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Editorial

Maxwell's Equations in Terms of the Flux-cutting Concept

AN interesting and thought-provoking article by Dr. C. V. Drysdale appeared in *Nature* of 5th February, entitled "A Simplification of Maxwell's Equations in Conformity with the Flux-cutting Principle." As he states, the question as to whether electromagnetic induction is caused by the change or by the cutting of magnetic flux has been debated at intervals during the last thirty years. In our opinion, these should not be regarded as two mutually exclusive "principles" for one of which a man is expected to plump. When the magnetic field relatively to the observer is everywhere constant in magnitude and direction ($dB/dt = 0$) it is obvious that no inductive electric forces can be due to variations of the magnetic flux. If conductors or dielectrics move in such a field, the electric phenomena produced must be due to their movement through the magnetic field, and although the e.m.f. induced in a circuit may be calculated from the change of flux through the circuit, this change of flux is due to the movement of the conductors through magnetised space, and this must be regarded as the primary cause. It is convenient and helpful to picture lines drawn in the direction of the magnetic field and of such a density that the number per square centimetre is equal to the value of B at every point. One can then express the product of the area swept out by the moving conductor and the value of the magnetic induction very picturesquely and conveniently by the number of magnetic lines cut by the moving conductor. But let not familiarity breed objectivity and turn our mathematical abstractions into veritable bristles. The example, *par excellence*, of the movement of a conductor in an unchanging field is the Faraday rotating disc; other examples are the various experiments involving a cylindrical bar magnet, either at rest or spinning on its axis. In all these experiments since dB/dt is everywhere zero the electric phenomena can only be due to the movement of conductors or dielectrics relatively to the observer.

If, however, the magnetic field relatively to the observer is undergoing changes, there are two cases to consider. When a magnet is moving, although to a stationary observer the field is undergoing changes in magnitude and direction, to another observer moving with the magnet the field is everywhere unchanging. Here the stationary observer may be tempted to endow the magnetic lines with objective existence and explain the electric phenomena as being due to these lines cutting through conductors or dielectrics or even through space itself, but one can hardly be surprised that such an explanation was not put forward by James Clerk Maxwell.

The other case is exemplified by the induction of e.m.f. in one circuit due to a changing current in a neighbouring circuit. Here the objective magnetic lines are assumed to spread out from the conductor like circular ripples on a water surface as the current increases, to remain frozen *in situ* while the current is constant, and then to shrink back into the conductor as the current dies away, cutting the other conductor, or failing that, the surrounding space, *en route*. These picturesque assumptions are often very convenient for the purposes of calculation, but as explanations of the causes of the phenomena we feel them to be unsatisfactory. That Maxwell was of the same opinion is shown by the fact that although, as Dr. Drysdale says, " his four fundamental equations were avowedly intended to put Faraday's concepts into mathematical form," he did not base them upon any line-cutting, but upon a much more fundamental concept, viz., that which is represented by the two foundation stones of his electromagnetic theory, the two formulae

$$\text{curl } \mathcal{E} = -dB/dt \text{ and curl } H = 4\pi dD/dt.$$

We cannot understand why Dr. Drysdale regards these two equations as " difficult to comprehend and to visualise physically." He also says that " if the flux cutting principle is the true one, they are not completely fundamental." Surely the magnetic induction and its variations are more fundamental than any mathematical or geometrical abstraction which we invent to indicate its strength and direction. We do not deny for a moment that the concept of cutting lines of force is of great utility and simplifies calculations in many cases. This is especially so in the type of problem which Dr. Drysdale takes as an example—the case of a magnet pole moving and carrying with it a distribution of magnetic flux which, viewed from the magnet, is unchanging. Every magnetic line can then be regarded as a distinct entity having a fixed position relative to the magnet, like a bristle attached to the magnet, and since the electric force induced in an element of conductor or dielectric can only depend on the relative motion between the magnet and element, it is immaterial which is considered at rest and which moving. The same method of calculation must be applicable to both cases.

When, however, the magnetic flux is changing in such a way that to no observer could it appear unchanging, it is impossible to explain the electrical phenomena solely by the movement of conductors or dielectrics through magnetised space. The changing value of B must be taken into account, but by making suitable assumptions this can be done by the line-cutting concept.

As Dr. Drysdale says, the induction of electric force by the cutting of magnetic flux is a much more familiar idea than the complementary one of the induction of magnetic force by the cutting of electric flux, although either can be developed equally well from Maxwell's equations.

Instead of following Dr. Drysdale's development of the flux-cutting formulae directly from the Maxwell equations, we shall consider the case of a surge or transient travelling along a transmission line.

