, 25th March, 1935, Vol. 200, No. 13, pp. 1124–1127.)

1775. Atmospheric Electricity in Australia [Note on Potential Gradient].—(*Nature*, 30th March, 1935, Vol. 135, p. 515.)

1776. The Diurnal Variation of Magnetic Disturbance in High Latitudes.—J. M. Stagg. (*Proc. Roy. Soc.*, Series A, 1st April, 1935, Vol. 149, No. 867, pp. 298–311.)

1777. The [Laboratory] Production of a Radiation of Energy comparable to That of Soft Cosmic Rays [20–30 × 10^6 eV].—Joliot and Kowarski. (*Comptes Rendus*, 4th March, 1935, Vol. 200, No. 10, pp. 824–827.)

1778. The Directional Distribution of Coincident Cosmic Rays at Sea-Level [Cosine Square Distribution: New Determination of Specific Ionisation and Other Constants].—W. Kolhörster and L. Jánossy. (*Zeitschr. f. Physik*, No. 1/2, Vol. 93, 1934, pp. 111–122.)

1779. Effect of the Earth's Magnetic Field on Cosmic Rays in the Stratosphere [Primary Radiation consists of Two Corpuscular Components].—M. Cosyns. (*Nature*, 23rd Feb. 1935, Vol. 135, pp. 313–314: preliminary results.)

1780. The East-West and Longitude Effects [in Cosmic Rays: Theoretical Effect of Dissymmetry of Earth's Magnetic Field].—H. V. Neher. (*Phys. Review*, 1st March, 1935, Series 2, Vol. 47, No. 5, pp. 417–418.)

1781. The Electrostatic Deflection of the Cosmic Rays.—B. Rossi: Lenz. (*La Ricerca Scient.*, No. 11/12, Vol. 2, 5th Year, 1934, pp. 470–471.) On Lenz's results. *See* also 1782.

1782. Electrical Deviation of Cosmic Ray Particles [Possible Method of Analysis: Preliminary Description].—E. Lenz. (*Physik. Zeitschr.*, 2nd Jan. 1935, Vol. 36, No. 1, pp. 24–26.) *See* also 381 of February, and 1781 and 1783.

1783. On the Electrostatic Deflection of Cosmic Radiation [Comparison of Results].—W. E. Danforth and W. F. G. Swann. (*Phys. Review*, 1st March, 1935, Series 2, Vol. 47, No. 5, p. 421.) *See* also 1782, above; Danforth, 1934 Abstracts, p. 316; and Swann, *Science*, 19th May, 1933.

1784. Studies of the Corpuscular Component of the Cosmic Radiation.—T. H. Johnson. (*Trans. Am. Geophys. Union*, June, 1934, Part I, pp. 143–147.)

1785. The Thermal Equilibrium of the Elementary Corpuscles [with Application to Origin of Cosmic Rays].—G. Wataghin. (*Comptes Rendus*, 11th March, 1935, Vol. 200, No. 11, pp. 909–912.)

1786. The Absorption of the Cosmic Radiation, *and* Characters of the Two Corpuscular Components [Protons and Electrons?] of the Cosmic Radiation.—Auger: Auger and others. (*Comptes Rendus*, 25th Feb. and 18th March, 1935, Vol. 200, Nos. 9 and 12, pp. 739–742 and 1022–1024.)

1787. ARE THE FORMULAE FOR THE ABSORPTION OF HIGH-ENERGY RADIATIONS VALID? [Discrepancy between Theory and Experiment for Absorption of Cosmic-Ray Electrons and Gamma Rays explicable on Classical Theory].—J. R. Oppenheimer. (*Phys. Review*, 1st Jan. 1935, Series 2, Vol. 47, No. 1, pp. 44–52.)

1788. COMPARISON BETWEEN THE "CURVES OF SHOWERS" AT SEA LEVEL AND AT 2 760 METRES.—Rossi and de Benedetti. (*La Ricerca Scient.*, No. 9/10, Vol. 2, 5th Year, 1934, pp. 379–380.)

1789. SOME RESEARCHES ON THE SO-CALLED "SHOWERS."—Bernardini and Bocciarelli. (*La Ricerca Scient.*, No. 11/12, Vol. 2, 5th Year, 1934, pp. 464–467.)

1790. THE ABSORPTION OF THE PENETRATING CORPUSCULAR RADIATION AT VARIOUS ZENITHAL INCLINATIONS.—Bernardini and Bocciarelli. (*La Ricerca Scient.*, No. 1, Vol. 1, 6th Year, 1935, pp. 33–39.)

1791. DEEP WATER MEASUREMENTS OF COSMIC RAYS IN THE NORTH SEA.—J. Clay and others. (*Physica*, Oct./Nov. 1934, Vol. 1, No. 10/11, pp. 1077–1081: in English.)

1792. VARIATION OF THE INTENSITY OF COSMIC RADIATION AT DIFFERENT HEIGHTS AND WITH ATMOSPHERIC PRESSURE: A BAROMETER PARADOX: THE INFLUENCE OF CLOUDS [and the Probability of the Existence of an Intermediate Photon Radiation].—Clay and van Alphen. (*Physica*, March, 1935, Vol. 2, No. 3, pp. 183–195.) In two papers on the 1933 Dutch expedition. For previous papers *see* 1934 Abstracts, pp. 316 and 556.

1793. RESEARCHES ON THE COSMIC RAYS CARRIED OUT AT SCORESBY SOUND DURING THE POLAR YEAR.—A. Dauvillier. (*Journ. de Phys. et le Rad.*, December, 1934, Series 7, Vol. 5, No. 12, pp. 640–648.) *See* also 1934 Abstracts, p. 492.

PROPERTIES OF CIRCUITS

1794. EFFECT OF OUTPUT IMPEDANCE ON THE PERFORMANCE OF SQUARE-LAW DETECTORS IN BEAT-FREQUENCY OSCILLATORS.—W. G. Baker. (*Journ. Inst. Engineers, Australia*, November, 1934, Vol. 6, No. 11, pp. 447–451: *A.W.A. Technical Review*, March, 1935, Vol. 1, No. 1, pp. 22–31.)

Author's summary:—Square-law detectors in beat-frequency oscillators would produce no harmonics of the beat frequency if the square law were not disturbed by the output impedance. A method is here developed for the determination of the magnitude of this effect, depending on the solution of a differential equation by a method of successive approximation. Expressions are given from which the distortion may be estimated, and the conditions for minimum distortion determined. It is shown that there is an optimum relation between the load resistance and the grid bias, resulting in a relative maximum voltage output. Keeping this relation satisfied, there is again an optimum value of load resistance, and at the corresponding bias with this resistance the maximum output at fixed plate voltage is obtained. The output is at once limited by grid current and cut-off of the plate current, both of which are just to be avoided.

1795. CALCULATION OF SYNCHRONISM ["Gleichlauf"] IN THE INTERMEDIATE-FREQUENCY [Superheterodyne] RECEIVER.—W. Kautter. (*E.N.T.*, January, 1935, Vol. 12, No. 1, pp. 31–33.)

The condition required for "Gleichlauf" is that the oscillator circuit shall be kept constantly tuned to a frequency differing from that of the preceding circuits by an amount equal to the intermediate frequency. This may be done by shortening the tuning capacity C by a fixed condenser C', using smaller inductances L' than in the preceding circuits and giving the two variable condensers different initial capacities. The best approximation to the ideal state is attained by making the desired and actual frequency curves coincide in three points; this paper gives a formula corresponding to the circuit of Fig. 1 for rapid calculation of appropriate values of circuit elements. The derivation of this formula for the frequency error is omitted but a numerical example of its use is given and illustrated by Fig. 2.

1796. OPERATIONAL CALCULUS AND THE STUDY OF ELECTRICAL CIRCUITS IN THE TRANSIENT RÉGIME.—A. M. Angelini. (*L'Elettrotec.*, 10th April, 1935, Vol. 22, No. 7, pp. 242–251: to be contd.)

1797. SELECTIVE TRANSFORMATIONS. PROPERTIES OF TRANSFORMATION AND SELECTIVITY CURVES [Application to Electric Filters gives Heaviside's Equations].—M. Lévy. (*Comptes Rendus*, 18th Feb. 1935, Vol. 200, No. 8, pp. 646–648.) For previous work *see* 1934 Abstracts, p. 573, r-h column, and 346 of January.

1798. MATHEMATICAL THEORY OF MECHANICAL AND ELECTRIC FILTERS [Electrical Conceptions have Counterparts in Mechanical Systems].—J. Haag. (*Comptes Rendus*, 18th Feb. 1935, Vol. 200, No. 8, pp. 607–609.) For previous work *see* 1934 Abstracts, p. 265, r-h col.

1799. "NEW REPRESENTATION OF THE PROPERTIES OF TWO COUPLED CIRCUITS": CORRECTION.—Mesny. (*L'Onde Élec.*, January, 1935, Vol. 14, No. 157, p. 49.) *See* 1934 Abstracts, p. 611.

1800. METHODS OF CALCULATING AND IMPROVING THE EFFECTIVE ATTENUATION, CHARGE IMPEDANCE AND REFLECTION LOSS OF ELECTRIC FILTERS.—H. Sterky. (*L'Onde Élec.*, February, 1935, Vol. 14, No. 158, p. 15 A: summary only.)

David remarks that "the reader has the agreeable surprise—very rare in the field of filters—of ending with a comparison of the curves thus calculated and the experimental ones. These are in connection with h.f. telephony along lines, and the agreement is very satisfactory." The effective attenuation is found directly.

1801. Method of Calculation for Networks of Impedances [Free from Limitations of Quadripole Theory].—V. Baranov. (*Rev. Gén. de l'Élec.*, 16th March, 1935, Vol. 37, No. 11, pp. 339–351.)

1802. "Electric Circuits and Wave Filters" [Book Review].—A. T. Starr. (*P.O. Elec. Eng. Journ.*, April, 1935, Vol. 28, Part I, p. 76.)

TRANSMISSION

1803. Dwarf Waves as Space-Charge Oscillation Overtones. I and II [Development of Valve generating Micro-Waves of Frequency variable within Wide Limits].—J. Müller. (*Ann. der Physik*, Series 5, Nos. 6 and 7, Vol. 21, 1935, pp. 611–648 and 649–666.)

Dwarf waves ($\lambda = 10$ to 30 cm) in the B.-K. circuit are regarded as the result of interaction between oscillations of the electrode circuit and the space-charge oscillations. A dwarf wave is generated when a natural frequency of one of these systems is nearly equal to one of the other system. Part I: the grid and its support are found to be the determining factors in the production of oscillations, and "push-pull" oscillations are produced when the grid has the symmetrical type of support shown in Fig. 15. A comprehensive series of experiments results in the design of a valve whose principle is shown in Fig. 25; the grid connections form a Lecher wire system, and the variable position of the bridge across this, outside the valve, determines the wavelength produced. The grid circuit is schematised (Fig. 28) and discussed mathematically. In Part II the interaction between space-charge and electrode oscillations is more fully discussed; the use of the new valve as a practical generator is described (photograph Fig. 35, dipole receiver with crystal detector Fig. 36) and various general considerations on the construction and use of the valve are given. A list of relevant literature is appended.

1804. Some Experiments on Electronic Oscillations [in B.-K. Circuit: Straight-Line Graph connects Wavelength with Valve Voltages: Suggested Use of Triodes thus connected as Oscillation Wavemeters].—W. A. Leyshon. (*Proc. Phys. Soc.*, 1st March, 1935, Vol. 47, Part 2, No. 259, pp. 277–286.)

1805. On the Theory of the Barkhausen-Kurz Oscillations [Space-Charge more Effective than Negative Resistance in Oscillation Generation].—E. W. B. Gill: Alfvén. (*Phil. Mag.*, April, 1935, Series 7, Vol. 19, No. 128, pp. 849–850.) *See* 993 of April and back references.

1806. Note on Vacuum Tube Electronics at Ultra-High Frequencies.—F. B. Llewellyn: Benham. (*Proc. Inst. Rad. Eng.*, February, 1935, Vol. 23, No. 2, pp. 112–127.) Revision, to meet Benham's criticisms, and extension of the work dealt with in 1934 Abstracts, p. 265.

1807. Modulation Method for Short and Ultra-Short Waves [by Discharge Tube connected across Feeders near Potential Antinode].—Esau and Pfetscher. (French Pat. 777 100, pub. 11.2.1935: *Rev. Gén. de l'Élec.*, 30th March, 1935, Vol. 37, No. 13, p. 108 D.)

1808. The Efficiency of Closed Iron Core Transformers as a Function of Frequency [Principles of Design for Wide Band Pass Curve for Transmitter Modulation].—G. Eckart. (*Arch. f. Elektrot.*, 12th March, 1935, Vol. 29, No. 3, pp. 215–220.)

The paper is a contribution to the theory of the production of a wide frequency band for the anode modulation of powerful emitters. The transformer is replaced by its equivalent circuit (Fig. 1) and the theory of this is worked out. At low frequencies the efficiency increases with the square of the frequency; it reaches a maximum and decreases again at high frequencies (Fig. 2). The optimum load resistance makes the ohmic (copper) losses equal to the iron losses. Figs. 4 and 5 give experimental curves for comparison.

1809. Grid-Bias Modulation for the General Purpose Transmitter, *and* Grid-Bias Modulation of the 100-Watt Type Power Amplifier.—G. Grammer: Wirkler and Collins. (*QST*, March, 1935, Vol. 19, No. 3, pp. 17–26: 29–31 and 62.)

1810. Tables for Calculation of Vacuum Tube Oscillator operating with Complex Form of Plate Current.—A. I. Berg. (*Izvestia Elektroprom. Slab. Toka*, December, 1934, No. 10, pp. 1–10.)

Author's summary:—Complete and accurate tables are developed which are destined to overcome difficulties encountered in the determination of the constants of the series for calculation of a vacuum tube oscillator operating with high grid excitation and complex form of plate current; tables under consideration are calculated by aid of formulae for flat-topped cosine pulse, and include data pertaining to all possible values of cut-off from 0° to 90°.

1811. Crystal Oscillators for Radio Transmitters: an Account of Experimental Work carried out by the Post Office.—C. F. Booth and E. J. C. Dixon. (*Wireless Engineer*, April, 1935, Vol. 12, No. 139, pp. 198–200: *Nature*, 6th April, 1935, Vol. 135, p. 552.) Summaries of I.E.E. paper.

1812. Two Emitter Circuits with Octode.—B. Pavlík. (*E.N.T.*, February, 1935, Vol. 12, No. 2, pp. 53–54.)

Fig. 1 shows a circuit for a crystal-controlled, modulated r.f. emitter using an octode, and Fig. 2 a crystal-controlled beat-tone generator.

1813. A Temperature-Compensated Dynatron Oscillator of High Frequency-Stability.—J. H. Piddington. (*Journ. Inst. Engineers, Australia*, February, 1935, Vol. 7, No. 2, pp. 53–61.)

"It is shown that a valve oscillator with carefully designed inductance and capacitance [each being temperature-compensated separately, or else the product being compensated by a condenser design giving negative temperature coefficient or by an inductance design, evolved from Griffiths' construction (1930 Abstracts, p. 112), also giving negative coefficient] and control on the threshold of oscillation [Groszkowski, Abstracts, 1933, p. 564, and 1934, p. 205] has a stability of about 20 parts in 10^6 for any normal variation in supply voltage, temperature, pressure (if condenser is sealed), or other less important factors mentioned above. If the supply voltage is regulated to within 1%, this figure may be reduced to about 10 parts in 10^6. . . . The above figures apply to the case of a tuning condenser of 1 000 μF with oscillation at 100 kc/s. For a larger C/L ratio better stability is possible, but the C/L ratio is limited by the size of the air-dielectric condenser, which becomes unwieldy.

"The stability of an oscillator may be decreased by any load which it has to supply, so that for oscillators supplying power the above stabilities are in general not attainable. By paying attention to the stability of the load circuit itself, its effect on the frequency variation may be reduced—thus a capacity load should be temperature-compensated if its effect is sufficiently large. Oscillators used in beat-frequency oscillators or as master-oscillators in transmitting systems should have a minimum of load. This may be accomplished by using a buffer valve between the oscillator and any load to be supplied."

1814. Multi-Frequency Dynatron Oscillator and Its Frequency Stability [and Comparison with the Duo-Dynatron].—T. Hayasi and A. Hukusaki. (*Journ. I.E.E. Japan*, February, 1935, Vol. 55 [No. 2], No. 559, pp. 105–109: English summary pp. 17–19.)

1815. Simplified [Suppressor-Grid] Oscillators: the Use of the 57 or 6C6 to obtain Negative Transconductance and Negative Resistance.—RCA Radiotron. (*Rad. Engineering*, March, 1935, Vol. 15, No. 3, pp. 15–17.) See also *ibid.*, pp. 20–21.

RECEPTION

1816. The Elimination of Interstation Interference [Heterodyne Interactions with Desired Carrier Wave, remaining after Reception by Highly Selective (*e.g.* Quartz Crystal) Receivers, eliminated by Multi-Aerial Reception with such a Receiver at each Aerial: Advantages of Low-Frequency over High-Frequency Combination: Simultaneous Reception of Various Services: etc.].—J. Robinson. (*Wireless Engineer*, April, 1935, Vol. 12, No. 139, pp. 179–189.)

1817. "Luxembourg Effect" [by Spark Station] noted in U.S. in 1919.—R. S. Kruse. (*Electronics*, March, 1935, p. 98.) The effect was very slight until the spark station power was increased so that audible corona was caused on its aerial. The imposed-on station was sending c.w. signals. The "straight-line rule" was observed.

1818. URSI Tests on "Luxembourg Effect": Interim Results in Paris Region.—(*L'Onde Élec.*, March, 1935, Vol. 14, No. 159, pp. 152–153.)

1819. A Method of Measuring Noise Levels on Short-Wave Radiotelegraph Circuits [Biased Tube Circuit feeding Slow-Period Ballistic Meter, showing Percentage Time with Noise exceeding Predetermined Level].—H. O. Peterson. (*Proc. Inst. Rad. Eng.*, February, 1935, Vol. 23, No. 2, pp. 128–131.)

1820. A Portable Measuring Apparatus for Investigating [the Frequency Distribution of] Interference Fields.—A. Dennhardt and E. H. Himmler. (*E.N.T.*, February, 1935, Vol. 12, No. 2, pp. 55–60.)