When a pulse or surge travels along a transmission line with the velocity of light (modified by μ and κ), since the surge resistance (neglecting losses) is independent of frequency and equal to $\sqrt{L/C}$, the wave shapes of current and voltage are the same and there is a fixed ratio between H and $\mathcal{E}$ at every part of the pulse. Perhaps the simplest example to consider is a transmission line consisting of two parallel strips of breadth b, separated by a small distance d. The inductance L per cm. of length is $4\pi\mu d/b$ and the capacitance C per cm. is $\kappa b/(4\pi d \,.\, 9 \,.\, 10^{20})$ all in e.m. units. The surge resistance $R = \sqrt{L/C} = 4\pi \dfrac{d}{b}\sqrt{\dfrac{\mu}{\kappa}} \,.\, c$ where $c = 3 \times 10^{10}$ and R is in e.m. units.

If the surge current in the conductor at any point and moment be i e.m. units then we have $H = 4\pi i/b$ and $B = 4\pi i\mu/b$. The P.D. between the lines is $iR = 4\pi i \dfrac{d}{b}\sqrt{\dfrac{\mu}{\kappa}}\, c$ e.m. units and the electric field strength

$$\mathcal{E} = \text{P.D.}/d = \frac{4\pi i}{b}\sqrt{\frac{\mu}{\kappa}}\, c = B\frac{c}{\sqrt{\mu\kappa}}$$

The displacement

$$D = \frac{\mathcal{E}\kappa}{4\pi c^2} = H\frac{\sqrt{\mu\kappa}}{4\pi c} \therefore H = 4\pi D\frac{c}{\sqrt{\mu\kappa}}$$

Now $c/\sqrt{\mu\kappa}$ is the velocity with which the pulse travels along the line; hence in the dielectric space between the strips

$$\mathcal{E} = B \times \text{velocity}$$

and $$H = 4\pi D \times \text{velocity}$$

(Dr. Drysdale gets rid of the 4π in his equations by introducing a symbol $J=4\pi D$.) Thus, if we assume the magnetic and electric lines to be persistent entities sweeping along with the pulse and cutting through space, we see that the correct results are obtained by the flux-cutting concept, which, however, is not surprising as it only differs from the Maxwell method in the same way as counting the rate at which people pass through the turnstile differs from counting the rate at which the number in the field is changing, and on certain assumptions the turnstile method is not only accurate but may be more convenient.

Dr. Drysdale approaches the travelling wave in a very ingenious and interesting manner. He assumes that the travelling magnetic field is produced by a moving electromagnet and shows by the flux-cutting formulae that as the speed increases one can weaken the excitation and yet maintain the same strength of field, because the displacement currents, being essentially capacitance currents, act magnetisingly on the field system as in an alternator supplying a leading current. When the magnet moves with the speed of light it is no longer necessary and can be removed, the electromagnetic pulse being self-maintaining, in accordance with the above formulae for $\mathcal{E}$ and H, which are only mutually consistent when the velocity is equal to $c/\sqrt{\mu\kappa}$.

When the current in a conductor is changing and it is assumed that electromotive force is induced in a neighbouring conductor by the cutting through it of expanding circular lines, it is to be noted that this is not calculated directly from the value of B and any observable radial velocity of the lines, but the rate of cutting is inferred from the increase or decrease in the total flux beyond the wire. The e.m.f. is thus really calculated by the Maxwell equation, even by those who regard it as being due to flux cutting. When the flux through any area is changing it is obviously possible to assume that this is due to lines of magnetic induction crossing the boundary, and if one assumes that electric force is induced equal to the rate of this cutting, it must give the same result as that calculated from the rate at which the flux through the area is changing.

It may be argued that Maxwell's magnetic induction B and its rate of change have no more objective existence than Faraday's lines and their movement, but we find it difficult to believe that anyone will maintain that the latter are more "completely fundamental." G. W. O. H.

Absolute Permittivity

IN the *British Standard Glossary of Terms used in Electrical Engineering*, published in 1936, there is on p. 13 a definition of the absolute permittivity of a dielectric medium or space, as follows: "The ratio of the electric displacement to the electric force producing it. Symbol for the absolute permittivity of a vacuum κ_0.

$$\kappa_0 = \frac{1}{4\pi} \text{ e.s. unit or } \frac{1}{4\pi \times 9 \times 10^{11}} \text{ farad/cm.''}$$

This, if not actually incorrect, is somewhat misleading, and as the writer was to some extent responsible for the definition, he is anxious to make the matter quite clear. The rational definition of permittivity is as stated, viz., the ratio of the displacement (*i.e.* the quantity of electricity displaced per square centimetre) to the electric force producing it. If the quantity of electricity is expressed in coulombs and the electric force in volts per cm., the permittivity of space is expressed in farads per cm. and the above expression is correct. If the quantity and the electric force are both expressed in electrostatic units, the value of the permittivity of space, as defined, is as stated, viz., $1/4\pi$, but it is not correct to state that κ_0 is therefore $1/4\pi$ electrostatic units. The electrostatic system of units is based on the formula $f = \frac{q_1 \times q_2}{\kappa_0 d^2}$ where $\kappa_0 = 1$ for a vacuum. Now at unit distance from unit charge in a vacuum the electric force is unity, but the displacement is only $1/4\pi$, since unit quantity is displaced through a surface of 4π square centimetres. Hence, in the electrostatic system permittivity must be taken as 4π times the ratio of the electric displacement, as above defined, to the electric force producing it. This gives for vacuous space $\kappa_0 = 1$. G. W. O. H.