General considerations of the Fourier spectrum of h.f. disturbances lead to the decision to use a frequency band of definite width but variable mean frequency (*cf.* Wild, Abstracts, 1933, p. 272). Simplicity and compactness are desired and a heterodyne method is chosen (Alexander, 1932, p. 639); its theory is discussed, on the assumption of a square-law rectifier. The basic idea of the apparatus is shown in Fig. 1; Figs. 2a and b show the input circuits used for measuring the magnetic and electric field vectors respectively and Fig. 2c that for measuring the antenna e.m.f. The theory of the measurement and calibration is then discussed and practical measurements are described. Fig. 3 shows the spectrum of the disturbance produced by a h.f. medical apparatus, and Fig. 4 that from a vacuum cleaner, measured below the feeding cable. Fig. 5 shows the result of measurements perpendicular to the feeder, and Fig. 6 the variation of the field along the feeder. Resonance effects in the latter are due to the arrangement of the conductors (Fig. 7). Fig. 8 gives the polar diagram of disturbance from an L-shaped antenna near a cable, as a function of the position of the horizontal part of the antenna; Fig. 9 is the same for an earth antenna, as a function of the position of the antenna relative to the cable.

1821. Editorial: The Ratio of the Electric and Magnetic Fields close to an Aerial [Resulting Difference in Effect on Frame and on Open Aerial: Application to Industrial Interference, Its Diagnosis and Elimination].—R. Mesny. (*L'Onde Élec.*, March, 1935, Vol. 14, No. 159, pp. 129–130.)

1822. Broadcast Interference Investigation—"Post Office Radio Service."—A. C. Warren. (*P.O. Elec. Eng. Journ.*, April, 1935, Vol. 28, Part I, pp. 23–26.)

1823. Broadcast Interference: P.O. Investigations—Methods of Suppression—Legislation Abroad—Non-interfering Plant.—J. Neale. (*Electrician*, 1st and 8th Feb. 1935, Vol. 114, Nos. 2957 and 2958, pp. 151–152 and 179–181.)

1824. Broadcast Interference and Its Suppression.—H. Reppisch. (*Zeitschr. V.D.I.*, 30th March, 1935, Vol. 79, No. 13, pp. 395–399.) Survey prompted by the imminent coming into force of the German anti-interference law.

1825. REVIEWS OF FRENCH BOOKS ON THE ELIMINATION OF RADIO INTERFERENCE.—Singer: Baize. (*Rev. Gén. de l'Élec.*, 16th and 23rd Feb. 1935, Vol. 37, Nos. 7 and 8, pp. 202 and 234.)

1826. SAFETY REGULATIONS FOR INTERFERENCE SUPPRESSORS. — (*Television*, May, 1935, Vol. 8, No. 87, p. 262.)

1827. V.D.E. REGULATIONS REGARDING MACHINES AND APPARATUS FOR THE DIMINUTION OF RADIO INTERFERENCE: ALTERATIONS.—(*E.T.Z.*, 14th March, 1935, Vol. 56, No. 11, pp. 332–333.)

1828. QUENCHING UNITS FOR SUPPRESSION OF BROADCAST INTERFERENCE.—AEG. (*E.T.Z.*, 28th March, 1935, Vol. 56, No. 13, p. 384: summary only.)

1829. PARASITES IN RADIO [Lecture on Industrial Interference and Its Suppression].—P. David. (*L'Onde Élec.*, February and March, 1935, Vol. 14, Nos. 158 and 159, pp. 69–85 and 140–151.) For Discussion see *ibid.*, April, 1935, pp. 216–220.

1830. INTERFERENCE SUPPRESSION ON HIGH-TENSION LINES BY TUNED CHOKING COILS.—C. V. Aggers and R. N. Stonnard. (*Electric Journal*, Vol. 31, 1934, p. 367.)

1831. SOME CHARACTERISTICS OF A.C. CONDUCTOR CORONA [and the Sudden Interference-Producing Bursts of Negative Corona: etc.].—F. O. McMillan. (*Elec. Engineering*, March, 1935, Vol. 54, No. 3, pp. 282–292.) For a previous paper *see* 1932 Abstracts, p. 224.

1832. "INSULATOR SURFACE AND RADIO EFFECTS": DISCUSSION.—Hillebrand and Miller. (*Elec. Engineering*, February, 1935, Vol. 54, No. 2, pp. 208–210.) *See* 1934 Abstracts, p. 561, l-h column.

1833. INVESTIGATION OF THE RADIO-INTERFERENCE ACTION OF HIGH-TENSION INSULATORS [New Method of Measuring, and Some Conclusions: Variation of Amount of Interference with High Frequency examined and with Voltage: etc.].—M. Dick. (*Bull. Assoc. suisse des Élec.*, No. 8, Vol. 26, 1935, pp. 192–196.)

1834. RADIO INTERFERENCE FROM TRAMWAY SIGNALS ON TWO-WIRE SYSTEMS.—W. Gerber. (*Bull. Assoc. suisse des Élec.*, No. 5, Vol. 26, 1935, pp. 127–130.)

1835. HIGH FREQUENCY COMPENSATION FOR HIGH-FIDELITY RECEIVERS [Increased Noise at High Frequencies avoided by Down-Sloping Characteristic from 4 to 7.5 kc/s and Corresponding Rise in Transmitter Characteristic].—L. Walsh. (*Electronics*, March, 1935, p. 94.)

1836. AUDIO-FREQUENCY AVC [and Its Desirability until All Stations use Same Degree of Modulation].—(*Rad. Engineering*, March, 1935, Vol. 15, No. 3, pp. 21–22.)

1837. [Experiments on Underlying Principles of] DETECTORS.—H. Geismann. (*Physik. Zeitschr.*, 15th Feb. 1935, Vol. 36, No. 4, pp. 132–138.)

Experiments made with a view to explaining the action of detectors are described. For experiments *in vacuo* the writer used Heineck's detector cell (Abstracts, 1932, p. 469, and 1934, p. 276), with an emitter giving frequencies between 10 000 and 100 kc/s. Tests on the barrier layer on doubly-sublimated PbS showed that the chemical nature of the layer had no influence on the detector action, provided that it was a worse conductor than PbS and was adsorbed by it. The procedure of forming a barrier layer is reversible; it thus depends purely on adsorption. Measurements of the break-down voltage with d.c. (Fig. 1) showed that the complete barrier layer is several molecules thick. A monomolecular film appears however to give rise to some detector action. §IV discusses the relative merits of investigations with d.c. and a.c. and §V describes remanence phenomena with d.c. (Figs. 2 and 3). Experiments with other detectors (§VI) showed that, with a.c., a semi-conductor is not necessary to obtain the rectifying effect, if only the barrier layer is an insulator. The preferred direction for the current (§VII) is that in which the positive semi-phase flows from the point to the surface. A point contact is a necessary condition for rectification but the effect decreases when several are present (§VIII). Various hypotheses which have been put forward to explain rectification are discussed in §IX.

1838. SOME CONSIDERATIONS ON DETECTORS.—P. David. (*Electronics*, March, 1935, pp. 99–100.) Long summary of the French paper dealt with in 416 of February.

1839. THE OPERATION OF SUPERHETERODYNE FIRST-DETECTOR VALVES.—Stewart. (*See* 1891.)

1840. WHISTLING NOTES IN SUPERHETERODYNE RECEIVERS [including Formula for Whistle/Music Ratio behind Second Detector: Input Signal for Best Compromise between Whistle and Valve Noises].—M. J. O. Strutt. (*Wireless Engineer*, April, 1935, Vol. 12, No. 139, pp. 194–197.)

1841. DESCRIPTION OF A DOUBLE FREQUENCY-CHANGE SUPERHETERODYNE, VERY SENSITIVE AND POWERFUL.—R. C. Couppez. (*L'Onde Élec.*, March, 1935, Vol. 14, No. 159, pp. 167–173: to be continued.)

The writer has, in his search for the most sensitive receiver for his long-distance experiments, been a devotee of the superheterodyne principle since 1922. In this paper he begins by an account of his experiences with different circuits: thus in 1927 his results with two complete superheterodynes in series taught him the advantages of a fairly high i.f. between 400 and 525 kc/s, while other tests convinced him that the great source of background noise was the frequency-changing stage, and led him to the conclusion that the MacCaa circuit (*Experimental Wireless*, 1928, p. 378), considered not merely as an anti-parasitic device but above all as a frequency changer, is the most perfect realisable form of such a circuit. In his final receiver now described he therefore uses a double-change combination, first to 450 kc/s and then to 100 kc/s, with a MacCaa circuit at each frequency change. The first change is immediate ("no pre-amplification" is one of his articles of faith—*see* 727 of March), using two type 77 valves (indirectly heated pentodes) with any triode for local oscillator: then follow 3 i.f stages and another and similar frequency-changing stage, followed by two stages of 100 kc/s amplification: then an anode-bend detector (2 type 77's) with another pair of 77's as fading compensator, and finally an a.f. output stage. The receiver is mains-fed, three rectifiers being employed, giving 267, 213 and 450 volts respectively, the last being for the direct-heated a.f. triode (output up to 4.6 watts).

1842. CALCULATION OF SYNCHRONISM ["Gleichlauf"] IN THE INTERMEDIATE-FREQUENCY [Superheterodyne] RECEIVER.—Kautter. (*See* 1795.)

1843. FILTERED OSCILLATOR [to prevent Hum and Audio Modulation].—(*Rad. Engineering*, March, 1935, Vol. 15, No. 3, p. 22.)

1844. OSCILLATOR PADDING [in Superheterodynes: New Method of Treatment, for Graphical or Mathematical Evaluation].—H. Roder. (*Rad. Engineering*, March, 1935, Vol. 15, No. 3, pp. 7–11.)

1845. "THE SUPERHETERODYNE RECEIVER, ITS DEVELOPMENT, THEORY AND MODERN PRACTICE."—A. T. Witts. (At Patent Office Library, London.)

1846. THE BRUNET "534" SUPERHETERODYNE RECEIVER.—P. Besson. (*L'Onde Élec.*, January, 1935, Vol. 14, No. 157, pp. 50–63.)

1847. THE 1935 RECEIVER OF THE "MIDWEST RADIO CORPORATION" [5 Wave Bands, 2 400 m—9 m: Special Valves for Fading, Tuning, and Automatic Tone Control].—P. Besson. (*L'Onde Élec.*, February, 1935, Vol. 14, No. 158, pp. 117–127.)

1848. THE "INTÉGRA 357" [3 Wave-Bands, Octode Frequency Changer, Fading Compensation by One Diode of a Duo-Diode, the Other giving Silent Tuning in combination with the Triode of a Diode-Triode whose Diode acts as Detector].—P. Besson. (*L'Onde Élec.*, March, 1935, Vol. 14, No. 159, pp. 174–190.)

1849. THE SINGLE-RANGE SUPERHET: WAVE-RANGE 200–2 000 M WITHOUT SWITCHING: I.F. 1 600 KC/S [Constructional Details of German Version of *Wireless World* "Single-Span" Receiver].—H. Sutaner. (*Funktech. Monatshefte*, January, 1935, No. 1, pp. 15–23.) *See* also 1042 of April.

1850. TELEFUNKEN-DEUTSCHLAND 656: A 7-CIRCUIT 5-VALVE SUPERHETERODYNE RECEIVER.—(*Funktech. Monatshefte*, March, 1935, No. 3, pp. 129–131.)

1851. NEW RECEIVER TYPES AT THE LEIPZIG FAIR: A CHANGE IN THE TREND OF DESIGN [Decline of the Two-Circuit Two-Valve Reflex Type and Return of the Two-Circuit Three-Valve "Straight" Type: etc.].—E. Schwandt. (*Funktech. Monatshefte*, March, 1935, No. 3, pp. 97–99.) A footnote points out that the reflex type still has advantages for the home constructor.

1852. TWO-VALVE REFLEX RECEIVER FOR A.C. MAINS, WITH 9-WATT OUTPUT STAGE.—H. Boucke. (*Funktech. Monatshefte*, March, 1935, No. 3, pp. 113–119.)

1853. THE LIMITATIONS OF THE REFLEX CONNECTION [High-Note Reduction: only Small Amplitudes permissible at Grid, demanding High-Amplification Tetrode and Volume Control of Both Frequencies: a Successful Fading-Control Circuit].—R. Oechslin. (*Radio, B., F. für Alle*, March, 1935, pp. 33–36.)

1854. SIEMENS 26, GEADUX 34 AND TELEFUNKEN-KURIER 127: A SINGLE-CIRCUIT TWO-VALVE RECEIVER.—(*Funktech. Monatshefte*, March, 1935, No. 3, pp. 131–132.)

1855. THE "PEOPLE'S" RECEIVER FOR D.C. AND A.C. MAINS, WITH HIGH-VOLT VALVES—(*Funktech. Monatshefte*, March, 1935, No. 3, pp. 92–93.)

1856. AC SHORT-WAVE CONVERTER [with Heptodes in Push-Pull].—H. B. Dent. (*Wireless World*, 12th and 19th April, 1935, Vol. 36, pp. 358–361 and 382–385.)

1857. D.C.-A.C. MAINS ["Universal" Receiver] PROBLEMS.—H. J. Wilhelmy. (*Funktech. Monatshefte*, January, 1935, No. 1, pp. 25–28.)

1858. SURVEY OF RADIO RECEIVER PRODUCTION IN THE U.S.A.—C. Borsarelli. (*Alta Frequenza*, February, 1935, Vol. 4, No. 1, pp. 39–59.)

1859. RADIO RECEIVER AND TUBE SALES INCREASE [1934 Data].—(*Electronics*, March, 1935, pp. 72–75.)

1860. BEAT OSCILLATORS FOR MODERN RADIO RECEIVERS [for C.W. Telegraphy and for Indicating Resonance: Best Method of Coupling to I.F. Amplifier].—A. G. Manke. (*Electronics*, March, 1935, pp. 88–89.) See also *Television*, May, 1935, p. 283.

1861. STABILISING RESISTANCES FOR D.C. AND UNIVERSAL RECEIVERS [particularly the Urdox and Iron-Urdox Barretters].—E. Schwandt. (*Funktech. Monatshefte*, March, 1935, No. 3, pp. 93–96.)

AERIALS AND AERIAL SYSTEMS

1862. RADIATION FROM A VERTICAL ANTENNA OVER FLAT PERFECTLY CONDUCTING EARTH.—P. O. Pedersen. (*Ingeniörvidenskabelige Skrifter*, A No. 38, 1935, 50 pp: in English.)

The immediate purpose of the work was in connection with the design of the aerial for the Copenhagen broadcasting station. It supplements the early work of Pierce and Ballantine. The calculations are based at first on sinusoidal current distribution and a loss-free aerial. It is assumed that the aerial current stops at a height $(l-b)$ above the surface (Fig. 1), at which height there is a top capacity consisting of a copper ring with spokes, or of symmetrically arranged horizontal wires. The field produced by the horizontal currents is neglected. Later, the current distribution for the Copenhagen aerial is calculated on the assumption (i) that the whole effective resistance is concentrated at the current loop (Fig. 31 I) and (ii) that the effective resistance is evenly distributed over the whole length $l-b$, and it is found that these two distributions are very similar to each other and that both agree fairly well with the measured values. The question whether the radiation diagrams calculated for sinusoidal current distributions will be sufficiently similar to those calculated from the actual distributions is answered (for the Copenhagen aerial) by Fig. 35a where the two diagrams are seen to be nearly identical. But the enlargement shown in Fig. 35b makes clear one difference: the diagram corresponding to the actual distribution shows no zero angle. The reason for this is found: when the phase angle ψ has not a constant value along the aerial, the radiated field cannot be zero for any value of the radiation angle unless *both* integrals in the last part of equation 2.08′ are zero, and this is generally impossible. If ψ = const., there is only one condition for zero field, and this condition may sometimes be fulfilled by real positive values of the radiation angle between 0 and $\pi/2$. "This circumstance may also explain, at least partly, the observations lately made by S. Ballantine" [1934 Abstracts, p. 379].

1863. THE FRACTION OF THE RADIATION FROM A VERTICAL DIPOLE ABSORBED BY THE EARTH.—Niessen. (*See* 1731.)

1864. THE RATIO OF ELECTRICAL AND MAGNETIC FIELDS CLOSE TO AN AERIAL.—Mesny. (*See* 1821.)

1865. THE PHASE AND MAGNITUDE OF EARTH CURRENTS NEAR RADIO TRANSMITTING AERIALS.—G. H. Brown. (*Proc. Inst. Rad. Eng.*, February, 1935, Vol. 23, No. 2, pp. 168–182.)

The current calculations are first made on the assumption of a perfectly conducting earth but then, as a first approximation, an estimate is reached of the losses in an earth of finite but high conductivity (conduction currents predominating greatly over displacement currents). Sinusoidal distribution in the aerial is assumed, and the field due to the horizontal part of the aerial neglected (but allowance made in appendix). Applied to localising the earth losses for simple half-wave aerial, the theory gives greatest losses at 0.35 λ from base.

1866. DISCREPANCIES BETWEEN THEORY AND PRACTICE IN BEHAVIOUR OF TOWER ANTENNAS FOR BROADCASTING: DUE TO NON-SINUSOIDAL CURRENT DISTRIBUTION.—H. E. Gihring and G. H. Brown. (*Proc. Inst. Rad. Eng.*, February, 1935, Vol. 23, No. 2, pp. 98–99: summary only.)

1867. ON THE IMPEDANCE OF A VERTICAL HALF-WAVE ANTENNA ABOVE AN EARTH OF FINITE CONDUCTIVITY [Calculated by "Induced E.M.F." Method: Applicable to Wavelengths down to about 10 Metres except for Very Dry Soil: a Principle of Similitude].—W. L. Barrow. (*Proc. Inst. Rad. Eng.*, February, 1935, Vol. 23, No. 2, pp. 150–167.)

1868. ON THE RADIATION RESISTANCE OF PARALLEL-WIRE HIGH-FREQUENCY TRANSMISSION LINES [Effect of Bends].—S. S. Banerjee. (*Phil. Mag.*, April, 1935, Series 7, Vol. 19, No. 128, pp. 787–805.)

The radiation resistance of straight parallel wires is first calculated by the "method of induced e.m.f.;" calculation and experiments for various separations show that the radiation becomes appreciable only when the separation becomes greater than $\lambda/20$. A formula for the radiation resistance of parallel wires bent in their own plane is found, following Carter (1932 Abstracts, p. 585); this bending involves considerable radiation losses. The radiation resistance of parallel wires bent so that the perpendicular to the plane containing the bent arms is parallel to the shortest length between the wires is next considered theoretically; integrals occurring in the formulae may be computed graphically. This type of bending gives hardly any radiation loss and is advised for practical purposes. The theory of measurement of radiation resistance is then given and the experimental method described. Experimental curves on wavelengths of about 3 metres are given, showing the change of radiation resistance as the spacing and angle between the wires are varied.