Television I.F. Amplifiers*

Designing Wide-Band Couplings

By W. T. Cocking

THE chief difference between an intermediate-frequency or radio-frequency amplifier designed for television purposes and one intended for sound reception lies in the band-width ; the pass-band must be some 2-5 Mc/s instead of merely 10-20 kc/s. In television the intermediate frequency cannot normally be below about 3 Mc/s and will not normally exceed 45 Mc/s—the carrier frequency of the Alexandra Palace vision transmitter. The ratio of band-width to intermediate frequency is consequently between 1.6-1 and 0.045-1, whereas in normal sound reception, with the usual intermediate frequency of 465 kc/s, it is about 0.0215-1 to 0.043-1.

In the relationship between band-width and operating frequency, the case of a 2 Mc/s band at 45 Mc/s is comparable with that of a 20 kc/s band at 465 kc/s, but in all other cases the ratio of band-width to operating frequency is much greater. Now although much work has been done on intervalve couplings in the past, it has nearly all been done with a view to the use of the circuits in sound receivers. In the circuit analyses various simplifications have usually been introduced, the most common being that the reactance of a coupling inductance or capacitance is constant over the pass-band. In general, this assumption leads to negligible error when the ratio of band-width to operating frequency is small and it greatly simplifies the circuit analysis. Unfortunately, the assumption is not permissible when the ratio is not small, for it then introduces serious error. The result is that most of the analyses made in the past are not directly applicable to television amplifiers.

One of the simplest forms of intervalve coupling, but not necessarily the best, is the familiar tuned anode circuit shown in Fig. 1(a). This circuit has already been dealt with from the point of view of design[1], but for the sake of completeness it will be considered here also. Provided that the coupling condenser C_1 has a reactance which is very low compared with R_1 in parallel with the input impedance of V_2, it may be neglected and the equivalent circuit becomes that of Fig. 1(b). Here C

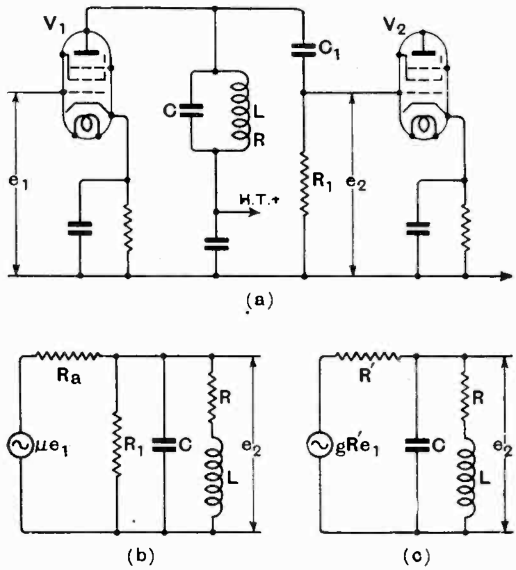

Fig. 1.

represents the total circuit capacitance—that is, it is the sum of the tuning capacitance, if any, the self-capacitance of the coil, the stray wiring capacitances, the output capacitance of V_1 and the input capacitance of V_2. The resistive component of the input impedance of V_2, when it is not negligible, is included in R_1. By Thévenin's theorem, the circuit can be reduced to the form of Fig. 1(c), where $R' = R_a R_1/(R_a + R_1)$ and $g = \mu/R_a$, and it is easily shown that the amplification

$$\frac{e_2}{e_1} = A = \frac{gR'Z}{R' + Z} = gZ'$$

* MS. accepted by the Editor, March, 1938.

[1] *The Wireless World*, February 26th, 1937.

where $Z = (j\omega L + R)/(j\omega CR + 1 - \omega^2 LC)$

This can be expressed in the form

$$A = \frac{gR\sqrt{1 + x^2z^2}}{\sqrt{[(1-x^2+R/R')^2+(1+z^2R/R')^2x^2/z^2]}} \quad \ldots \quad (1)$$

where $x^2 = \omega^2 LC$, $y^2 = L/CR'^2$, $z^2 = L/CR^2$

When R' is so large that it can be neglected, equation (1) reduces to

$$A = \frac{gR\sqrt{1 + x^2z^2}}{\sqrt{[(1 - x^2)^2 + x^2/z^2]}} \quad \ldots \quad (2)$$

and when R is so small that it can be neglected, equation (1) reduces to

$$A = \frac{gR'}{\sqrt{[1 + (1 - x^2)^2/x^2y^2]}} \quad \ldots \quad (3)$$

The two arrangements give entirely different characteristics. When R' is very large and R is finite so that equation (2) applies the stage amplification has the value gR at low frequencies; indeed, it will only fall below this value at very low frequencies, through the time constant C_1R_1 of Fig. 1(a) and with suitable values the response can be maintained down to 10 c/s or less. At high frequencies, the response depends largely upon the value of z. When $z^2 = 0.5$ the response is maintained very evenly up to a certain frequency and then cuts off; when $z^2 > 0.5$ a noticeable peak occurs in the response and is pronounced for large values of z^2. When $z^2 < 0.5$, the response tails off at high frequencies in the manner of an ordinary resistance-coupled amplifier, but to a lesser degree; the amplification then never exceeds gR. McLachlan has shown [2] that the circuit is liable to be set into oscillation at its natural frequency by transients unless the damping is critical or greater. This limits the value of z and for the avoidance of the effect $z^2 \leqslant 0.25$.

Under these conditions the circuit is unsuitable for an I.F. amplifier, but it finds wide application in vision-frequency stages. Even when z is large and there is a marked peak in the response curve, the arrangement is not very satisfactory because the curve is markedly unsymmetrical about the peak frequency.

[2] "Reproduction of Transients by Television Amplifiers," H. W. McLachlan, *The Wireless Engineer*, Vol. 13, October, 1936.

The arrangement to which equation (3) applies, that R should be negligibly small, is much more suitable and gives a resonance curve which is nearly symmetrical. At resonance $x = 1$ and $A = gR'$, the relative response S at any other frequency is given by $1/S = \sqrt{[1 + (1 - x^2)^2/x^2y^2]}$, whence

$$y = \frac{(1 - x^2)}{x\sqrt{1/S^2 - 1}} = \frac{n}{f_r\sqrt{1/S^2 - 1}} \quad \ldots \quad (4)$$

since $f_r = \sqrt{f_1 f_2}$, $f_2 - f_1 = n$,

and $f_2 - n/2 = f_1 + n/2 = f_m$

Now $y = \sqrt{L/CR'^2} = 1/\omega_r CR'$, therefore,

$$\left.\begin{aligned} CR' &= \frac{\sqrt{1/S^2 - 1}}{2\pi n} \quad \ldots \quad \ldots \\ L &= 1/\omega_r^2 C \end{aligned}\right\} \quad (5)$$

Equation (5) shows that R', and hence the stage gain, is inversely proportional to both the circuit capacitance C and the bandwidth n and is independent of the resonance frequency.

The minimum value which C can assume in practice is about 25 $\mu\mu$F. and the maximum value of mutual conductance obtainable is about 6.0 mA/V. without increasing the capacitance beyond this figure. If we assume $S = 0.707$ and $n = 3.0$ Mc/s, we have from equation (5) $R' = 2,120$ ohms and $A = 12.62$.

The stage gain obtainable is by no means high and in practice will be lower because a value of 0.707 for S is too small when three or four stages are used. It is, in fact, rarely possible to secure a good overall frequency response with an amplification per stage of more than 6 to 9, even using high-g valves.

It might be thought that the use of a pair of coupled circuits would offer no advantage in the way of improved amplification, since it is often stated that the amplification with such an arrangement is one-half of that with a single tuned circuit. This comparison, however, is only correct when all circuits have identical constants, as is usually the case in a broadcast set. With television apparatus, the capacitance on each circuit of a coupled pair is less than with a single circuit, because each circuit has only one valve connected to it. Consequently, the L/C ratio is increased and also the damping resistance. Furthermore, owing to the tendency towards a double-humped resonance curve less damping is needed for the maintenance of a flat response curve near resonance, and R can again be higher. The net result of these two factors is to make possible higher gain per stage with a two-circuit coupling than with a single circuit.

The circuit to be investigated is shown in Fig. 2(a) and the same approximation will be made as before, namely, that the series R.F. resistance of the coils can be neglected. Further, it will be assumed that the A.C. resistance of V_1 is high enough in relation to the circuit impedance to be ignored. Both these assumptions lead to negligible errors in practice. The circuit can then be represented by the equivalent diagram of Fig. 2 (b) and the gain is given by the expression

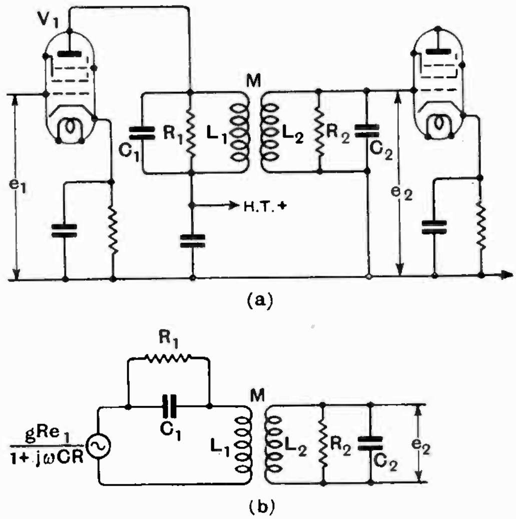

Fig. 2.