1869. MEASUREMENT OF ANTENNA POWER BY OYAMA'S RADIOMETER.—Kimpara, Tanaka and Hashimoto. (*Journ. I.E.E. Japan*, January, 1935, Vol. 55 [No. 1], No. 558, p. 68: Japanese only.) For other work on similar lines *see* 1932 Abstracts, p. 163, Groszkowski.

1870. THE ANTI-FADING AERIAL OF THE BUDAPEST [Lakihegy] BROADCASTING STATION.—(*Alta Frequenza*, February, 1935, Vol. 4, No. 1, pp. 118–123.)

1871. THE HORIZONTAL RADIATION [Anti-Fading] AERIAL AT HILVERSUM.—(*Alta Frequenza*, February, 1935, Vol. 4, No. 1, pp. 124–127.)

1872. A SPACE-SAVING ADJUSTABLE ANTENNA ["Sliding-Rod" Adjustment at Top of Vertical Quarter-Wave Aerial for Short Waves].—R. N. Eubank. (*QST*, March, 1935, Vol. 19, No. 3, pp. 48–49.)

VALVES AND THERMIONICS

1873. INPUT RESISTANCE OF VACUUM TUBES AT HIGH FREQUENCIES.—B. J. Thompson and W. R. Ferris. (*Proc. Inst. Rad. Eng.*, March, 1935, Vol. 23, No. 3, pp. 195–196: summary only.)

"A theoretical analysis showed that with no direct current flowing to the grid, there should be an effective shunt resistance between grid and cathode inversely proportional to the product of the transconductance of the tube, the square of the transit time of electrons between cathode and anode, and the square of the operating frequency. Experimental data concerning this relationship showed an effective input resistance of 20 000 ohms at a frequency of 30 Mc/s for a conventional type of r.f. amplifier tube."

1874. INVESTIGATION OF VALVE PERFORMANCE BY AN ELECTRODYNAMOMETER METHOD.—D. A. Bell. (*Journ. I.E.E.*, April, 1935, Vol. 76, No. 460, pp. 415–420.)

"An electrodynamometer is employed to pick out the component of fundamental frequency from the output of a valve working under non-linear conditions but with sinusoidal input. By this means, effective values of valve parameters can be deduced for working conditions at large amplitudes."

1875. SHOT EFFECT AND THERMAL AGITATION IN AN ELECTRON CURRENT LIMITED BY SPACE CHARGE [Experimental Confirmation of Theory: Reduction of Shot Voltage by Space Charge and Production of Thermal Agitation Voltage].—G. L. Pearson. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, pp. 327–328: abstract only.) For Llewellyn's work *see* 1930 Abstracts, pp. 279–280.

1876. TABLES FOR CALCULATION OF VACUUM TUBE OSCILLATOR OPERATING WITH COMPLEX FORM OF PLATE CURRENT.—Berg. (*See* 1810.)

1877. DOUBLE-GRID VALVES [Space-Charge-Grid and Screen-Grid Valves, and a Screen-Grid Valve with Screen Grid on Further Side of Anode: the Difference between "Shadow" and "Gap" Types: etc.].—E. Schulze. (*Hochf:tech. u. Elek:akus.*, March, 1935, Vol. 45, No. 3, pp. 80–84.)

Following on the work dealt with in 398 of February. Author's summary:—"1. The characteristic of the space-charge-grid valve is constructed from the brake-field characteristic [from previous paper] and from the profile curves of the potential surfaces [derived from electrolytic trough determinations of the equipotential lines—*see* Below, 1929 Abstracts, p. 44, and Barkhausen, 1933, p. 273—and subsequent contour modelling in plaster of Paris]. The theoretically obtained characteristics are compared with the experimentally plotted curves" [Fig. 5, where the measured curve 1 is seen to be of the same character as the theoretically derived curve 2, but slightly displaced to the left: this is attributed to a slight unavoidable bend in the filament producing a 2% greater "durchgriff" than the calculated value].

"2. The action of the space charge in front of the control-grid wires is elucidated theoretically, and the theoretical results confirmed by measurements" [here the distinction between "shadow" and "gap" valves is brought forward: if the spiral control grid has its turns "in the shadow" of the turns of the space-charge grid, only a very slight space charge will be formed in front of it, and the characteristic will be of uniformly ascending character ("Schattenrohr" curve, Fig. 8). If, on the other hand, the control-grid spiral corresponds to the "gaps" of the space-charge grid, a much larger space charge will be formed and a pronounced bend in the characteristic will result ("Luckenrohr" curve, same diagram: these are experimentally plotted curves). The cutting of one curve by the other is due to the greater "durchgriff" of the control grid through the space-charge grid in the case of the "gap" valve. The writer's work also explains Alberti's 1926 result (Fig. 9) that for a constant anode voltage the anode current passes through a maximum as the filament current is increased].

"3. The electron-ray formation in the screen-grid valve is discussed [for "shadow" and "gap" types: Figs. 10 and 11]. Further, the dependence of the slope of the screen-grid-valve characteristic on the screen-grid potential is investigated [Fig. 11: the "profile curve" is again made use of]. 4. Finally, the electron-ray formation in a screen-grid valve having its screen-grid outside the anode is examined" [Fig. 12, representing a special valve of "gap" type where the outer of the two grids is used as the anode and the surrounding cylinder as the screen grid].

1878. A MULTIPLE SPACE CHARGE EFFECT [in Multi-Grid Tubes: Conditions for Negative Anode-Current Emission Characteristic: Suggested Application for High Gain Amplification].—E. W. Thatcher. (*Physics*, March, 1935, Vol. 6, No. 3, pp. 81–85.)

Favourable conditions for the anode-current curve to have two horizontal tangents and a region of negative slope are (1) an accelerating field for electrons as they leave the emitting surface and (2) a retarding field to reduce stream velocity before passing into outer space—the second grid is only slightly positive with respect to the cathode. Experimental results are shown in the diagrams and explained theoretically from considerations of space charge action. An application to d.c. amplifiers of the electrometer type is suggested. For an abstract see *Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 327.

1879. THE MAGNETRON AS A NEGATIVE RESISTANCE [Anomalies with Oblique Magnetic Field attributed to Electronic Oscillations only].—N. Carrara. (*Alta Frequenza*, February, 1935, Vol. 4, No. 1, pp. 20–38.)

Author's summary:—"It has been observed (Ranzi: Slutzkin and Steinberg [Abstracts, 1930, p. 98—two: 1929, p. 326]) that the magnetron, when the direction of the magnetic field is oblique to that of the catbode, may give abnormal values of anode current and negative resistance. Ranzi attributes the former phenomenon to the presence of electronic oscillations inside the tube, and suggests that the latter phenomenon is due to the particular form of the paths traversed by the electrons. According to others, however (Hollmann [1931, pp. 617–618]) this particular path form is responsible for the abnormal values of both anode current and negative resistance. On this basis are founded the latest studies (Megaw [1933, p. 324]) on the use of the magnetron as an oscillation generator (dynatron).

"The present work develops some theoretical considerations, confirmed by experiment, tending to disprove this latter explanation [it is shown by consideration of the electron paths in a plane-electrode, and then in a cylindrical-electrode, magnetron that, if $\eta = p/l$ is very small, the anode current increases continually with increase of v_a and decrease of H; the general observance of this condition is examined (p. 33) and it is concluded that the anomalies in anode current and negative resistance cannot be attributed to the particular shape of the trajectories]. Other considerations lead to the hypothesis that the cause of [both] the phenomena described resides only in the electronic oscillations which, as we have ascertained [experimentally], the magnetron always exhibits at the same time."

1880. Development of Valve generating Micro-Waves of Frequency variable within Wide Limits.—Müller. (*See* 1803.)

1881. Vacuum Tubes for Generating Frequencies above One Hundred Megacycles.—Fay and Samuel. (*Proc. Inst. Rad. Eng.*, March, 1935, Vol. 23, No. 3, pp. 199–212.) The full paper, a summary of which was referred to in 1934 Abstracts, p. 503, l-h col. *See* also 748 of March. "The negative grid tube compares very favourably with other types of oscillators in respect to output, and always at a much higher efficiency."

1882. "Acorn" Valves for Ultra-Short [and Micro-] Waves [especially Type 955 RCA, Its Construction and Circuits: Wavelengths 0.5 m to 5 m].—A. Cannas. (*Alta Frequenza*, February, 1935, Vol. 4, No. 1, pp. 109–114.)

1883. High-Power Transmitting Valves: the Philips Triode TA 20/250.—(*Alta Frequenza*, February, 1935, Vol. 4, No. 1, pp. 115–118.)

1884. High-Power Valves: Future Development of Continuously Evacuated Type.—Burch and Sykes. (*Electrician*, 8th Feb. 1935, Vol. 114, No. 2958, p. 178.) Summary of I.E.E. paper.

1885. A Demountable Power-Oscillator Tube [10 kW and 30 kW Types: also 5 kW oscillating at Wavelengths down to 7 Metres: for Induction Furnaces, X-Rays, etc.].—D. H. Sloan, R. L. Thornton, and F. A. Jenkins. (*Review Scient. Instr.*, March, 1935, Vol. 6, No. 3, pp. 75–82.) For higher power oscillators of similar design *see* 2063.

1886. Transmitting Valves—Three New Designs developed for Broadcasting Service [Cat. 14, Cat. 15 and Act. 9].—(*Electrician*, 25th Jan. 1935, Vol. 114, No. 2956, p. 137.)

1887. All-Metal Valves [New Construction of General Electric Company of America].—(*Wireless World*, 19th April, 1935, Vol. 36, p. 393). Made possible by the introduction of Fernico (*see* 1184 of April) and the development of thyratron welding control, this move "represents a distinct step towards greater mechanisation in the manufacture of valves."

1888. New "Universal" [D.C.-A.C.] Multiple Valves.—E. Schwandt: Loewe Company. (*Funktech. Monatshefte*, January, 1935, No. 1, pp. 29–30.)

1889. The Triadyne (6B5) Valve.—Brewster and Bellem. (*See* 1912.)

1890. Mixing Valves [and the Formulae for the Conversion Conductance: Conditions for Greatest Signal/Shot-Noise Ratio: etc.].—R. J. Wey: Strutt. (*Wireless Engineer*, April, 1935, Vol. 12, No. 139, pp. 201–202.) Discussion of Strutt's paper (1455 of May) by the writer of the paper on "heptode frequency changers" (1458 of May).

1891. The Operation of Superheterodyne First-Detector Valves [Equivalent Anode Circuit and Its Analysis: Six Methods of Measuring Conversion Conductance, including a Dynamometer Method, and Their Comparative Merits: etc.].—J. Stewart. (*Journ. I.E.E.*, February, 1935, Vol. 76, No. 458, pp. 227–235.)

1892. The Problem of the "Cold" Amplifier Valve [Farnsworth "Electron Multiplier" and Its Possibilities].—(*Funktech. Monatshefte*, January, 1935, No. 1, p. 24.) *See* also 208 of January.

1893. "Elektronen-Röhren": Vol. 3: Retroactive Coupling [Book Review].—H. Barkhausen. (*Rev. Gén. de l'Élec.*, 23rd March, 1935, Vol. 37, No. 12, p. 362.)

1894. Apparent Re-Activation of Tubes after Long Rest.—(*Electronics*, March, 1935, p. 95.)

1895. Tube Metal Processing [particularly Svea Metal].—L. L. McMaster, Jr. (*Rad. Engineering*, March, 1935, Vol. 15, No. 3, pp. 12–14.)

1896. A Bariated Nickel Filament with Oxidised Outer Surface, with Barium Contents up to 1%: and Its Advantages.—R. A. Wolfe. (*Proc. Inst. Rad. Eng.*, February, 1935, Vol. 23, No. 2, p. 97: summary only.)

1897. Contact Potential of Thoriated Tungsten [Measured with Varying Surface Coverage and Temperature].—D. B. Langmuir. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 328.)

1898. [Quantum] Theory of Electrical Double Layers in Adsorbed Films [Effect on Work Function].—R. W. Gurney. (*Phys. Review*, 15th March, 1935, Series 2, Vol. 47, No. 6, pp. 479–482.)

1899. The Relation between Field Emission and Work Function of Liquid Mercury.—L. R. Quarles. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 328: abstract only.)

1900. ELECTRON EMISSION FROM TUNGSTEN-MOLYBDENUM AMALGAMS [Measurements of Work Function and Richardson Constant].—H. Freitag and F. Krüger. (*Ann. der Physik*, Series 5, No. 7, Vol. 21, 1935, pp. 697–742.)

1901. MODELS OF THE SUPERPOSITION AND INTERPENETRATION OF COMPONENTS IN GAS MIXTURES ADSORBED UPON THERMIONIC, PHOTOELECTRIC, AND CATALYTIC SURFACES [Formation of Surface Layers]: PART I.—M. C. Johnson. (*Proc. Phys. Soc.*, 1st March, 1935, Vol. 47, Part 2, No. 259, pp. 287–305.)

DIRECTIONAL WIRELESS

1902. SOME PRINCIPLES UNDERLYING THE DESIGN OF SPACED-AERIAL DIRECTION-FINDERS [U-Type, Elevated, Coupled, and Balanced Types: and the "Balanced-Coupled" Type].—R. H. Barfield. (*Journ. I.E.E.*, April, 1935, Vol. 76, No. 460, pp. 423–443: Discussion pp. 443–447.) The full paper, summaries of which were referred to in 762 of March and 1471 of May.

1903. REPORT OF THE INTERNATIONAL TECHNICAL CONFERENCE ON MARINE SIGNALLING, PARIS, 1933 [Direction Finding Errors: Frequency Stability of Beacons: the "Talking Beacon": etc.].—(*Rev. Gén. de l'Élec.*, 23rd March, 1935, Vol. 37, No. 12, pp. 376–378.)

1904. DIRECTIONAL RADIO AS AN AID TO MARINE NAVIGATION [Note on American Radio-Beacon Installations].—Nat. Bureau of Stds. (*Journ. Franklin Inst.*, March, 1935, Vol. 219, No. 3, pp. 365–367.)

1905. THE LORENZ BLIND LANDING SYSTEM.—R. Denman. (*Wireless World*, 5th April, 1935, Vol. 36, pp. 332–335.)

Employing ultra-short waves. The system delineates paths in the vertical as well as in the horizontal plane. It has already been installed at Berlin, Zurich, Hanover and Munich.

ACOUSTICS AND AUDIO-FREQUENCIES

1906. GENERATING SINE WAVES WITH A GAS-DISCHARGE TUBE [Simple, Rugged and Stable A.F. Oscillator] *and* THE INDUCTIVE GLOW DISCHARGE OSCILLATOR [Analysis of].—W. E. Kock. (*Electronics*, March, 1935, pp. 92–93: *Rad. Engineering*, April, 1935, Vol. 15, No. 4, pp. 7–9.) For previous papers *see* 1934 Abstracts, p. 33, and 156 of January.

1907. A TEMPERATURE-COMPENSATED DYNATRON OSCILLATOR OF HIGH FREQUENCY-STABILITY.—Piddington. (*See* 1813.)

1908. EFFECT OF OUTPUT IMPEDANCE ON THE PERFORMANCE OF SQUARE-LAW DETECTORS IN BEAT-FREQUENCY OSCILLATORS.—Baker. (*See* 1794.)

1909. THE EFFICIENCY OF CLOSED IRON CORE TRANSFORMERS AS A FUNCTION OF FREQUENCY.—Eckart. (*See* 1808.)

1910. THE OCTAVE FROM TUNING-FORKS [Experimental Investigation and Dynamical Theory], *and* ON THE INTENSITY DISTRIBUTION OF SOUND FROM A TUNING-FORK.—Yamashita and Aoki: Araki. (*Jap. Journ. of Phys.*, 17th Feb. 1935, Vol. 10, No. 1, Abstracts p. 8: 8.)

1911. ON NEW HIGH-PITCH AIR-WAVE GENERATORS [based on Seebeck and Latour Sirens].—Takéuchi and Saito. (*Jap. Journ. of Phys.*, 17th Feb. 1935, Vol. 10, No. 1, Abstracts p. 11.)

1912. A NEW HIGH-EFFICIENCY HIGH-GAIN AUDIO POWER AMPLIFIER: A 203-A CLASS B MODULATOR WITH 6B5 [Triadyne] DRIVER.—Brewster and Bellem. (*QST*, March, 1935, Vol. 19, No. 3, pp. 45–47 and 84.)

1913. A SWEEP OSCILLATOR METHOD OF RECORDING WIDE FREQUENCY-BAND RESPONSE SPECTRA ON SHORT LENGTHS OF MOTION PICTURE FILM.—J. Crabtree. (*Bell Tel. S. Tech. Pub.*, Monograph B-823, 3 pp.)

1914. MAINS-DRIVEN SOUND-FILM AMPLIFIER [for Recording and Reproducing] WITH BUILT-IN MODULATION-METER, FOR HOME CONSTRUCTION.—J. Kessler. (*Funktech. Monatshefte*, March, 1935, No. 3, pp. 99–112.)

1915. "PHYSIK DES TONFILMS" [Book Review].—A. Haas. (*Elektrot. u. Masch:bau*, No. 43, Vol. 52, 1934, p. 511.)

1916. HARMONICS PRODUCED IN HORN LOUDSPEAKERS [General Equation for Acoustic Propagation in a Horn of Any Cross Section, and Deductions therefrom for Exponential Type].—Y. Rocard. (*L'Onde Élec.*, January, 1935, Vol. 14, No. 157, pp. 27–32.)

Leading to the conclusions that "for an equal cut-off frequency [below which there is no true propagation, all the air in the horn vibrating in phase with the imposed frequency] the production of the second harmonic by propagation becomes the more marked the higher the frequency in question and the larger the power per cm² at the entrance; for constant power and a definite frequency, the 2nd harmonic production is the greater the lower the cut-off frequency." For previous work *see* 1933 Abstracts, p. 627.

1917. LOUDSPEAKER CONES [Comparison of 5, 8 and 10-Inch Cones].—E. V. Wait. (*A.W.A. Technical Review*, March, 1935, Vol. 1, No. 1, pp. 14–16.) In the new quarterly published by Amalgamated Wireless (Australasia).

1918. THE PERMANENT MAGNET INDUSTRY.—(*Wireless World*, 29th March and 26th April, 1935, Vol. 36, pp. 312–314 and 414–416.)

Tracing the historical development of the modern permanent magnet for use in moving-coil loudspeakers, and discussing the various processes adopted in constructing these special magnets. Some of the plant and equipment used is described.

1919. MODULATION WITH A SINGLE STAGE ["Amperite" Copper-Oxide-Button Pick-Up].—E. L. Gardiner. (*Television*, April, 1935, Vol. 8, No. 86, p. 204.)

1920. PHONOGRAPH OSCILLATOR [Miniature Transmitter for Use with Pick-Up].—(*Electronics*, March, 1935, p. 101.)

1921. NEW MUSICAL USES OF ELECTRICAL GRAMOPHONE RECORDS.—Karapetoff. (*Science*, 15th Feb. 1935, Vol. 81, No. 2094, Supp. pp. 8–9.)

1922. THE DESIGN CONSIDERATIONS FOR A SIMPLE AND VERSATILE ELECTRONIC MUSIC INSTRUMENT.—B. F. Miessner. (*Journ. Acous. Soc. Am.*, January, 1935, Vol. 6, No. 3, pp. 181–187.)

1923. SENSITIVE-FLAME FREQUENCY METER.—Carrière. (*See* 2024.)

1924. METHODS AND APPARATUS FOR THE MEASUREMENT OF SOUND ENERGY [Survey, including the Bernini Electrophonometer].—A. C. Bernini. (*L'Elettrotec.*, 25th Jan. 1935, Vol. 22, No. 2, pp. 42–48.)

1925. "SIMPLIFIED MEASUREMENTS OF SOUND ABSORPTION": DISCUSSION.—Albert and Wagner. (*Elec. Engineering*, February, 1935, Vol. 54, No. 2, pp. 233–234.) *See* 1934 Abstracts, p. 567, l-h column.

1926. TIME OF ADJUSTMENT OF OSCILLATION ENERGY IN OXYGEN AND THE INFLUENCE OF FOREIGN GASES THEREON [Measurement of Sound Absorption by Echo Method].—H. O. Kneser and V. O. Knudsen. (*Ann. der Physik*, Series 5, No. 7, Vol. 21, 1935, pp. 682–696.)

1927. VARIATION OF TIME OF ADJUSTMENT OF THE THERMAL OSCILLATION IN CO_2 WITH ADDITION OF FOREIGN GASES AND WITH PRESSURE [Measurements of Sound Velocity and Dispersion].—Marie-Helene Wallmann. (*Ann. der Physik*, Series 5, No. 7, Vol. 21, 1935, pp. 671–681.)

1928. REVERBERATION IN TWO ADJACENT ROOMS.—K. Yamashita. (*Jap. Journ. of Phys.*, 17th Feb. 1935, Vol. 10, No. 1, Abstracts p. 8.)

1929. AN AUTOMATIC REVERBEROGRAPH AND ITS APPLICATION TO STUDIES OF THE ACOUSTIC PROPERTIES OF A ROOM.—Z. I. Mitiagina. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 4, 1934, pp. 1575–1587.)

Developed at the Electro-Physical Institute of Leningrad, and similar in principle to that used by Meyer (1928 Abstracts, p. 649). To assist the subsequent study of the records the gain of the amplifier is automatically increased 10 times as the loudspeaker is short circuited for the reception of the reverberation alone. A detailed account is given of some of the measurements made with this apparatus and specimen oscillograms are shown.

1930. THE BROADCASTING CABLE TO THE BISAMBERG HIGH-POWER STATION.—H. Schmid. (*Elektrot. u. Masch:bau*, No. 43, Vol. 52, 1934, pp. 504–506.)

1931. TRANSPORTATION NOISE STUDIED BY NEW ANALYSER.—Osbon. (*Electronics*, March, 1935, p. 90.) Using the Osbon analysing noise-meter (1934 Abstracts, p. 212) resembling a superheterodyne receiver with mechanical filter in i.f. circuit.

1932. DISCUSSION OF GROUP OF PAPERS ON NOISE MEASUREMENT.—(*Elec. Engineering*, April, 1935, Vol. 54, No. 4, pp. 437–441.) *See* 780 of March and 1113–1115 of April.

1933. VALVE VOLTMETER WITH LOGARITHMIC SCALE AND ITS APPLICATIONS IN ACOUSTICS.—Meyer and Keidel. (*See* 2006.)

1934. PAPERS AT THE TWELFTH MEETING OF THE ACOUSTICAL SOCIETY OF AMERICA [December, 1934].—(*Journ. Acoust. Soc. Am.*, January, 1935, Vol. 6, No. 3, pp. 194–197: summaries only.)

1935. INVESTIGATIONS OF ACOUSTIC THRESHOLD VALUES. IV. ACOUSTIC DAMPING IN TUBES [Experimental Methods and Discussion: Application to Impedances in the Ear].—E. Waetzmann and L. Keibs. (*Ann. der Physik*, March, 1935, Series 5, Vol. 22, No. 3, pp. 247–256.)

1936. THE AUDIBLE MINIMUM AS LINEAR FUNCTION OF THE CONTRAST THRESHOLD.—van Soest and Groot. (*Physica*, March, 1935, Vol. 2, No. 3, pp. 196–200.)

1937. ON THE PRINCIPLE OF UNCERTAINTY IN SOUND [Frequency Vibrato].—W. E. Kock. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 339: abstract only.)

1938. OPTICAL MEASUREMENTS OF SUPERSONIC VELOCITIES IN [Various Organic] LIQUIDS.—C. Bachem and E. Hiedemann. (*Zeitschr. f. Physik*, No. 1/2, Vol. 94, 1935, pp. 68–71.)

1939. THE DOPPLER EFFECT FOR SOUND IN A MOVING MEDIUM.—R. W. Young. (*Journ. Acoust. Soc. Am.*, October, 1934, Vol. 6, No. 2, pp. 112–114.)

1940. IMPRESSION OF PHOTOGRAPHIC PLATES BY SUPERSONIC WAVES.—Marinesco and Reggiani. (*Comptes Rendus*, 11th Feb. 1935, Vol. 200, No. 7, pp. 548–550.)

1941. AN OBJECTIVE METHOD FOR MEASURING THE LENGTH OF HIGH-FREQUENCY SOUND WAVES [Photographic Registration].—J. Zühlke. (*Ann. der Physik*, Series 5, No. 7, Vol. 21, 1935, pp. 667–670.)

1942. THE PRACTICAL APPLICATION OF DIFFRACTION OF LIGHT BY SUPERSONIC WAVES.—Sokoloff. (*See* 2030.)

1943. ON THE PRODUCTION OF VERY HIGH FREQUENCY SOUNDS BY MAGNETIC VIBRATORS.—A. I. Danilenko. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 4, 1934, pp. 1608–1612.)

This describes experimental work for the production of sounds at frequencies of the order of 20000 c/s by the vibration of a metal disc driven by a nickel rod under the combined action of a constant magnetic field and that produced by a coil in the plate circuit of a valve oscillator. Various forms of rod were used, and curves are given showing the intensity of sound produced plotted against ampere-turns in the coil. The object was to obtain sounds of greater intensity, and with a hollow rod intensities up to about 20 ergs per cm^2 per second were produced.

1944. THE SHOAL FATHOMETER [using Magnetostriction Transceiver].—H. G. Dorsey. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, pp. 334–335: abstract only.) *See* also *Electronics*, March, 1935, pp. 90–91, and *cf.* Matsuo, 1116 of April.

1945. PAPERS ON THE PROPAGATION OF SOUND IN THE SEA.—K. Kitagawa. (*Jap. Journ. of Phys.*, 17th Feb. 1935, Vol. 10, No. 1, Abstracts pp. 6–7: 7.)

PHOTOTELEGRAPHY AND TELEVISION

1946. TELEVISION RECEPTION WITH CATHODE-RAY TUBES [and a Receiver for the Berlin Ultra-Short-Wave Programmes].—M. von Ardenne. (*Hochf: tech. u. Elek:akus.*, March, 1935, Vol. 45, No. 3, pp. 73–80.)

"While very thorough treatments of the scientific principles are available [the writer cites as example Schröter's survey—1934 Abstracts, pp. 567–568], descriptions of important circuit details, particularly of the time-base circuits, synchronising circuits and the design of the receiver, have not yet appeared. In the present paper the writer therefore confines himself to giving these circuit details, at the same time discussing the reasons for their selection." The description is based on the equipment put together by the writer for tests on the Berlin transmissions and forming the main subject of his little book reviewed in *The Wireless World* for 26th April, 1935, p. 416. After discussing the superheterodyne receiver (i.f. chosen to be suitable for the 450 kc/s band, or for 700–800 kc/s single-sideband reception) the writer pays special attention to the two next parallel stages—the rectifying stage for the image signals and the amplitude filter for the synchronising signals. Reasons against rectification in the cathode-ray tube itself are given, and a full-wave rectifying unit is described. The amplitude filter, for the Berlin synchronising signals on the Schriever principle (the advantages of which are discussed), is dealt with, and finally a description, with diagram, is given of a push-pull "kipp" unit, for the generation of high-amplitude time-base oscillations symmetrical with respect to earth.

1947. PHOTOMETRIC INVESTIGATIONS AND MEASUREMENTS OF THE SPECTRAL INTENSITY DISTRIBUTION IN FLUORESCENT SCREENS, ESPECIALLY FOR EXCITATION BY CATHODE RAYS.—M. von Ardenne. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 16, 1935, pp. 61–67.)

For a previous paper *see* 1934 Abstracts, pp. 623–624. The present paper describes measurements with a Pulfrich photometer on 17 different screen materials, 4 000 v electrons being used for the cathode-ray tests. "The cause of the marked dependence, found with some of the materials [Figs. 6 and 7], of the spectral distribution on the strength of excitation is the fact that the long-wave band of phosphorescent light displays a distinct saturation effect, in contrast to the simultaneously observed short-wave fluorescence band." Thus a screen of material 16 (zinc sulphide) if used for television with a small format, so that the average screen-loading was high, would give the darker parts in a brownish tint and the lighter parts in a whiter tint (*see* Fig. 5, diagram 16). But "in television the specific loading is as a rule of the order of 10^{-3} to 10^{-4} watt/cm^2, so that only the behaviour in the region of very weak screen-excitation is important. Here, as the measurements in Fig. 7 show, a distinctly more favourable efficiency is indicated than that given by Fig. 5, which represents measurements at higher specific loads."

The writer points out that the results on this material 16 indicate a way to obtain television screens yielding white light, by so choosing the activating metal and arranging the production process that the phosphorescence band has its maximum near the long-wave end of the eye's spectrum and the fluorescence band near the short-wave end; taking care also to arrange that at 10^{-3} w/cm^2 (where saturation is not reached) the amplitude of the phosphorescence band has the same absolute intensity as the fluorescence band and finally that the after-glow time for the phosphorescence band is not greater than about 1/25th second. Such conditions are very closely observed by material 17, the Lorenz-Leybold "Standard" television screen (Fig. 6). Many substances do not allow their phosphorescent and fluorescent components to be thus separated by selective photometry: Fig. 8 illustrates another method of separation, depending on the behaviour under constant ray energies 100% modulated at varying frequencies. Section III discusses the spectra of the materials 1–12 whose photographs are shown in Figs. 9 and 11, and compares them with other light sources. Thus the top spectrum of Fig. 12 is that of a 75 w lamp, the second down represents daylight, and the fourth is given by material 1 ("old television screen, sepia, with after-glow": spectrum 1 of Fig. 9) but with an admixture of calcium tungstate: this is seen to have a character combining that of lamplight with that of daylight. Figs. 10 and 11 show the great similarity of the spectrum of material 1 to that of the well-known "sepia-toned" photographic print seen by lamplight. The four spectra in each of these two figures represent four different exposures. The final section deals briefly with results obtained with illumination by X-rays and ultra-violet light. Although the spectral distributions thus obtained are, for most materials, of practically the same character as those given by electron excitation (*cf.* Figs. 13 and 11), there is an inclination to exaggerate the phosphorescence band, and for this and other reasons it is concluded that observations with X-rays and ultra-violet light can only serve as a preliminary rough test.

1948. [De Haen's] FLUORESCENT COMPOUNDS.—(*Television*, January, 1935, Vol. 8, No. 83, p. 48.) *See* also *Electronics*, March, 1935, p. 102.

1949. CHANGING OPTICAL PICTURES INTO ELECTRON PICTURES.—W. Schaffernicht. (*Zeitschr. f. Physik*, No. 11/12, Vol. 93, 1935, pp. 762–768.)

This work is a development of a method described by Brüche (1934 Abstracts, p. 107, l-h column). An inhomogeneous distribution of light (an optical picture) is projected on to a uniformly sensitive cathode, producing electron emission corresponding to the inhomogeneity. The scheme of the arrangement is shown in Fig. 2. A large photocell has two chemically produced silver mirrors for anode and cathode; the latter has a thin photo-sensitive layer of potassium. An image of a picture is focused on the cathode and the electrons produced are accelerated and condensed by a magnetic lens M. An electron picture is produced on the screen F and may be photographed from outside. Fig. 3 gives a photograph of the apparatus. The construction of the cell is described; the field distribution inside it is shown in Fig. 4. This is designed to give a distortionless electron image of the largest possible part of the cathode. Fig. 5 gives the calculated and observed curves of magnification V as a function of the length of the cell. They differ because the effect of the electric focusing was not considered in the calculation. Figs. 6 and 7 illustrate the quality of electron picture obtained; Fig. 8 gives the variation of brightness with the accelerating voltage used. For other relevant literature *see* Holst and others, Abstracts, 1934, p. 331; Farnsworth, 207 of January, and Kluge, 1950, below.

1950. Contribution to the "Transparent" Photocathode [Spectral Sensitivity] and its Suitability for Electron-Optical Systems.—W. Kluge. (*Zeitschr. f. Physik*, No. 11/12, Vol. 93, 1935, pp. 789–791.)

Transparent photocathodes were described by Holst and his colleagues (1934 Abstracts, p. 331); they used red-sensitive cs cathodes. This paper gives measurements of the spectral sensitivity of transparent cathodes, using a spherical form of the type $Ag\text{-}cs_2o\text{-}cs$. The "long-wave" maximum in the incident light was very weak and was not present at all in the transmitted light (Fig. 1, which gives a comparison with the output from an opaque cathode). Experiments were also made with a transparent cathode and the method of oblique projection used by Pohl (855 of March) and Schaffernicht (1949, above) (arrangement Fig. 2). Fig. 3 shows electron pictures obtained with visible and infra-red light, with the optical picture for comparison.

1951. Formation of Electron-Optical Images of Photocathodes as a Basis for Television Transmission.—W. Heimann. (*E.N.T.*, February, 1935, Vol. 12, No. 2, pp. 68–70.)

An arrangement is described for obtaining an image of a plane transparent photocathode, using magnetic or electric focusing or a combination of the two. Fig. 1 shows the scheme. The current in the magnetic coils may be adjusted to give any desired rotation of the image, and the sharpness of focus is obtained by the electric lens. The cathode was a transparent silver film with an alkali metal distilled on to it *in vacuo*, of the type $Ag/cs_2o/cs$ (*see* Kluge, 1950, above, and 1933 Abstracts, p. 221). The characteristic curve of sensitivity distribution along the spectrum is shown in Fig. 2a. Sensitivity at the red end is high, giving good transmission of films. For pictures in ordinary light a rubidium film is recommended (Fig. 2b), as it gives a better resemblance to the sensitivity of the human eye (Fig. 2c). Fig. 3a shows examples of the images obtained with short and long coils: Fig. 3b illustrates reproduction of half-tones.

1952. Ray Focusing in Cathode-Ray Tubes [and the Use and Application of Colloidal Graphite on the Interior Walls].—(*Television*, April, 1935, Vol. 8, No. 86, pp. 223 and 236.)

1953. "Photométrie des Lumières brèves et variables" [including Chapters on Television and Sound Recording: Book Review].—Moreau-Hanot. (*L'Onde Élec.*, January, 1935, Vol. 14, No. 157, p. 8 a.)

1954. Problems of Television Amplification.—C. W. Carnahan. (*Proc. Inst. Rad. Eng.*, March, 1935, Vol. 23, No. 3, pp. 192–193: summary only.)

1955. The Effect of Distortion of the Lower Frequencies on the Quality of Television Reproduction.—R. G. Schiffenbauer. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 4, 1934, pp. 1387–1400.)

The quality of images in television reception is affected by distortion in the electrical circuits of the apparatus. This article is confined to an examination of the effects of phase shift and amplitude distortion of the lower frequencies. A survey of the literature on the subject, taken almost entirely from the *Bell S. Tech. Journ.*, is given and the main conclusions summarised. The author offers the following critical remarks:—(1) In formulating the permissible limits of distortion no consideration has been given to the type and operating conditions of the modulated source of light. (2) In Steinberg's paper (1931 Abstracts, p. 44) the maximum permissible phase shift is stated in terms of $dB/d\omega$ instead of B/ω. The consequences of this are pointed out. (3) When a square painted half black and half white is scanned in the direction parallel to the dividing line the fundamental frequency obtained is the picture frequency. When the direction of scanning is perpendicular to this line the fundamental frequency is the strip frequency. It can be shown that the permissible phase shift on the lower frequency is much greater than for the higher frequency. The ratio of the phase shifts obtained for this particular case has been applied without sufficient justification to totally different ranges of frequencies.

The author then gives a detailed investigation of the distortion produced when such a square is transmitted. The discussion throughout takes account of the characteristics of the neon lamp used and theoretical curves are obtained showing the output from the lamp for a predetermined phase shift in the amplifiers. The conclusions reached have been completely confirmed experimentally.

The effect of non-uniform frequency response is next investigated and an experimental verification of the results obtained is given. For these experiments a special resistance-coupled amplifier, developed by the author and compensated for phase shift, was used. In conclusion, the author

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points out that the object of this article is not to give universal limits for permissible phase and amplitude distortion but to indicate methods enabling these limits to be determined in each particular case from the characteristics of the modulated source of light.

1956. THE EFFECT OF DISTORTION OF THE HIGHER FREQUENCIES ON THE QUALITY OF TELEVISION REPRODUCTION.—R. G. Schiffenbauer. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 4, 1934, pp. 1551–1559.)

The upper frequency limit required for distortionless transmission is usually specified as $Nn/2$. The author investigates the effect on the picture quality of cutting off all frequencies above this limit, and finds that the transmission of these frequencies gives no appreciable improvement. In considering the distortion due to the higher frequencies within the range specified above the following two cases are examined separately :—(*a*) *Amplitude Distortion.* In considering the maximum permissible amplitude distortion an object should be chosen which contains details of the same brightness but requiring different frequencies for their transmission. Accordingly experiments were made with a rectangle of which one half was painted black and the other white, and which had in one corner black and white strips of the width of a picture element. These experiments showed that the quality of reproduction is hardly affected when the losses do not exceed 8% on the element frequency, 35% on the first harmonic of this and 100% on higher frequencies. Considerable distortion of the clearness of the strips resulted when the loss on the element frequency was of the order of 20%.