$$\frac{e_2}{e_1} = A = \frac{gR_1xy_2k\sqrt{\frac{R_2}{R_1}}\sqrt{\frac{C_2R_2}{C_1R_1}}}{\sqrt{\left[\left\{(1-x^2)^2 - x^2y_2^2(1-k^2)\frac{C_2R_2}{C_1R_1} - x^4k^2\right\}^2 + x^2y_1^2\left(1+\frac{C_1R_1}{C_2R_2}\right)^2(1-x^2+x^2k^2)^2\right]}} \quad (6)$$

where $x^2 = \omega^2L_1C_1 = \omega^2L_2C_2$

$y_1^2 = L_1/C_1R_1^2$

$y_2^2 = L_2/C_2R_2^2$

$k^2 = M^2/L_1L_2$

When primary and secondary circuits are equally damped $y_1 = y_2 = y$ and equation (6) reduces to

$$A = \frac{gxyk\sqrt{R_1R_2}}{\sqrt{[\{(1-x^2)^2 - x^2y^2(1-k^2) - x^4k^2\}^2 + 4x^2y^2(1-x^2+x^2k^2)^2]}} \quad \ldots \quad \ldots \quad (7)$$

The gain is a maximum when $x^2 = 1/(1-k^2)$ and becomes

$$A = \frac{gyk\sqrt{1-k^2}\sqrt{R_1R_2}}{y^2k^2 - y^2 - k^2} \quad \ldots \quad (8)$$

When $y^2 < 1$ the optimum coupling is $k^2 = y^2/(1+y^2)$ and with this value

$$A = \frac{gxy^2\sqrt{1+y^2}\sqrt{R_1R_2}}{\sqrt{[(1-x^2)^2(1+y^2-x^2)^2 + 4x^2y^4(1+y^2)]}} \quad \ldots \quad \ldots \quad (9)$$

which reduces to $A = g\sqrt{R_1R_2}/2$ .. (10)

when $x^2 = 1 + y^2$ or 1.

At a value of x^2 between $1 + y^2$ and 1, A is less than $g\sqrt{R_1R_2}/2$, so that the resonance curve is double-humped. In practice, however, with the values of y normally used for a television amplifier the amplification at the trough frequency is indistinguishable from that at the peak frequencies since it is at least 99.5 per cent. of it. The resonance curve is thus in practice flat-topped.

For design purposes the frequencies f_1 and f_2 corresponding to the limits of the pass-band, and the drop in response at these frequencies, are usually known, as is also the circuit capacitance. In order to find the values of components required it is necessary first to find y, for once this is fixed all other constants can be readily obtained from the relationships already established. Unfortunately, equation (9) does not lend itself readily to the precise determination of y by direct means, such as those applicable in the case of the single circuit coupling already discussed. It is, however, possible to calculate and plot the resonance curves corresponding to a series of values of y, and if these curves are plotted with x as one ordinate they are of universal application in the sense that they can be applied to any actual frequencies. From such a series of curves it is readily possible with a little ingenuity to find the value of y which will satisfy the requirements of the design.

Such a family of curves is shown in Fig. 3 and it is possible to derive from it a new set of curves connecting band-width with y for various values of response at the edges of the band. Thus for a response of 0.89 (− 1.0 db.) and $y^2 = 0.2$, there are two values of x, corresponding to the limits of the band; these may be called x_1 and x_2 and for this case are 0.816 and 1.282. Consequently $x_2 - x_1 = 0.466$. By taking a series of different values in this way, the curves of Fig. 4 can be plotted, and to find y from these it is only necessary to find $x_2 - x_1$

Now $x_2 - x_1 = (\omega_2 - \omega_1)\sqrt{LC} = (f_2 - f_1)2\pi\sqrt{LC} = n/f_r$.

Further, in Fig. 4 f_r occurs in both scales so that it can be eliminated. This has been done in Fig. 5 and the curves here show the relation between band-width and CR and are independent of the intermediate frequency.

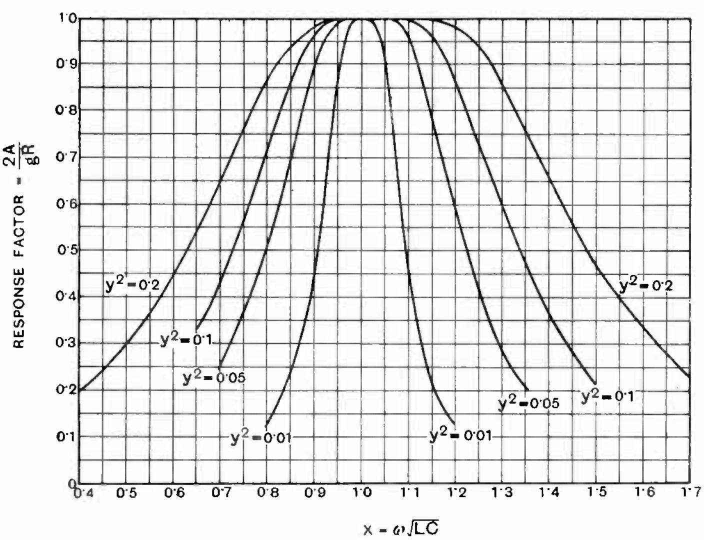

Fig. 3.