(*b*). *Phase Distortion.* The examination of this effect is complicated by the fact that phase shift increases with the increase of frequency and also that it is in some cases accompanied by amplitude distortion. Distortion produced by phase shift is therefore a complex phenomenon and it is only possible to establish the order of the magnitude of the permissible shift. Two separate cases were considered. In the first, a filter was used cutting off all frequencies above the element frequency. In the second the filter passed all frequencies and acted purely as a phase-shifting device. The picture transmitted in each case consisted of a strip one element in width. Both theoretical and practical considerations indicate that, taking into account the distortion introduced on lower frequencies, the maximum permissible time shift for a frequency of 10 000 c/s is of the order of 15–20 μs for case 1 and 10–15 μs for case 2.

1957. THE TELEVISION COMMITTEE'S REPORT.—(*Television*, February, 1935, Vol. 8, No. 84, Supplement.)

1958. DEFINITION AND VIEWING DISTANCE [240-Line Picture 10 Inches Square gives as much Detail as Average Seat in Average Cinema].—J. M. Bartlett. (*Television*, May, 1935, Vol. 8, No. 87, p. 285.)

1959. A HIGH-DEFINITION SERVICE READY IN LONDON [with Field-Strength Chart of Crystal Palace 7 m Transmitter].—(*Television*, March, 1935, Vol. 8, No. 85, pp. 117–121.)

1960. ULTRA-SHORT-WAVE TELEVISION TESTS [in California: 56 Miles over Mountains on 6.7 m Wavelength].—(*Television*, March, 1935, Vol. 8, No. 85, p. 116.)

1961. A TELEVISION TEST TRANSMITTER FOR 7 METRES.—J. H. Reyner. (*Television*, May, 1935, Vol. 8, No. 87, pp. 271–273 and 295, 296.)

1962. TELEVISION SYSTEM EMPLOYING VELOCITY MODULATION.—Bedford and Puckle. (*L'Onde Élec.*, January, 1935, Vol. 14, pp. 33–38: continued for several months.) French version of the I.E.E. paper dealt with in 1934 Abstracts, p. 506.

1963. THE BERLIN TELEVISION TRANSMITTER [and the Receivers used for Tests].—P. Besson. (*L'Onde Élec.*, March, 1935, Vol. 13, No. 159, pp. 131–139.)

1964. TRANSMITTING AND RECEIVING SYSTEMS USED BY "SAFAR" S.A. MILAN.—(*Television*, November, 1934, Vol. 7, No. 81, pp. 499–500.)

1965. THE PECK TELEVISION SYSTEM.—(*Television*, February, 1935, Vol. 8, No. 84, pp. 57–58.)

1966. THE ELECTRON MULTIPLIER AND MECHANICAL TRANSMISSION [Possibility of Photocell embodying Multiplying Principle, for High-Definition Scanning by Disc or Drum].—G. B. Banks. (*Television*, May, 1935, Vol. 8, No. 87, pp. 249–250 and 252.)

1967. SCANNING WITH THE MIRROR SCREW [Equations for Proper Correlation of Distances between Light Source, Mirror Screw, and Observer: Formula for Reproduced Light Intensity: Limits for Successful Operation].—A. A. Raspletin. (*Izvestia Elektroprom. Slab. Toka*, December, 1934, No. 10, pp. 16–21.)

1968. 240-LINE PICTURES WITH A 30-LINE MIRROR-DRUM [by Use of Prism Ray-Divider].—B. H. Dakin. (*Television*, May, 1935, Vol. 8, No. 87, pp. 281 and 282.)

1969. SOME PROBLEMS OF HIGH-DEFINITION MECHANICAL SCANNING [and the Use of Two Mirror-Drums at Right Angles].—R. Desmond. (*Television*, May, 1935, Vol. 8, No. 87, pp. 269 and 270.)

1970. A MIDGET MIRROR-DRUM RECEIVER [using 3½ inch Drum and Double-Image Kerr Cell.]—R. L. Ashmore. (*Television*, February, 1935, Vol. 8, No. 84, pp. 53–56.) For "Scophony" comments regarding the double-image cell see *ibid.*, April, p. 215.

1971. THE PAPER-DRUM RECEIVER.—J. Sieger-(*Television*, April, 1935, Vol. 8, No. 86, pp. 181–184.)

1972. CONTINUOUS OSCILLATORY SCANNING [using Almost Sinusoidal Oscillators driving Vibration Galvanometers].—R. W. Hughes. (*Television*, September, 1934, Vol. 7, No. 79, pp. 385–386.)

1973. DISPLACED MULTIPLE SCANNING [for Increased Brightness and Reduced Flicker].—R. I. Rosenfelder. (*Television*, November, 1934, Vol. 7, No. 81, pp. 483–484.)

1974. The Optical Efficiency of Lenses.—R. Turpin. (*Television*, November, 1934, Vol. 7, No. 81, p. 505.) *See* also Wilson, *ibid.*, December, 1934, pp. 557–558.

1975. A "Triggered" Synchroniser [using Mercury-Vapour Relay].—J. H. Reyner. (*Television*, February, 1935, Vol. 8, No. 84, pp. 97–98 and 112.)

1976. An Ingenious Speed Control System [Direct Mechanical Control of Motor Speed by Tuning Fork with Detent working in Toothed Wheel].—A. J. Ashdown. (*Television*, February, 1935, Vol. 8, No. 84, p. 70.)

1977. Kerr Cell Design for 240-Line Reception [Multi-Plate Cells have Too High Self-Capacity: Suitability of Wright Diverging Electrodes and Marconi Double-Image Polariscope: etc.].—L. M. Myers. (*Television*, May, 1935, Vol. 8, No. 87, p. 304: summary of lecture.)

1978. The Circular Polariscope in Television [Cylinder and Coaxial Wire as "New Type of Kerr Cell"].—L. M. Myers. (*Television*, May, 1935, Vol. 8, No. 87, pp. 277–279 and 280.)

1979. The White-Light Television Lamp.—C. G. Lemon. (*Television*, November, 1934, Vol. 7, No. 81, p. 518.)

1980. Fluorescent Lamps [using Fluorescent Glass].—W. J. Nobbs. (*Television*, December, 1934, Vol. 7, No. 82, pp. 554 and 568.)

1981. The "Escura" Gas-Discharge Double-Walled Lamp.—(*Television*, January, 1935, Vol. 8, No. 83, p. 44.)

1982. The Position of Picture Telegraphy.—H. Stahl. (*E.T.Z.*, 21st March, 1935, Vol. 56, No. 12, pp. 341–344.)

1983. Anglo-Australian Picturegram Service.—J. M. Johnson. (*A.W.A. Technical Review*, March, 1935, Vol. 1, No. 1, pp. 17–21.) *See* 1917 regarding this journal.

1984. Frequency Investigations with Photocells [Testing Apparatus: Characteristics of Modern Cells].—W. Leo and C. Müller. (*Physik. Zeitschr.*, 15th Feb. 1935, Vol. 36, No. 4, pp. 113–122.)

The first part of the paper describes the apparatus developed at the P.-T. Reichsanstalt for frequency testing of photocells. The requirements to be fulfilled are tabulated; Fig. 1 gives the circuit diagram of the amplifier and valve voltmeter, Fig. 2a the scheme of the perforated disc and Fig. 2b the path of the light rays through the optical siren. A photograph of the set-up is given in Fig. 3. Fig. 4 shows the frequency characteristic of the apparatus and Fig. 5 the calibration curves of the amplifier.

Several gas-filled cells have been tested under various experimental conditions and a résumé of results is given. Figs. 6a–6d show the frequency characteristics of gas-filled cs cells at various working voltages. The conditions for coupling the cell to the amplifier are discussed (circuit Fig. 7) and Fig. 8 shows the influence of the coupling impedance. Tests on modern thallium and selenium cells are described (Fig. 9). Modern se barrier-layer cells give greater variation with frequency than did the older types (Figs. 9, 12–14); reasons for this are suggested. The influence of modulating the light at various audio-frequencies is shown in Figs. 10 and 11 and discussed; this modulation should be avoided if the true frequency characteristic is desired. cu_2o cells are comparatively free from inertia defect (Fig. 9d). Measurements on barrier-layer cells in general indicate that the marked frequency variations they show are due to capacity changes; it seems not impossible that, by suitable treatment, films may be obtained of thicknesses which give improved frequency characteristics with no loss of sensitivity.

1985. On the Selective Photoeffect [traced to Changes of the Electromagnetic Field Intensity with the Wavelength and Polarisation State of the Light].—P. I. Lukirsky and J. L. Hurgin. (*Physik. Zeitschr. der Sowietunion*, No. 1, Vol. 7, 1935, pp. 99–107: in German.)

The writers find that curves free from any selective maximum are obtained, for alkali and other usual metals, if the observed intensity of photoeffect at various wavelengths, angles of incidence, and conditions of polarisation are referred to the values of electromagnetic energy density below the metal surface, as calculated from the values of n and k (indices of refraction and absorption).

1986. The Emission of Electrons under the Influence of Chemical Action. Part V—The Theory of the Chemical Electron Emission and Its Application to Certain Reactions involving Haloids [including Values of Total Potential Barriers of Alkali Metals].—A. K. Denisoff and O. W. Richardson. (*Proc. Roy. Soc.*, Series A, 15th Feb. 1935, Vol. 148, No. 865, pp. 533–564.)

1987. Models of the Superposition and Interpenetration of Components in Gas Mixtures Adsorbed upon Thermionic, Photoelectric, and Catalytic Surfaces [Formation of Surface Layers]: Part I, [Theoretical] Principles.—M. C. Johnson. (*Proc. Phys. Soc.*, 1st March, 1935, Vol. 47, Part 2, No. 259, pp. 287–305.)

1988. Photoelectric Effect in a Layer of Silver deposited on Nickel.—N. Fedeneff. (*Physik. Zeitschr. der Sowietunion*, No. 1, Vol. 7, 1935, pp. 58–65: in French.)

The work function, measured by the method of retarding potential, increases with the thickness of the silver layer till it reaches a maximum at a thickness just above that of a monomolecular layer, and then falls to a value corresponding to pure silver.

1989. Current-Voltage Relations in Blocking Layer Photocells.—L. A. Wood. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 337: abstract only.)

1990. BARRIER-LAYER PHOTOELECTRIC EFFECT IN SEMI-CONDUCTOR COMBINED WITH ARTIFICIAL BARRIER LAYER.—Jusé. (*See* 2048.)

1991. THE CRYSTAL PHOTOEFFECT WITH SINGLE CRYSTALS OF CUPRITE [New Measurements]. —R. Deaglio. (*Physik. Zeitschr.*, 15th Feb. 1935, Vol. 36, No. 4, pp. 144–146.)

A description of experiments in support of Deaglio's theory of the electrolytic nature of the crystal photoeffect. The results agree with those of the previous experiments and the effect cannot be explained on thermal grounds alone, as suggested by Teichmann (Abstracts, 1934, p. 160: *also* 1933, p. 400). The effect is proportional to the degree of purity of the crystal; a comparison is given between crystals from different sources.

1992. THE INFLUENCE OF A MAGNETIC FIELD ON THE CRYSTAL PHOTOEFFECT.—G. Groetzinger. (*Physik. Zeitschr.*, 1st March, 1935, Vol. 36, No. 5, pp. 169–173.)

See 1991 and back references. Experiments are described which show that a transverse magnetic field diminishes the e.m.f. produced by the crystal photoeffect in the direction of illumination; a magnetic field produces a component of the e.m.f. perpendicular to both the direction of the field and the direction of illumination. This is distinguished from the Hall effect. For a correction see *ibid.*, 15th March, 1935, p. 216.

1993. MECHANISMS OF THE PHOTOPOTENTIAL OF OXIDISED COPPER ELECTRODES [Photoelectronic *versus* Water-Photolysis Hypothesis].—R. Roulleau. (*Comptes Rendus*, 11th March, 1935, Vol. 200, No. 11, pp. 920–922.)

"As regards the Becquerel effect on Cu_2O electrodes, it may thus be said that the electronic effect, always possible, only appears to a perceptible extent if one takes the precaution of forming a barrier layer at the electrode surface. In all other cases the photoelectrochemical effect is predominant. Further, with copper electrodes covered with CuO the electronic effect is never obtained."

1994. ELECTRICAL AND OPTICAL BEHAVIOUR OF SEMI-CONDUCTORS. XI. PHOTOELECTRIC CONDUCTIVITY OF MINERAL LEAD CHROMATE [Dependence of Photocurrent on Intensity, Frequency and Period of Intermittent Light: Spectral Distribution of Absorbed Light: Life Duration of Photoelectrons].—G. Kapp. (*Ann. der Physik*, March, 1935, Series 5, Vol. 22, No. 3, pp. 257–280.) For Part X *see* 2055.

1995. STATISTICS OF THE IMPULSES OF A PHOTON COUNTER [of Photoelectrons] IN THE ULTRA-VIOLET REGION.—A. Kolin. (*Ann. der Physik*, Series 5, No. 8, Vol. 21, 1934/35, pp. 813–831.)

Registration of radioactive rays was approximately statistical, but that of photoelectrons was not statistical; small intervals between impulses occurred less frequently than they should theoretically. The form of the curves obtained may be explained by assuming that the work function is increased after every impulse. For a qualitative description of photon counters *see* Locher, 1933 Abstracts, p. 170.

1996. A NEW TYPE OF PHOTOELECTRIC APPARATUS FOR THE INVESTIGATION OF LIGHT COUNTERS. —K. H. Reiss. (*Zeitschr. f. Physik*, No. 5/6, Vol. 93, 1935, pp. 411–415.)

A description of an apparatus designed to produce monochromatic light of known, arbitrarily small intensity in the range 300 to 500 mμ. The optical arrangement (shown in Fig. 1a) consists of a monochromator with adjustable slit from which light falls on a rotatable concave mirror; by this means the light is focused either on the slit of a special bolometer or on that of the experimental apparatus. The bolometer reading is found to be a linear function of the width of the adjustable slit (Fig. 2). Measurements are also given of the number of quanta obtained from light counters with a defined cathode film near the long-wave limit of the cathode metal (cd).

1997. THE SENSITIVITY OF PHOTON COUNTERS [as used for Radiations from Chemical Reactions]. —R. Audubert. (*Comptes Rendus*, 11th March, 1935, Vol. 200, No. 11, pp. 918–920.) *See* 1934 Abstracts, p. 54.

1998. A NEW DESIGN OF THE GEIGER POINT COUNTER FOR THE MEASUREMENT OF LIGHT [Counting Photoelectrons] AND EXAMPLES OF ITS APPLICATION.—B. Sturm. (*Zeitschr. f. Physik*, No. 1/2, Vol. 94, 1935, pp. 85–103.)

1999. LOSS AND RESTORATION OF PHOTO-CONDUCTIVITY IN RED MERCURIC IODIDE.— —F. C. Nix. (*Phys. Review*, 1st Jan. 1935, Series 2, Vol. 47, No. 1, pp. 72–78.)

2000. THE PRESENT STATE OF KNOWLEDGE OF PHOTOELECTRIC PHENOMENA.—J. Bärisch. (*Funktech. Monatshefte*, March, 1935, No. 3, pp. 89–91.)

MEASUREMENTS AND STANDARDS

2001. THE DIRECT MEASUREMENT OF CONDENSER LOSSES AT HIGH FREQUENCIES.—M. Boella. (*Alta Frequenza*, February, 1935, Vol. 4, No. 1, pp. 5–19.)

Author's summary:—"A substitution method of measuring the losses in condensers employed in r.f. circuits is described. The method has been evolved to avoid a serious inconvenience in the ordinary substitution method applied to the higher frequencies—namely the necessity for knowing the losses in the variable air condenser used as the comparison condenser: losses which in such cases vary with the value of the capacity. The difficulties met with are described, and the methods by which these are overcome. Results of loss measurements on three different variable air condensers are reported, which bring out the importance, even at comparatively low frequencies (2 Mc/s), of the variable losses due to the ohmic resistance of the metallic parts traversed by current, compared with the constant losses due to the insulating materials supporting the parts." The method has the further advantage that it eliminates the effects of the resistance of the connections between condensers and measuring circuit—a particularly useful fact when the condenser or dielectric sample is to be tested in a closed space, as when studying the effect of temperature or humidity. The difference between the new method and the old depends on the special design of the comparison condenser (Fig. 3), which has the effect of converting the equivalent circuit from Fig. 1 to Fig. 2 and the equation for the required loss G_x (*i.e.* the loss conductance of the condenser under test) from equation 3 to equation 3′, which is free from that term in equation 3 which causes the trouble in the old method. The two 10 cm plates (the upper one adjustable) are supported by separate insulating systems both fixed to an earthed metallic base, and there is no insulating material in the electric field between the plates.

2002. ON THE MEASUREMENT OF DAMPING [Survey and Comparison of Methods].—G. Weiss. (*Funktech. Monatshefte*, March, 1935, No. 3, pp. 85–89.)

2003. THE M.I.T. POWER FACTOR BRIDGE AND OIL CELL [and Some Results: Air Condensers may have Power Factors well over 0.000001: etc.].—Balsbaugh and others. (*Elec.Engineering*, March, 1935, Vol. 54, No. 3, pp. 272–279.) For a companion paper *see* 1934 Abstracts, p. 511.

2004. A NEW SEMI-ABSOLUTE METHOD OF MEASURING LARGE HIGH-FREQUENCY CURRENTS [2% Error for Currents up to 50 Amperes at 20 m Wavelength].—R. E. Albrandt. (*E.T.Z.*, 21st March, 1935, Vol. 56, No. 12, pp. 340–341.) Short illustrated version of the Russian paper (517 of February.)

2005. THE EMPLOYMENT OF THERMIONIC VALVES FOR THE MEASUREMENT OF VERY SMALL CURRENTS.—J. Thovert. (*Journ. de Phys. et le Rad.*, March, 1935, Series 7, Vol. 6, No. 3, pp. 89–93.)

2006. VALVE VOLTMETER WITH LOGARITHMIC SCALE AND ITS APPLICATIONS IN ACOUSTICS.—E. Meyer and L. Keidel. (*E.N.T.*, February, 1935, Vol. 12, No. 2, pp. 37–46.)

The desirability and difficulties of constructing measuring instruments with logarithmic scales for use in acoustics are discussed in §1; §2 describes the requirements and construction of a logarithmic rectifier (scheme Fig. 1) on the principle that the rectified voltage at the output of an amplifier regulates the adjustment of a potentiometer in the amplifier. Friction is minimised by using a liquid electrolytic resistance (tap water is the electrolyte chosen), graded approximately exponentially. The calibrating curve of this regulator is shown in Fig. 2; Fig. 3 gives the resistance characteristic, Fig. 4 a photograph of the system and Fig. 5 an oscillogram of the regulating process.

Electroacoustic applications are described in §3. A condenser microphone and an amplifier were prefixed to the voltmeter. Fig. 6 shows the frequency curve of the whole apparatus for investigating loudspeakers and microphones, Figs. 7a and b the frequency curve of the total radiation from an electrodynamic and an electromagnetic loudspeaker respectively. The method of investigating the frequency curve of a microphone is described and curves are shown in Figs. 8a and b. Applications to investigations of the acoustic properties of building materials and music rooms are discussed in §4; curves of damping by walls are given in Figs. 9b and c, which contrast the effect of a single and a double wall. The chief application is, however, to the investigation of echoes; the method adopted for this is described and curves of decay of echoes of pure tones of various frequencies are shown in Figs. 10 and 11. A phosphorescent screen may be used to render these visible. The decay curve is almost accurately exponential when the frequency is one of the natural frequencies of the room and the apparatus is at an antinode of pressure (Fig. 10c). The voltmeter may also be used to measure the decay of tuning-fork vibration (Fig. 12).

2007. A WIDE-RANGE VACUUM-TUBE VOLTMETER CIRCUIT [Symmetrical Two-Valve Circuit].—G. A. Woonton. (*Canadian Journ. of Res.*, January, 1935, Vol. 12, No. 1, pp. 1–5.)

Designed for fundamental frequencies ranging from a few to 100 cycles per second, but "its design suggests that it should give excellent results throughout the whole range of audio-frequencies and well up into the radio-frequency band."

2008. MEASUREMENT OF ANTENNA POWER BY OYAMA'S RADIOMETER.—Kimpara and others. (*See* 1869.)

2009. A WATTMETER FOR COMMUNICATION CIRCUITS [Network in which Elements are balanced with Valve Voltmeter: Direct Reading of Power Factor].—K. R. Eldredge. (*Elec. Engineering*, March, 1935, Vol. 54, No. 3, pp. 279–281.) As described, the equipment is suitable for 10^{-2} to 10^{-4} A and 0.5 to 2.0 V, at 200 to 3 000 c/s.

2010. THE DEVELOPMENT OF A SENSITIVE PRECISION WATTMETER FOR THE MEASUREMENT OF VERY SMALL POWERS.—N. H. Searby. (*Journ. I.E.E.*, February, 1935, Vol. 76, No. 458, pp. 205–221.)

2011. A VECTOR METER [Direct Reading: for 0.15–150 V and 0.005–5 A: Many Applications].—(*E.T.Z.*, 28th March, 1935, Vol. 56, No. 13, p. 380.)

2012. THE USE OF THE ROTARY VOLTMETER FOR MEASUREMENTS UP TO 830 KILOVOLTS.—Henderson, Goss and Rose. (*Review Scient. Instr.*, March, 1935, Vol. 6, No. 3, pp. 63–65.) For previous papers *see* 1934 Abstracts, p. 217 (Kirkpatrick).

2013. A METHOD OF MEASURING NOISE LEVELS ON SHORT-WAVE RADIOTELEGRAPH CIRCUITS.—Peterson. (*See* 1819.)

2014. A FIELD-STRENGTH MEASURING SET USING THERMAL AGITATION NOISE AS THE CALIBRATING SOURCE.—A. H. Mumford and P. L. Barker. (*P.O. Elec. Eng. Journ.*, April, 1935, Vol. 28, Part I, pp. 40–47.)

The principles used can be applied to sets for short or ultra-short waves, and to instruments for measuring (*e.g.*) the decrements of tuned circuits or losses in dielectrics. "It can therefore be concluded that the possibilities of utilising thermal agitation noise as a source of e.m.f. for measurement purposes are very great and are likely to be developed extensively in the near future."

2015. FADING MEASUREMENTS [U.R.S.I. Tests].—D. A. Bell. (*Wireless World*, 5th April, 1935, Vol. 36, pp. 338–339.)

Discussion of the results obtained from the recent test transmission for the comparison of frequency standards and for the investigation of fading and similar effects.

2016. A PORTABLE MEASURING APPARATUS FOR INVESTIGATING INTERFERENCE FIELDS.—Dennhardt and Himmler. (*See* 1820.)

2017. MEASUREMENT OF THE CAPACITY AND DAMPING OF A BALLISTIC GALVANOMETER.—I. Lucchi. (*L'Elettrotec.*, 10th Jan. 1935, Vol. 22, No. 1, pp. 20–22.)

2018. THE SELF-CAPACITANCE OF SINGLE-LAYER COILS [Independence of Frequency: Effect of Radius].—W. Jackson. (*Phil. Mag.*, April, 1935, Series 7, Vol. 19, No. 128, pp. 823–835.)

Measurements of the natural frequencies of a series of coils, with immersion in a liquid of known dielectric constant, show that the self-capacitance is independent of frequency, while its ratio to the radius is independent of the radius for a given coil shape. The results are compared with existing theories. The effect of end-connections, wire diameter, wire covering, and the presence of a coil former on the effective self-capacitance are also considered. A few measurements on double- and treble-layer coils are given.

2019. THE DESIGN, CONSTRUCTION, AND USE OF RESISTORS OF CALCULABLE REACTANCE [100–1 000 and 1 000–10 000 Ohms: Primary Standards].—N. F. Astbury. (*Journ. I.E.E.*, April, 1935, Vol. 76, No. 460, pp. 389–396.)

2020. MEASUREMENT OF THE DIELECTRIC CONSTANT OF AIR AT RADIO-FREQUENCIES [900 kc/s: Result agrees with Low-Frequency Value].—L. G. Hector and H. L. Schultz. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 327: abstract only.)

2021. A METHOD FOR DETERMINING THE DIELECTRIC CONSTANT OF CONDUCTING SOLUTIONS.—W. M. Mazee. (*Physik. Zeitschr.*, 1st March, 1935, Vol. 36, No. 5, pp. 177–180.)

The principle of the method depends on measuring the maximum resonance of a circuit. Details of the circuit (Fig. 1) and of the liquid resistance (Fig. 2) are given, and the experimental procedure is described.

2022. LOW-FREQUENCY [500 c/s] CONDUCTIVITY OF MIXTURES OF AQUEOUS SOLUTIONS OF ELECTROLYTES [Measurements and Discussion of Theory].—A. Deubner and A. Dobenzig. (*Physik. Zeitschr.*, 15th Feb. 1935, Vol. 36, No. 4, pp. 139–142.)

2023. INTERNATIONAL FREQUENCY COMPARISONS BY MEANS OF STANDARD RADIO-FREQUENCY EMISSIONS [Method, Accuracy and Results of Measurements].—L. Essen. (*Proc. Roy. Soc.*, Series A, 10th April, 1935, Vol. 149, No. 868, pp. 506–510.)

2024. RADIOELECTRIC FREQUENCY METER [Loudspeaker acting on Sensitive Flame whose Striations are observed Stroboscopically].—Z. Carrière. (*Journ. de Phys. et le Rad.*, November, 1934, Series 7, Vol. 5, No. 11, pp. 571–574.) A frequency of 10 000 c/s gives striae spaced one millimetre.

2025. THE USE OF A TRIODE IN B.-K. CONNECTION AS OSCILLATION WAVEMETER.—Leyshon. (*See* 1804.)

2026. THE QUESTION OF THE NATURAL FREQUENCIES OF PIEZOELECTRIC QUARTZ PLATES EXCITED TRANSVERSALLY [Optical Measurements show that Overtone Frequencies follow True Harmonic Law, though Measured and Extrapolated Fundamentals disagree].—L. Bergmann. (*Ann. der Physik*, Series 5, No. 6, Vol. 21, 1935, pp. 553–563.) *See* also 1934 Abstracts, pp. 332 (Bergmann) and 569 (Asbach and others).

2027. ON THE LAWS OF THE DISENGAGEMENT OF ELECTRICITY BY TORSION IN QUARTZ [Discrepancy between Authors' Formula and That of Tawil].—Ny Tsi-Ze and T. Ling-Chao: Tawil. (*Comptes Rendus*, 25th Feb. 1935, Vol. 200, No. 9, pp. 732–733.) *See* 505 of February, and 2028, below.

2028. CONSIDERATIONS ON THE DISENGAGEMENT OF ELECTRICITY BY TORSION OF QUARTZ.—E. P. Tawil. (*Comptes Rendus*, 25th March, 1935, Vol. 200, No. 13, pp. 1088–1090.) *See* 2027.

2029. THE DISPERSION OF THE OPTICAL ACTIVITY OF QUARTZ IN DIRECTIONS INCLINED ARBITRARILY TO THE OPTICAL AXIS [Direction with No Dispersion: Use in Optical Instruments].—C. Münster and G. Szivessy. (*Physik. Zeitschr.*, 1st Feb. 1935, Vol. 36, No. 3, pp. 101–106.)

2030. THE PRACTICAL APPLICATION OF DIFFRACTION OF LIGHT BY SUPERSONIC WAVES [including Study of Piezoquartz Crystals].—S. J. Sokoloff. (*Physik. Zeitschr.*, 15th Feb. 1935, Vol. 36, No. 4, pp. 142–144.)

Cf. Hiedemann and others, 195 and 247 of January. Short notes are made of the effect on the diffraction spectra of an oscillating crystal produced by different directions of cut, surrounding media, temperatures, electrode arrangements and oscillation frequencies.

2031. THE THERMODYNAMICS OF MAGNETISATION [including Magnetostriction Relations].—E. C. Stoner. (*Phil. Mag.*, March, 1935, Series 7, Vol. 19, No. 127, pp. 565–588.)

2032. "MEASURING PRACTICE (Technisches Messen)" [No. 10 of "Bildwort-Englisch": Book Review].—(*Zeitschr. f. tech. Phys.*, No. 3, Vol. 16, 1935, pp. 87–88.) For previous reference to this series *see* 646 of February.

SUBSIDIARY APPARATUS AND MATERIALS

2033. CONCERNING THE FLUCTUATIONS OF CURRENT IN A HIGH RESISTANCE [Metallised Resistors cause Fluctuations analogous to Shot Effect: Measurement of Apparent Multiple Electronic Charge on Molecular Aggregates].—G. W. Barnes. (*Journ. Franklin Inst.*, January, 1935, Vol. 219, No. 1, pp. 100–107.)

Introduction of metallic resistors (films on glass) into the anode circuits of amplifiers used for measuring cosmic ray ionisation causes short period fluctuations of the same type as those due to the shot effect in valves. If conduction takes place by communication of electricity between molecular aggregates, the apparent unit of charge should be much larger than that on the electron; the object of the experiments described here was to verify this. The variation of the fluctuation with the total current through the resistor was investigated. The circuit diagram is given; in this the resistance to be studied was arranged in a Wheatstone bridge circuit and the fluctuations were indicated by a short-period galvanometer. Samples of traces obtained and the theory of the interpretation are given. From the experimental results, the value of the multiple charge seemed to be about 72 times that of one electron.

2034. MODIFICATIONS OF THE COLD-CATHODE CATHODE-RAY TUBE [Metal Discharge Tube fused into Sealed-Off Hard-Glass Tube: Multiple-Ray Tubes: etc.].—Szeghö. (*Journ. Roy. Tech. College*, Glasgow, January, 1935, Vol. 3, Part 3, pp. 475–480.)

Other points are: cathode carried on steatite insulation: fine ray produced without use of aperture (anode opening 2 cm diam. instead of 0.5 mm): use as rectifier: multiple-ray tubes with single spherical cathode: with single anode as well (ray directed alternately into two deflecting systems): and a self-renewing cathode (thin wire burning away like candle).

2035. CATHODE-RAY OSCILLOGRAPHS—PAPERS AND DEMONSTRATIONS AT THE INSTITUTION OF ELECTRICAL ENGINEERS—A H.V. GAS-FILLED COLD-CATHODE EQUIPMENT.—MacGregor Morris and Henley: Parker Smith, Seegrö and Bradshaw. (*Electrician*, 11th Jan. 1935, Vol. 114, No. 2954, pp. 33–34.)

2036. A COMPLETE PORTABLE CATHODE-RAY OSCILLOGRAPH [weighing 38 lbs. with 3-inch Tube: A.C.-Operated].—Diehl. (*Proc. Inst. Rad. Eng.*, February, 1935, Vol. 23, No. 2, p. 99: summary only.)

2037. SYLVANIA CATHODE-RAY TUBE RATINGS [Modifications to Data].—(*Rad. Engineering*, March, 1935, Vol. 15, No. 3, p. 22.) *See* 1619 of May.

2038. THE FOCUSING OF NARROW ELECTRON BEAMS *in Vacuo* [Derivation of Simple Formulae: Application to "Einzellinse" and Other Converging Systems].—Bouwers. (*Physica*, March, 1935, Vol. 2, No. 3, pp. 145–154: in English.)

2039. THE POTENTIAL OF SLITS AND CIRCULAR STOPS [in Electron Microscopes: Calculations and Diagrams].—Henneberg. (*Zeitschr. f. Physik*, No. 1/2, Vol. 94, 1935, pp. 22–27.)

2040. TIME-MARKING A CATHODE-RAY OSCILLOGRAPH BY HARMONICS [Oscillograph acts as Triode, giving Retroaction in Tuned Circuit: Harmonic Selected and Applied to Wehnelt Cylinder].—Richardson. (*Proc. Phys. Soc.*, 1st March, 1935, Vol. 47, Part 2, No. 259, pp. 258–262.)

2041. ELECTRONIC COMMUTATOR FOR CATHODE-RAY TUBE [giving Simultaneous Observation of Two Waves].—Du Mont. (*Electronics*, March, 1935, p. 101.)

2042. EXCITATION SPECTRA OF THE LUMINESCENCE OF SOLID SOLUTIONS OF RHODULINE [in Sugar: Identity of Fluorescence and Phosphorescence Spectra].—Goloub. (*Physik. Zeitschr. der Sowietunion*, No. 1, Vol. 7, 1935, pp. 49–57: in French.)

2043. THE AUTOMATIC OSCILLOGRAPH [for recording Transient Conditions].—MacAffer. (*Gen. Elec. Review*, March, 1935, Vol. 38, No. 3, pp. 146–151.)

2044. THE SIX-STRING OSCILLOGRAPH.—Curtis. (*Bell Lab. Record*, January, 1935, Vol. 13, No. 5, pp. 145–150.)

2045. NOTE ON AN OPTICAL SYSTEM FOR SHADOW RECORDING WITH OSCILLOGRAPHS [simplifying the Methods of obtaining Time and Amplitude Rulings].—Woonton and Pye. (*Canadian Journ. of Res.*, February, 1935, Vol. 12, No. 2, pp. 261–264 and Plates.)

2046. THE DETERMINATION OF THE NATURAL FREQUENCY AND DAMPING OF OSCILLOGRAPH LOOPS FROM THEIR FREQUENCY CURVES.—Söchting. (*Elektrot. u. Masch:bau*, No. 33, Vol. 52, 1934, pp. 381–384.) *See* also 1933 Abstracts, p. 165, l-h col.

2047. ELECTRONIC DISCHARGE TUBE WITH LENGTH OF LUMINOUS COLUMN VARYING WITH AMOUNT OF CURRENT PASSING.—Thomson-Houston Company. (French Pat. 775 774, pub. 9.1.1935: *Rev. Gén. de l'Élec.*, 30th March, 1935, Vol. 37, No. 13, pp. 105–106 D.)

2048. SOME RESULTS ON THE WORKING MECHANISM OF DRY-PLATE ELECTRONIC RECTIFIER [and a New Type with Artificial Barrier Layer].—Jusé. (*Physik. Zeitschr. der Sowietunion*, No. 1, Vol. 7, 1935, pp. 1–18: in German.)

For a preliminary letter *see* 1933 Abstracts, p. 636. Author's summary:—"A method has been found of constructing a new type of dry-plate rectifier from Cu_2O with an artificial barrier-layer composed of a poorly conducting substance (SiO_2, B_2O_3, NaCl, S, glass, or bakelite). The rectifying coefficient reaches 100 (at 1 volt). The volt/ampere characteristics of such rectifiers—with a barrier-layer thickness of 1×10^{-6} to 5×10^{-4} cm—are measured in the range up to 20 volts, the electrical field being switched on for times up to $\tau = 0.8 \times 10^{-4}$ sec. It is found that in the case of a wedge-shaped barrier layer the maximum rectifying coefficient occurs for a thickness of 2×10^{-6} to 1×10^{-5} cm, but rectification still occurs for a thickness of 1×10^{-4} cm. The influence of temperature, from $+ 50°$ to $- 100°C$, on the rectifying coefficient is examined. It is found that a barrier-layer photo-effect can be obtained if an artificial barrier layer with high internal photo-effect is applied to an electronic semi-conductor."

2049. "CONTRIBUTION TO THE STUDY OF CONTACT RECTIFICATION" [Notice of Publication as Supplement to *L'Onde Élec.*].—Cayrel. (*L'Onde Élec.*, February, 1935, Vol. 14, No. 158, p. 128.)

2050. A METHOD ALLOWING THE RECTIFYING ACTION OF THE TWO CONTACTS OF A RECTIFIER TO BE STUDIED SEPARATELY, THE ACTION OF ONE BEING COMPLETELY SUPPRESSED: APPLICATION TO THE LOCALISATION OF β RECTIFICATION [Metal/Semi-Conductor] IN COPPER SULPHIDE DETECTORS.—Cayrel. (*Comptes Rendus*, 21st Jan. 1935, Vol. 200, No. 4, pp. 303–304: extract only.)

2051. THE ELECTRICAL RESISTANCES AT THE CONTACT OF TWO SEMI-CONDUCTING SUBSTANCES.—Dèchêne. (*Comptes Rendus*, 18th Feb. 1935, Vol. 200, No. 8, pp. 648–651.)

"All the results indicated in this work are similar to those observed at the contact between a semi-conducting substance and a metal. The interpretation is the same: the passage of electrical centres (ions or electrons) across the surface bounding a semi-conducting substance requires the production of an intense electrical field on this surface."

2052. PAPERS ON DETECTORS.—Geismann: David. (*See* 1837, 1838.)

2053. PROGRESS IN THE APPLICATION OF SELENIUM DRY-PLATE RECTIFIERS.—Maier. (*E.T.Z.*, 28th Feb. 1935, Vol. 56, No. 9, pp. 237–238.)

2054. THE ELECTRICAL CONDUCTIVITY OF ELECTRONIC SEMI-CONDUCTORS.—Gudden. (*E.T.Z.*, 21st Feb. 1935, Vol. 56, No. 8, p. 213: summary only.)

2055. ELECTRICAL AND OPTICAL BEHAVIOUR OF SEMI-CONDUCTORS. X. ELECTRICAL MEASUREMENTS WITH ZINC OXIDE.—Fritsch. (*Ann. der Physik*, March, 1935, Series 5, Vol. 22, No. 3, pp. 375–401.) For Part XI *see* 1994.