The steps in design are now straightforward and are tabulated below.

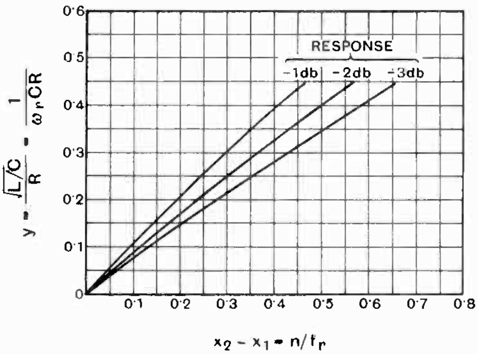

Fig. 4.

Knowing C_1, C_2, g, n, f_r and response at the edges of pass-band,—

(1) From Fig. 5 read off CR for the value of n required.

(2) $R_1 = CR/C_1$, $R_2 = CR/C_2$

(3) $A = g\sqrt{R_1R_2}/2$

(4) $L_1 = 1/\omega_r^2C_1$, $L_2 = 1/\omega_r^2C_2$

(5) $k = y/\sqrt{1+y^2} = 1/\sqrt{1+\omega_r^2C^2R^2}$

(6) $M = k\sqrt{L_1L_2}$.

In these equations, the practical units, amperes, volts, ohms, henrys, farads, and cycles per second are naturally employed.

As an example of the results to be expected the earlier example may be used, with $n = 3.0$ Mc/s, $g = 6.0$ mA/V.; response $= -3.0$ db. and $C = 25$ μμF. With a single circuit, $A = 12.62$.

If the coil capacitance be taken as 5 μμF, a probable figure, the circuit capacitances above total 20 μμF. With two circuits approximately one-half this figure is effective on each coil and the self-capacitance of each coil will be about 5 μμF. Consequently the effective capacitance in each circuit is about 15 μμF. or $C_1 = C_2 = C = 15$ μμF. Then from the above expressions we have

$$CR = 73{,}000\ \mu\mu\text{F-}\Omega$$
$$R_1 = R_2 = 4{,}860\ \Omega$$
$$A = 14.6.$$

Thus the use of a pair of coupled circuits results in a higher gain per stage as compared with a single circuit, better selectivity outside the pass-band for the same response at the limits of the band, and a flatter response near the centre of the pass-band. The advantages to be gained by using such circuits are thus considerable, especially when several stages of amplification are used.

Although it is theoretically possible to use such circuits in a radio-frequency amplifier, it seems doubtful whether satisfactory results would be secured at 45 Mc/s, the frequency of the Alexandra Palace vision transmitter. At this frequency the input resistance of the valves, due to electron transit time effects, is very low and is likely to be lower than the damping resistance needed. The stage gain and selectivity would thus be below optimum. Moreover, the input resistance varies with mutual conductance and hence with the setting of the gain control, if this functions in the usual way by varying the grid bias.

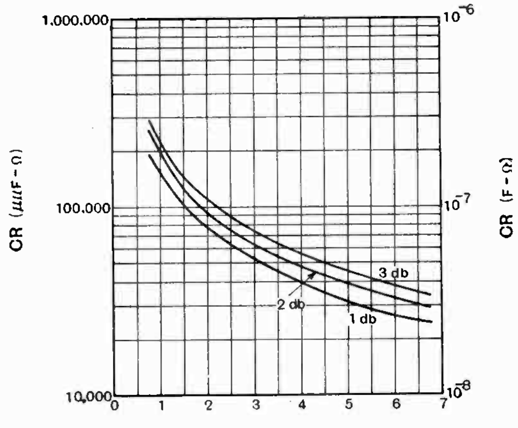

Fig. 5.

At very low intermediate frequencies n/f_r is large and consequently k is large; as a result there may be difficulty in constructing a transformer with tight enough coupling. When very tight coupling is needed, the coils may have to be overwound, or be in several interleaved sections. The capacitance between primary and secondary then seriously modifies the performance and in an incalculable manner. The design of the transformer must then be largely experimental.

At frequencies around 14 Mc/s, however, no difficulties in transformer design arise and it is usually possible to wind primary and secondary as single-layer coils end to end on the same former. At this frequency, moreover, the input resistance of the valve is reasonably high.