2056. [Theoretical and Experimental Considerations on] MECHANICAL RECTIFIERS FOR LABORATORY MEASUREMENTS.—Pianta. (*L'Elettrotec.*, 25th Feb. 1935, Vol. 22, No. 4, pp. 127–134.)

2057. HOT-CATHODE MERCURY RECTIFIER TUBES FOR HIGH-POWER BROADCAST TRANSMITTERS [Radiotron RCA-870, used at WLW].—Steiner. (*Proc. Inst. Rad. Eng.*, February, 1935, Vol. 23, No. 2, pp. 103–111.)

2058. THE GRID-CONTROLLED RECTIFIER WITH ZERO-POINT ANODE.—Babat. (*Journ. I.E.E.*, April, 1935, Vol. 76, No. 460, pp. 397–406.)

2059. THE MUTATOR: USEFUL INNOVATION IN ELECTRICAL TERMINOLOGY.—(*Electrician*, 25th Jan. 1935, Vol. 114, No. 2956, p. 132.) For severe criticism see *Rev. Gén. de l'Élec.*, 16th Feb. 1935, Vol. 37, No. 7, p. 202.

2060. AN ELECTRONIC VOLTAGE REGULATOR [with External-Grid Rectifier—"Kathetron"].—Craig and Sanford. (*Elec. Engineering*, February, 1935, Vol. 54, No. 2, pp. 166–170.) *See* also Abstracts, 1933, p. 339, and 1934, p. 394.

2061. THE STATIC TRANSFORMATION OF D.C. INTO A.C. BY MAGNETIC CONTROL OF THE MERCURY-VAPOUR ARC.—Savagnone. (*L'Elettrotec.*, 5th Dec. 1934, Vol. 21, No. 34, pp. 789–803.)

2062. QUICK PHOTOGRAPHS [One Millionth of a Second] POSSIBLE WITH NEW IGNITRON TUBE.—(*Sci. News Letter*, 16th Feb. 1935, Vol. 27, No. 723, pp. 102–103.)

2063. A RADIO-FREQUENCY HIGH-VOLTAGE GENERATOR [Resonance Transformer produces Voltage entirely inside Tank for X-Ray Production and Positive Ion Acceleration].—D. H. Sloan. (*Phys. Review*, 1st Jan. 1935, Series 2, Vol. 47, No. 1, pp. 62–71.) *See* also 1885.

2064. A NEW SOURCE OF "KILOCYCLE KILOWATTS" [the "Arc Oscillator Tube," generating Power at 1 to 100 kc/s].—Miles. (*Elec. Engineering*, March, 1935, Vol. 54, No. 3, pp. 305–307.)

2065. MAINS ADAPTOR WITH GLOW-DISCHARGE VOLTAGE-DIVIDER AS SUBSTITUTE FOR BATTERY [for Laboratory and other uses: an Improved Bridge-Circuit Equipment].—Meyer. (*Bull. Assoc. suisse des Élec.*, No. 19, Vol. 25, 1934, pp. 516–519.)

2066. NEON LAMP IN THE RÉGIME OF COUNTER.—Valle and Rossi. (*Nuovo Cimento*, December, 1934, Vol. 11, No. 10, pp. 708–716.)

2067. OSCILLOGRAPH PROBE MEASUREMENTS [of Potential and Electron Temperature] IN MOVING LAYERS OF THE POSITIVE COLUMN OF NOBLE GASES [Discharge in Argon].—Pupp. (*Physik. Zeitschr.*, 15th Jan. 1935, Vol. 36, No. 2, pp. 61–66.)

2068. THE GLOW DISCHARGE [in Air and Argon] IN A HIGH-VELOCITY GAS CURRENT [Delay in Starting removed by Current: Effect of Change of Space-Charge Distribution].—Maier. (*Zeitschr. f. Physik*, No. 1/2, Vol. 93, 1934, pp. 65–85.)

2069. THE INDUCTIVE GLOW DISCHARGE OSCILLATOR.—Kock. (*See* 1906.)

2070. THE MERCURY-SUPER-HIGH-PRESSURE LAMP, A NEW MERCURY-VAPOUR LAMP WITH VERY HIGH PRESSURE.—Halbertsma. (*Elektrot. u. Masch: bau*, No. 16, Vol. 53, 1935, Supp. pp. 1–3.)

2071. "GASENTLADUNGS - TABELLEN" [Tables, Formulae and Graphs pertaining to Physics of Electrons and Ions: Book Review].—Knoll and others. (*Gen. Elec. Review*, March, 1935, Vol. 38, No. 3, p. 157.)

2072. CURRENT TRANSFORMER FOR HIGH FREQUENCIES [*e.g.* for Stepping-Down Large Aerial Currents for Measuring Purposes].—MacGahan. (*Elektrot. u. Masch:bau*, No. 43, Vol. 52, 1934, p. 508: summary only.)

2073. THEORY OF TRANSIENT PHENOMENA ON HOMOGENEOUS CONDUCTORS [Method of Estimating Loss, if Loss-Less Solution is known].—Kosten. (*E.N.T.*, February, 1935, Vol. 12, No. 2, pp. 60–68.)

2074. EXPERIMENTAL STUDY ON HIGH-FREQUENCY INDUCTANCE COILS.—Kanazawa. (*Journ. I.E.E. Japan*, January, 1935, Vol. 55 [No. 1], No. 558, pp. 17–20: English summary p. 4.). The full paper, in Japanese, a summary of which was dealt with in 1205 of April.

2075. HIGH-FREQUENCY COIL WITH "SIRUFER" [Powdered Iron] CORE [Losses, Forms and Materials, Inductance Adjustment].—Weis. (*E.N.T.*, February, 1935, Vol. 12, No. 2, pp. 47–53.)

§A. Losses in iron-cored coils are due to the iron (hysteresis, eddy currents, magnetic inertia), the dielectric and the copper. These are discussed for coils with "Sirufer" cores. Figs. 3 and 4 show the influence on the quality of the coil of the effective permeability of the core and the stranding ["Litzenaufbau"] of the wire respectively. §B considers the material and form of the core (typical forms in Fig. 5). The H-core in Fig. 5a is the most suitable one possible; its advantages are described. § C describes inductance adjustment by means of a disc introduced into the field of a coil (Fig. 6) or by alteration of the effective diameter of the core (Fig. 7). §D mentions various uses to which these coils may be put.

2076. NEW TYPE IRON-CORED COIL.—Boucke. (*Wireless World*, 5th April, 1935, Vol. 36, p. 341.)

The same iron core is used for both medium and long wave windings which are wound at right angles to each other: the total assembly is more compact and is therefore smaller relatively to a screening container of given size, thus giving reduced eddy-current losses. Other advantages are claimed. For a rather fuller version see *Funktech. Monatshefte*, January, 1935, pp. 41–44.

2077. THE HOME CONSTRUCTION OF H.F. IRON-CORED COILS.—(*Funktech. Monatshefte*, January, 1935, No. 1, pp. 44–45.)

2078. IMPROVEMENTS IN POWDERED-IRON CORES FOR R.F. COILS: REDUCTION OF EDDY-CURRENT LOSS: METHOD OF ADJUSTMENT OF INDUCTANCE.—Nissen. (French Pat. 773 066, pub. 10.11.1934: *Rev. Gén. de l'Élec.*, 23rd Feb. 1935, Vol. 37, No. 8, pp. 61–62 D.)

2079. MAGNETIC PROPERTIES AND ORIENTATION OF FERROMAGNETIC PARTICLES [Alignment increases Magnetisation and Remanence: Coercive Force Unaffected].—Davis. (*Physics*, March, 1935, Vol. 6, No. 3, pp. 96–99.)

2080. FERROMAGNETIC ALLOYS AND THE LAWS GOVERNING THEIR PROPERTIES.—Kussmann. (*Chemiker-Zeit.*, 6th April, 1935, Vol. 59, No. 28, pp. 285–287.)

2081. A SURVEY OF MAGNETIC MATERIALS IN RELATION TO STRUCTURE.—Ellis and Schumacher. (*Bell S. Tech. Journ.*, January, 1935, Vol. 14, No. 1, pp. 8–43.)

2082. EDDY CURRENT LOSS IN TUBE IN AXIAL ALTERNATING MAGNETIC FIELD [Theory Applicable to Tubes of Any Thickness: Application to Effect of Solenoid Core].—McLachlan and Meyers. (*Phil. Mag.*, April, 1935, Series 7, Vol. 19, No. 128, pp. 846–849.) For previous work *see* 287 of January.

2083. SUPERIMPOSED D.C. AND A.C. IN IRON-CORED TRANSFORMERS AND CHOKES: INVESTIGATIONS WITH A CATHODE-RAY OSCILLOGRAPH.—Cosens. (*Wireless Engineer*, April, Vol. 12, No. 139, pp. 190–193.)

2084. INTERRELATION BETWEEN TIME OF OPERATION OF ELECTRO-MAGNETIC RELAYS, NUMBER OF TURNS ON MAGNET COIL, AND AMPERE TURNS FOR STEADY STATE [and the Effect of Inductance and Resistance in Series with Winding].—Kovalenkov. (*Izvestia Elektroprom. Slab. Toka*, December, 1934, No. 10, pp. 29–55.)

2085. THE RATE OF HEATING OF A METALLIC CONTACT [with Current Variation: Formulae and Curves showing Variation with Time, Contact Surface and Material].—Holm. (*Arch. f. Elektrot.*, 12th March, 1935, Vol. 29, No. 3, pp. 207–210.)

2086. MEASUREMENTS ON COMMERCIAL SOLID INSULATING MATERIALS AT 3×10^6 TO 7.5×10^7 CYCLES/SECOND.—Kessler. (*Hochf:tech. u. Elek:akus.*, March, 1935, Vol. 45, No. 3, pp. 91–100.)

Author's summary:—"The dielectric constants and loss angles of random samples of 40 ceramic and organic substances have been measured by the resonance method in the short-wave region between 4 m and 100 m. The loss angles for 4 m and 8 m were measured by a method in which the wavelength of the test oscillator was varied" [the resonance curve being plotted with the sample in place in one of two condensers in series; the sample was then removed and the empty condenser increased in capacity till the circuit was again in tune with the middle wave, and finally the resonance curve was plotted with the new circuit in the absence of the sample. By this method the two resonance curves were plotted with only one change of condenser in the sensitive circuit].

"At 4 m [4.20 m] the dielectric constant was measured by comparison with liquids [whose dielectric constants were predetermined by a Lecher-wire system fused into a 4 m long glass tube, a $\lambda/4$ length of the system projecting for coupling to the detector]. In the wave-range investigated the dielectric constant is constant; *i.e.* no absorption region occurs. For a few organic liquids [table 4] the dielectric constants at 4 m were determined, some of them for the first time. With an eye to television, the dielectric constant of purified nitrobenzol was also measured at this wavelength" [value 32.7 at 20°].

"With the solid materials the damping increases as the wavelength is decreased, as a rule regularly, in the case of the ceramic materials; but for the organic materials on the other hand a maximum of damping occurs at 10 m [*see* curves of Fig. 11]: this maximum however does not exceed 0.07. (This damping region corresponds to the phenomenon observed by Beck in insulating oils at the same wavelength [Abstracts, 1934, p. 52, r-h column]). An explanation of this region is not attempted. Preliminary measurements were carried out regarding the influence of atmospheric moisture on the damping and regarding the destruction of the prepared surface in layered materials and a consequent increase in damping [*e.g.* sand-papered Pertinax: the effect is insignificant]. The damping was measured at 60°C for a series of solid materials [table 5: with 100 m and 50 m wavelengths. The marked increase of damping with the organic materials agrees with the results of Müller and Zinke, 1934, p. 509: the decrease with the ceramic materials may be explained by decreased moisture]. Mixed materials of high dielectric constant were composed [prompted by the new substances such as Kerafar: the writer employed aluminium bronze and Canada balsam and obtained dielectric constants of 16 and 23] and the damping determined as a function of the mixing ratio" [at various wavelengths from 4 m to 100 m: table 6]. The writer points out that for most of the materials only one sample was available, so that too definite conclusions as to the relative merits of the various substances should not be drawn: the results were, however, reproducible after intervals of weeks. Table 2 shows how the writer's loss-angle measurements on Trolitul, Bakelite, etc., differ from the results obtained by Rohde and Schwarz (1934, pp. 509–510). It is suggested that the samples may have come from different sources and may have varied considerably: also that the different conditions of mounting may have an effect. Unexplained results on a sample of Calan are discussed at the beginning of p. 97: the dielectric constant value of 6.4, first found, fell to about 4.3 when the original surface was removed, and this lower value was again found for particles in a fluid mixture.

2087. DIPOLE ROTATION IN SOLID NON-CRYSTALLINE MATERIALS [Solid Dielectrics: Applicability of Dipole Theory].—Gemant. (*Phil. Mag.*, April, 1935, Series 7, Vol. 19, No. 128, pp. 746–758.)

2088. TWO TYPES OF DIELECTRIC POLARISATION [Studies of Temperature Variation of Dielectric Loss showing Possibility of Differentiating between Types due to Heterogeneous Structure (*e.g.* Halowax and Paper) and to Polar Molecules (*e.g.* Glycerine)].—Morgan. (*Bell Tel. S. Tech. Pub.*, Monograph B–828, 8 pp.)

2089. GLASS AS A DIELECTRIC [Summarising Discussion].—Morey. (*Journ. Franklin Inst.*, March, 1935, Vol. 219, No. 3, pp. 315–330.)

2090. SOME ELECTRICAL PROPERTIES OF CERESIN WAX [Use as Insulator].—Wikstrom. (*Physics*, March, 1935, Vol. 6, No. 3, pp. 86–92.)

2091. THE THERMAL BREAKDOWN OF BAKELITE INSULATORS [at Voltages only just over Working Voltage: Agreement with Thermal Breakdown Theory].—Zalessky. (*Elektrot. u. Masch:bau*, 10th March, 1935, Vol. 53, No. 10, pp. 112–116.)

2092. ESTERIFIED FIBROUS INSULATING MATERIALS [especially "Cotopa" and "Crestol"].—New. (*Elec. Communication*, January, 1935, Vol. 13, No. 3, pp. 216–225.)

2093. THE TURNING, GRINDING AND POLISHING OF ARTIFICIAL RESIN MOULDING MATERIALS AND SIMILAR INSULATORS.—Mehdorn. (*Zeitschr. V.D.I.*, 16th March, 1935, Vol. 79, No. 11, pp. 347–350.)

2094. PAPERS ON INSULATING MOULDING MATERIALS [Leipzig Fair Addresses].—(*E.T.Z.*, 7th March, 1935, Vol. 56, No. 10, pp. 269–291.)

2095. NON-INFLAMMABLE AND NON-EXPLOSIVE INSULATING LIQUIDS [Pyranol, Inerteen, etc.].—Bölsterli. (*Bull. Assoc. suisse des Élec.*, No. 8, Vol. 26, 1935, pp. 185–188.)

2096. MEASURING THE ARC-RESISTANCE OF INSULATING MATERIALS IN AIR.—Race and Warner. (*Gen. Elec. Review*, February, 1935, Vol. 38, No. 2, pp. 97–102.)

2097. INVESTIGATION OF THE RADIO-INTERFERENCE ACTION OF HIGH-TENSION INSULATORS.—Dick. (*See* 1833.)

2098. A VACUUM TUBE AMPLIFIER FOR SMALL DIRECT VOLTAGES [D.C. Voltage connected in Series with A.C. Voltage and passed through Rectifier].—Razek. (*Journ. Franklin Inst.*, February, 1935, Vol. 219, No. 2, pp. 137–155.)

The copper-oxide rectifier suppresses one part of the cycle, to a degree depending on the magnitude of the direct voltage; a conventional amplifier may then be used to amplify the resulting fluctuating voltage. The method has been used to amplify the output from a thermocouple and as a galvanometer power multiplier.

2099. VACUUM TUBE AMPLIFIER FOR THERMOCOUPLE E.M.F. [Magnetic Energy, stored in Transformer in Series with Voltage Source, Balancing Voltage and Cam-Driven Contact, delivers Voltage Pulse to Grid when Released].—Johnson, Bell and Nottingham. (*Phys. Review*, 1st March, 1935, Series 2, Vol. 47, No. 5, pp. 426–427: abstract only.)

2100. A NEW BALANCED CIRCUIT FOR [Portable Instruments] RESISTANCE THERMOMETERS, COMBUSTIBLE GAS INDICATORS, ETC.—Jacobson. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 336: abstract only.)

2101. A New Type Buzzer [giving Constant Alternating E.M.F. with Varying Load, and with Other Advantages].—Osida and Hashimoto. (*Rep. of Rad. Res. in Japan*, October, 1934, Vol. 4, No. 3, Abstracts p. 48: summary only, in English.)

2102. Stabilising Resistances for D.C. and Universal Receivers [particularly the Urdox and Iron-Urdox Barretters].—Schwandt. (*Funktech. Monatshefte*, March, 1935, No. 3, pp. 93–96.)

2103. Protecting the Brass Binding Posts and Soldered Joints of an Accumulator against Corrosion [by a Short Sleeve of Zinc, Marble, etc., intercepting the Creeping Acid].—Seitz. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 16, 1935, pp. 12–13.)

2104. The Design of Resistance Pads [Simple Formulae and Curves].—Nordica. (*Rad. Engineering*, December, 1934, Vol. 14, No. 12, pp. 12–15.)

2105. A Useful Method of Graph Plotting [avoiding Several Separate Calibration Sheets or Overlapping and Crossing of Several Curves on Same Sheet].—Horgan. (*Journ. Scient. Instr.*, April, 1935, Vol. 12, No. 4, pp. 123–124.)

2106. The Circle Nomogram [with Rotating Disc] and Its Advantages over the "Moving Line" Table [Alignment Chart].—Maass. (*Radio, B., F. für Alle*, February, 1935, No. 2, pp. 28–30.)

STATIONS, DESIGN AND OPERATION

2107. Investigation of the Quality of Broadcasting Services [Report to French Ministry of P.T.T.].—Adam. (*Rev. Gén. de l'Élec.*, 20th April, 1935, Vol. 37, No. 16, pp. 519–520.)

2108. Radio at the Paris Aviation Exhibition.—(*L'Onde Élec.*, Jan. and Feb. 1935, Vol. 14, Nos. 157 and 158, pp. 39–49 and 111–116.)

2109. The Standard Carrier Broadcast System [over Open-Wire Lines without interfering with Existing Facilities: Czechoslovakian Test Results].—Hodgson, Ralph and Jacobsen. (*Elec. Communication*, January, 1935, Vol. 13, No. 3, pp. 197–205.)