In the example quoted above, very little difference in gain is to be found between the two methods of coupling, for the single circuit gives an amplification of 12.62 and the double circuit 14.6. The difference is rather greater, however, if one chooses a smaller degree of attenuation at the edges of the pass-band as one would do in practice. For a 3 Mc/s band-width and 1 db. drop CR is 27,500 for a single circuit and 52,000 for two circuits; assuming the same circuit values as before, the stage amplifications are 6.6 and 10.4 respectively.

A total I.F. amplification of 3,000–6,000 times is often needed. Four stages with transformer coupling will give 11,650, but five stages with single circuit couplings will be needed for an amplification of 12,500.

It is clear that the advantage of the coupled circuits depends largely upon the self-capacitance of the coils used. The valve and stray circuit capacitance remain the same with both types of coupling, but the total capacitance on each tuned circuit is not half of that with a single circuit coupling because the coil capacitance is not split between primary and secondary but is transferred in its entirety to one circuit and there is an additional coil with its own self-capacitance in the other. The capacitance on each circuit is consequently generally greater than one-half of that with a single circuit coupling.

It is also clear that with neither type of coupling is it permissible to tune the circuits by means of capacitance trimmers, for these inevitably increase the circuit capacitance and reduce the stage gain. If the stray circuit capacitance can be relied upon to remain constant, the inductances can initially be adjusted for resonance by stripping turns. Otherwise an inductance trimmer must be used. This can take the form of spade tuning since efficiency is not important. Inductance trimmers are not, in general, easy to arrange with a pair of coupled circuits, but quite easy with a single circuit only.

The Behaviour of Resistors at High Frequencies*

By L. Hartshorn, D.Sc.

SUMMARY.—Howe's calculation of the effect of the distributed capacity of a resistor of the rod type on its resistance at high frequencies is verified by measurements made on resistors of nominal values ranging from 1,000 ohms to 1 megohm, at frequencies up to 100 megacycles per second.

IN his Editorial in *The Wireless Engineer* of June, 1935 (Vol. 12, p. 291) Prof. G. W. O. Howe has given a theoretical discussion of the behaviour of resistors of the short rod type at very high frequencies. He shows that the distributed self-capacitance of such a resistor, although very small, is not negligible, and that its value may be approximately calculated from the dimensions of the rod. For a typical rod of diameter say 1 mm. and length 2 cm., the value turns out to be about 0.12 $\mu\mu$F. per cm. length of the rod; that is to say, if we take two elements of the rod, each of length δl symmetrically placed with respect to its mid-point, the lines of electric force joining them are equivalent to those which would exist in a small condenser of capacitance 0.12 δl $\mu\mu$F. connected to the two elements. The capacitance is not, strictly speaking, uniformly distributed along the rod, but the distribution may be regarded as uniform to a first approximation, and it follows that the rod may be treated as a transmission line with a uniformly distributed resistance and capacitance. Prof. Howe shows that this method of treatment of the problem yields results of great practical importance to experimenters using such resistors for short-wave work. It shows that the effective resistance of such a rod must diminish with rise of frequency, and that a resistor of 1 megohm correctly adjusted at low frequencies may possess a value of only 0.1 megohm at frequencies approaching 100 megacycles. The fractional diminution of resistance is shown to be a function of the variable $flCR$, where f is the frequency, R the value at low frequencies, l the length of the resistor, and C the distributed capacitance per unit length, which depends only on the ratio of diameter to length of the rod. A curve showing the variation of resistance with this parameter is given, and from this curve the behaviour of any resistor of this type may be predicted.

The practical importance of this theory and its bearing on the design and use of resistors is obvious, and it is therefore very desirable that it should be verified by experiment. The results of experiments showing a diminution of resistance with rise of frequency had already been published,[1] but in a later Editorial (August, 1935) Prof. Howe stated that a comparison of experimental and calculated values had met with but little success. It was considered that the difficulties of the experiments might well account for the discrepancies, but the fact that alternative explanations, based on discontinuities in the material of the resistors have been offered, make it the more desirable that Howe's calculations should be verified, so that experimenters may use the curves and formulae with confidence.

During the last year or so measurements have been made at the National Physical Laboratory on resistors of the rod type, of values from 1,000 ohms to 1 megohm, and at frequencies up to 100 megacycles. It is now proposed to consider the results in the light of Howe's calculations, and to show that the latter fully account for the observed varia-

* MS. accepted by the Editor, December, 1937.

[1] O. S. Puckle, *Wireless Engineer*, 1935, Vol. 12, p. 303.

tions of resistance, provided due allowance is made for the effects of neighbouring apparatus.