2110. A B.B.C. Dramatic Control Unit.—Colborn and Mitchell. (*Wireless World*, 26th April, 1935, Vol. 36, pp. 408–412.)

2111. The B.B.C.'s Flying Squad [Mobile Recording Unit].—(*Wireless World*, 19th April, 1935, Vol. 36, pp. 386–387.)

GENERAL PHYSICAL ARTICLES

2112. Papers on the New Field Theory.—Born and Schrödinger: Hoffmann: Pryce: Feenberg. (*Nature*, 2nd March, 1935, p. 342: *Proc. Roy. Soc.*, Series A, 1st Feb. 1935, pp. 353–364: *Proc. Camb. Phil. Soc.*, January, 1935, pp. 50–68: *Phys. Review*, 15th Jan. 1935, pp. 148–157.)

2113. The Connecting Link between Classical Electromagnetic Theory and Wave Mechanics *via* a Derivation of the Schrödinger Equations as a Boundary Value Problem on the Atom.—DeVore. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, pp. 333: abstract only.)

2114. "Electrons (+ and −), Protons, Photons, Neutrons, and Cosmic Rays" [Book Review].—Millikan. (*Journ. Scient. Instr.*, April, 1935, Vol. 12, No. 4, pp. 135–136.)

MISCELLANEOUS

2115. Talk of Interesting New Developments.—(*Electronics*, March, 1935, p. 71.)

Photographs transmitted in 8–10 minutes by ordinary long-distance telephone call: binaural recordings both in one groove: cellophane "sound-strings"—cheap continuous sound-recording medium (from Germany): intense cold light from new fluorescent materials bombarded by cathode rays: pocket transceivers on floor of Stock Exchange.

2116. The Application of a General Principle, for the Development of the Functions of a Variable, to Series of Bessel Functions.—Delsarte. (*Comptes Rendus*, 25th March, 1935, Vol. 200, No. 13, pp. 1084–1086.)

2117. Some Expansions associated with Bessel Functions.—Bateman and Rice. (*Proc. Nat. Acad. Sci.*, March, 1935, Vol. 21, No. 3, pp. 173–179.)

2118. Standard Nomographic Forms for Equations in Three Variables.—Wood. (*Canadian Journ. of Res.*, January, 1935, Vol. 12, No. 1, pp. 14–40.)

2119. The Graphical Transformation of Curves into Straight Lines and the Construction of Alignment Charts.—Wertheimer. (*Journ. Franklin Inst.*, March, 1935, Vol. 219, No. 3, pp. 343–363.)

2120. A Semi-Determinate Cam Problem requiring Unusual Mathematical Treatment.—Edison. (*Journ. Franklin Inst.*, March, 1935, Vol. 219, No. 3, pp. 331–342.)

2121. Similarity Relations in Electrical Engineering [and the Application of Dimensional Analysis and Model Experiments].—Brainerd and Neufeld. (*Elec. Engineering*, March, 1935, Vol. 54, No. 3, pp. 268–272.)

2122. Probability in Engineering.—Molina. (*Elec. Engineering*, April, 1935, Vol. 54, No. 4, pp. 423–427.)

2123. International Union of Pure and Applied Physics. Report of the Commission of Symbols, Units and Nomenclature [Resolutions and Remarks].—(*Nature*, 16th March, 1935, Vol. 135, pp. 419–420.)

2124. Miscellaneous Papers.—Pedersen. (*Ingeniörvidenskabelige Skrift.*, B No. 12, 104 pp.)

Not on new work in Radio. One paper discusses the possibility of applying scientific-technical methods to other fields of research such as economics.

A list is given of papers, etc., published by the writer.

2125. AN ADVANCED COURSE IN ENGINEERING [General Electric Company's Three-Year Course].—Stevenson and Howard. (*Elec. Engineering*, March, 1935, Vol. 54, No. 3, pp. 265–268.)

2126. AN ELECTRONICS LABORATORY FOR TECHNICAL STUDENTS [Massachusetts Institute of Technology].—(*Electronics*, March, 1935, pp. 86–87 and 89.)

2127. THE "RAVAG" JUBILEE IN AUSTRIA [Survey of Miscellaneous Accomplishments].—(*Elektrot. u. Masch:bau*, No. 47, Vol. 52, 1934, pp. 553–557.)

2128. REVIEW OF PROGRESS: RADIO-TELEGRAPHY AND RADIO-TELEPHONY.—Angwin. (*Journ. I.E.E.*, February, 1935, Vol. 76, No. 458, pp. 177–184.)

2129. SPECIAL ANNUAL REVIEW FEATURES [including Radio Research, Phototelegraphy, etc.].—(*Electrician*, 25th Jan. 1935, Vol. 114, No. 2956, pp. 86–126.)

2130. DEVELOPMENTS IN THE ELECTRICAL INDUSTRY DURING 1934 [including Lightning Investigation, u.s.w. Police Radio, etc.].—(*Gen. Elec. Review*, January, 1935, Vol. 38, No. 1, pp. 5–62.)

2131. "ELECTROMAGNETISM" [Book Review].—H. M. Macdonald. (*Wireless Engineer*, April, 1935, Vol. 12, No. 139, p. 200.)

2132. "RADIO ROUND THE WORLD" [Book Review].—Haslett. (*P.O. Elec. Eng. Journ.*, April, 1935, Vol. 28, Part I, p. 76.)

2133. PHYSICAL SOCIETY'S EXHIBITION: RESEARCH AND EXPERIMENTAL SECTION.—(*Electrician*, 11th Jan. 1935, Vol. 114, No. 2954, pp. 39–41.)

2134. "LES ONDES COURTES ET ULTRACOURTES" [Book Review].—Hémardinquer and Piraux. (*Rev. Gén. de l'Élec.*, 13th April, 1935, Vol. 37, No. 15, p. 472.)

2135. KILLING INSECTS BY SHORT [and Ultra-Short] WAVES [Greenhouse Researches at Rutgers University].—(*Electronics*, October, 1934, p. 309.)

2136. THE STERILISATION [Destruction of Moths, etc.] OF FLOUR AND GRAIN BY CORONA DISCHARGE.—(*E.T.Z*, 7th Feb. 1935, Vol. 56, No. 6, p. 133.)

2137. THE APPLICATION OF THE DIELECTRIC CONSTANT TO PRACTICAL MEASUREMENTS [of Thickness of Wires and Bands: Purity of Liquids: Permeability to Water: Moisture Content: Grain Size: etc.].—Büll. (*Zeitschr. V.D.I.*, 2nd Feb. 1935, Vol. 79, No. 5, pp. 133–137.)

2138. THE "DIELKOMETER" FOR DIELECTRIC CONSTANT MEASUREMENTS OF LIQUIDS FOR ANALYTICAL PURPOSES.—Ebert and Waldschmidt. (*Elektrot. u. Masch:bau*, No. 43, Vol. 52, 1934, p. 508: summary only.)

2139. AUTO-RADIO—AN AID TO GEOLOGIC MAPPING.—Cloos. (*Trans. Am. Geophys. Union*, June, 1934, Part I, p. 176: abstract only.)

2140. ELECTRON-TUBE VOLTAGE CONTROL FOR PHOTOMETRY.—Kilpatrick and Bernhardt. (*Electronics*, November, 1934, pp. 352–353.)

2141. DETECTS METAL PARTICLES IN FOOD MANUFACTURE [and Concealed Weapons on Arrested Persons].—(*Electronics*, November, 1934, p. 355: no description.)

2142. CRYSTAL MICROPHONE AND NEON-LAMP STROBOSCOPE FOR DIAGNOSING DEFECTS IN WATCHES AND FOR RAPID REGULATION.—(*Electronics*, January, 1935, p. 21.) For another method *see* 1934 Abstracts, p. 449 (Tamm).

2143. AN ACOUSTIC [Stretched String] TORSION METER FOR THE DETERMINATION OF SHAFT LOADS [for Ships, etc.].—Krapf. (*Elektrot. u. Masch:bau*, No. 41, Vol. 52, 1934, pp. 485–486.) *See* also 1291 of April.

2144. A NEW METHOD AND APPARATUS FOR THE PRODUCTION OF HIGHLY DISPERSED CONDITIONS [Emulsions and Colloidal Solutions by use of Piezoelectric Quartz].—Claus. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 16, 1935, pp. 80–82.)

2145. THE PIEZOELECTRIC VIBROGRAPH-ACCELEROGRAPH.—Gondet and Beaudouin. (*Rev. Gén. de l'Élec.*, 20th April, 1935, Vol. 37, No. 16, pp. 499–508.) Following on Langevin's survey (1286 of April).

2146. ON THE ELECTRICAL METHOD OF MEASURING SMALL VIBRATIONS, AND ITS APPLICATION TO THE MEASUREMENT OF VIBRATIONS OF AIRSCREW BLADES.—Obata, Morita and Yoshida. (*Jap. Journ. of Phys.*, 17th Feb. 1935, Vol. 10, No. 1, Abstracts p. 9.) Improvements to the method referred to in 1934 Abstracts, p. 516.

2147. MEASUREMENT OF THE SPEED OF MARINE, SUBMARINE, AND AIR CRAFT BY COMPENSATED THERMOCOUPLES.—Egal. (*Comptes Rendus*, 4th March, 1935, Vol. 200, No. 10, pp. 812–814.) *See* also *Génie Civil*, 23rd March, 1935, Vol. 106, No. 12, pp. 286–287.

2148. CUPROX [Rectifier] DISCS AS HEAT RELAYS.—Siroksky and Teitel. (*Elektritchestvo*, January, 1935, pp. 6–7: in Russian.)

2149. AN ELECTRONIC VOLTMETER FOR D.C. ARC WELDING.—Richter. (*Electronics*, March, 1935, pp. 82–83.)

2150. ON THE USE OF RADIO BROADCAST CARRIERS FOR CONSTANT HIGH FREQUENCY CURRENTS [Removal of Modulation by Special Type of Amplifying Circuit delivering Equal Pulses of Power to Low-Loss Resonant Circuit].—Schultz and Hector. (*Phys. Review*, 15th Feb. 1935, Series 2, Vol. 47, No. 4, p. 327: abstract only.)

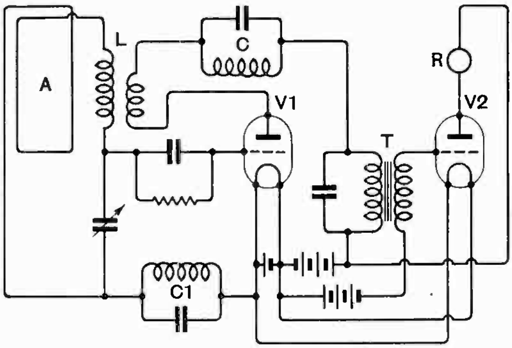
Some Recent Patents

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

CALLING-UP ARRANGEMENTS

Application date, 11th April, 1933. *No.* 417725

In order to "call up" certain selected receivers, the carrier wave is interrupted at a frequency which corresponds to that allotted to the particular subscribers. The calling frequency can be varied as required so as to change the group of receivers concerned.



No. 417725.

The receiving set is of the super-regenerative type. As shown in the drawing, the first valve *V1* is back-coupled to a frame aerial *A* at *L*, and is quenched at a frequency determined by the coupled circuits *C*, *C1*. The output transformer is tuned by a condenser to a fixed frequency, which, when it corresponds to the "call" sent out from the transmitting station, operates a relay *R* in the output circuit of a valve *V2*. The relay gives an audible or visible warning of the incoming call.

Patent issued to G. Monteavaro.

TRANSMITTING VALVES

Convention date (Germany), 4th May, 1933. *No.* 417837

The cooling-fluid used for the anodes of high-powered amplifiers is frequently fed through a spirally-wound conduit of porcelain or stoneware, which for reasons of space must be connected through a pipe-line to the distant reservoir. Since the pipe-line carries both D.C. and H.F. voltages, it is liable to act as an aerial and so give rise to undesirable radiation, particularly at harmonic frequencies of the working wavelength. In order to overcome this difficulty, the stoneware conduit is shunted by a high-frequency choke coil which, whilst maintaining a D.C. connection with the anode of the amplifier, blocks out H.F. energy from the pipe-line. The low-potential end of the choke is connected to earth through a condenser.

Patent issued to Telefunken Ges. für drahtlose Telegraphie m.b.h.

CATHODE-RAY TUBES

Convention dates (Germany), 10th, 18th and 24th March, and 4th April, 1932. *No.* 417850

A gas-filled cathode-ray tube is fitted with an indirectly heated cathode and a control grid in the form of a perforated diaphragm arranged at a distance not greater than 2 mm. from the cathode. Both electrodes are surrounded by a Wehnelt cylinder. It is stated that at this short distance from the emissive surface there are none—or very few—free ions, so that the conditions favour a "free" electron discharge, even when the tube contains a gas filling. A highly-sensitive control can accordingly be obtained with voltages less than those required for tubes of the evacuated type.

Patent issued to Radio Akt. D. S. Loewe.

GRAMOPHONE PICK-UPS

Application date, 8th March, 1933. *No.* 417927

In order to control the pressure of the needle on the record, the pick-up arm is made in two parts, one pivoted to the other. Mounted on the common pivot is an independent lever, one end of which carries a sliding weight, whilst the other end engages with a pin projecting from the needle-carrying arm. The upward thrust on this pin from the weighted lever opposes the normal pressure of the needle on the record, and is controlled by the distance of the sliding weight from the common pivot.

Patent issued to H. A. H. Schuler.

TELEVISION SYSTEMS

Convention date (Germany), 6th April, 1932. *No.* 417932

The line-scanning frequency used at the receiving end is automatically derived from the picture-repetition frequency sent out from the transmitter. This comparatively low single frequency is passed at the receiving end through a frequency-multiplier comprising a number of differently-biased full-wave rectifiers which are arranged so that, as the input voltage increases, the output develops evenly-spaced "peaks" corresponding to the required higher or line-scanning frequency. Alternatively the frequency-multiplier may consist of differently-saturated inductances combined with rectifiers which convert all the "peaks" to the same polarity. One advantage of the arrangement is that the two scanning frequencies have always the same fixed ratio.

Patent issued to Telefunken Ges. für drahtlose Telegraphie m.b.h.

RADIOGRAMS

Convention date (Germany), 11th May, 1933. *No.* 418117

In a combined superhet and radiogram, the local oscillator is made ineffective, when the set is being used for gramophone reproductions, and the signal input circuits are simultaneously de-tuned so as to prevent interference from any station operating in a wavelength near that of the intermediate-frequency circuits. The set utilises an electron-coupled "mixer" valve, the mixing grid of which is earthed when the set is switched over to the gramophone pick-up, so that the normal back-coupling coil is short-circuited and the local oscillator put out of action. Simultaneously the primary side of the input circuit is switched over to the "long-wave" setting and the secondary side to the "short-wave" setting, thus preventing any H.F. signals from getting through to the I.F. circuits of the set.

Patent issued to Telefunken Ges. für drahtlose Telegraphie m.b.h.

MULTI-GRID VALVES

Convention date (Germany), 11th February, 1932. No. 418132

In addition to the ordinary control grid, two other grids are arranged in close proximity to the cathode, in order to obtain what is termed a "virtual cathode" of regulatable electron density and velocity. The grid nearest the cathode carries a fixed positive bias, which does not vary with the signal frequency, but is used to control the density of the electron stream. The second auxiliary grid similarly carries an unvarying positive bias, and is used to control the velocity with which the electrons move forward. A screening grid may be interposed between the two last-mentioned grids in order to allow each to function independently of the other. Also a further screening grid may occupy its usual position between the control grid and the anode. The valve may be of the gas-filled type and may also be provided with an auxiliary magnetic field at right-angles to the path of the discharge stream.

The cathode-regulating grids enable the discharge stream to be controlled so that it consists either of a small number of high-speed electrons or of a large number of low-speed electrons.

Patent issued to Telefunken Ges. für drahtlose Telegraphie m.b.h.

VALVE ELECTRODES

Application date, 30th May, 1933. No. 418238

Instead of using the usual spring or resilient metal strip for tensioning the filament wire of a thermionic valve, the loop of the filament is threaded through a hook carried by a flexed strip of mica, which is bridged across the top of the supporting posts for the electrode structure.

Patent issued to A. E. F. Thomas and C. E. Thomas.

Convention date (Germany), 6th February, 1933. No. 418412

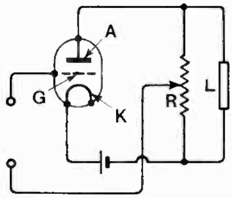
To hold the electrodes as rigidly as is necessary to avoid microphonic tendencies, whilst at the same time allowing sufficient play to accommodate temperature variations, the supporting wires for the electrodes are mounted so that they can move slightly in the longitudinal direction, but not laterally. This is effected by forming holes in the mounting-member larger than the diameter of the supporting wires, and spring-pressing the latter in each hole, so that whilst it is free to expand up or down it is held firmly against any sideway movement.

Patent issued to Telefunken Ges. für drahtlose Telegraphie m.b.h.

VALVE AMPLIFIERS

Convention dates (Germany), 18th March and 27th, 29th and 31st October, 1932. No. 418435

In order to avoid "overtones" caused by valve curvature or to the presence of iron-cored inductances, etc., particularly in multi-channel carrier systems, the inherent distortion is counteracted by applying an equal and opposite distortion derived from the falling mu-factor grid-voltage characteristic of one or more of the valves. Within certain limits this result can be obtained with standard valves, but preferably special "counter-control" valves are used when a wide range of control is desired. In such valves the cathode K is located between the anode A and the grid or control electrode G, the anode circuit being coupled to the grid through a tapping on a resistance R in shunt with the load L.



No. 418435.

Patent issued to Siemens and Halske Akt.

MODULATING SYSTEMS

Application date, 27th April, 1933. No. 418596

Amplitude modulation is effected by first producing phase-modulated energy of constant amplitude. This is then fed to two amplifiers through input circuits which, in one case, include a phase-retarding and, in the other, a phase-advancing network, the combined output from the amplifiers being wholly amplitude-modulated. The method combines the known advantage of phase modulation—so far as higher valve-efficiency is concerned—with the practical utility of amplitude modulation, particularly for broadcasting work.

Patent issued to Marconi's Wireless Telegraph Co., Ltd., and W. T. Ditcham.

MAINS-DRIVEN RECEIVERS

Application date, 29th November, 1933. No. 418711

In a mains-driven set, excessive potentials may be developed in the supply-unit in the interval when the valves are warming-up. In order to avoid damage from this cause, a fixed resistance is shunted across the leads, so that it acts as an artificial "load" when the set is switched on, and until such time as the valves begin to pass their normal anode current. As soon as this point is reached, a relay inserted in the H.T. positive or negative lead automatically operates an armature to disconnect the load resistance.

Patent issued to D. P. Davies.