Method of Measurement

In his reference to the experimental results previously available Prof. Howe emphasised the difficulties of the measurements. He was referring to measurements made on resistances of the order of a megohm at frequencies up to about 6 megacycles. As some of the measurements to be discussed were made at frequencies of ten times this value and even higher, at which frequencies the difficulties are correspondingly greater, a brief account of the method is perhaps desirable. A detailed account of the apparatus employed has been published elsewhere.[2] It takes the form of a self-contained test-set designed primarily for making measurements on dielectrics over the frequency range 0.01 to 100 megacycles. Essentially it consists of a screened coil, a variable condenser of the parallel plate type with micrometer adjustment, a small vernier condenser of the cylindrical type, also with micrometer adjustment, and a thermionic voltmeter, all connected in parallel to form a tuned circuit, which in use is loosely coupled to any convenient oscillator. The apparatus which is shown in Figs. 1 and 2 was specially designed to avoid errors due to stray capacities and to residual inductance and resistance in connecting leads; indeed, connecting leads are almost entirely avoided. The sensitive thermionic voltmeter, incorporating an anode-bend rectifying valve, compensating valve, reflecting galvanometer and batteries, is contained in a metal box, on the top panel of which is mounted the flat-plate tuning condenser, the insulation consisting of tubes of fused quartz. A hole rather more than an inch deep is bored in the edge of the insulated plate of the condenser, and into this hole the stem of a micrometer head projects, with a clearance of about 0.5 mm., thereby forming the cylindrical vernier condenser. Thus all the components of the circuit have a common screen or earth terminal, and the only connecting links in the system consist of short thick copper rods of a length not exceeding 3 cm. Connection to the moving plate of the tuning condenser is made by means of a copper bellows of about 4 cm. diameter and length 4 cm. Thus there are no variable resistances in the circuit, all the links have the minimum possible resistance and inductance, while the common screen gives freedom from stray capacities.

The measurements are made by the

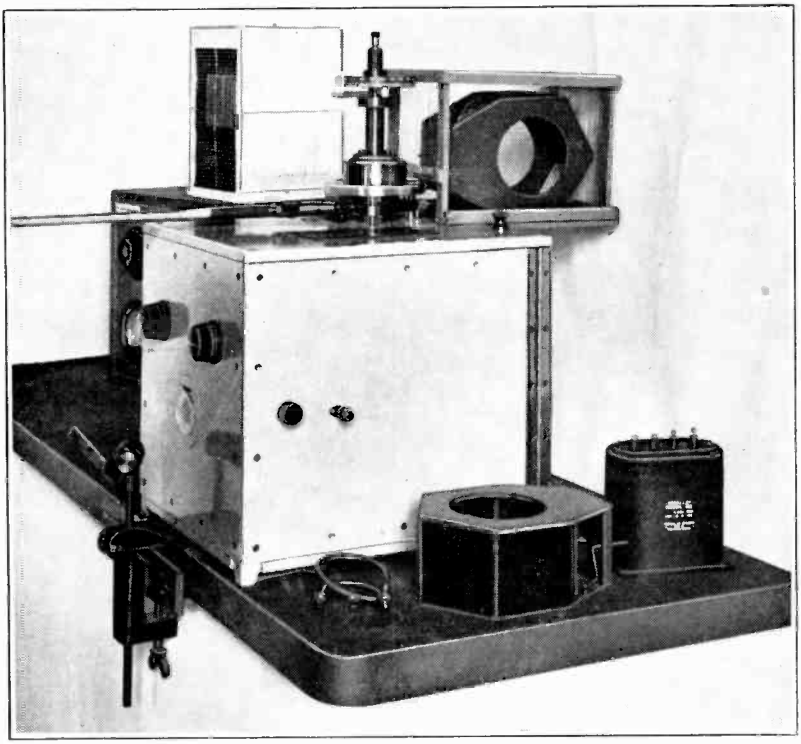

Fig. 1.
General assembly of apparatus.

[2] L. Hartshorn and W. H. Ward, *Journ. I.E.E.*, 1936, Vol 79, p. 597.

detuning or reactance variation method. Thus the parallel plate condenser is adjusted until resonance is roughly established using the thermionic voltmeter as detector. The final tuning is then carried out using the vernier condenser with distant control. The vernier condenser is then adjusted until the deflection is halved, and the two readings of the micrometer condenser giving this half-deflection are noted. Then it may be shown that if ΔC_0 is the difference between these two readings, we have

$$G_0 = \omega \times \Delta C_0/2 \quad \ldots \quad \ldots \quad (1)$$

where G_0 is the effective conductance of the whole circuit, including coil, condensers and voltmeter. The value of ΔC_0 may be obtained with high accuracy from the calibration of the micrometer condenser.

The resistor to be tested is now placed in parallel with the tuned circuit. Two terminals are provided for this purpose, one on the edge of each of the plates of the tuning condenser. Here again the connecting leads are reduced to a minimum. The above readings are now repeated, and the new value ΔC_i of the difference between the two condenser readings corresponding to the half-deflection determines the effective conductance of the whole circuit in the second condition (resistor in). If R' denote the effective resistance of the resistor at the frequency of the experiment, its conductance is given by $1/R'$, and evidently the conductance of the whole circuit in the second experiment exceeds that in the first by this amount.

Thus

$$G_0 + 1/R' = \omega \times \Delta C_i/2 \quad \ldots \quad \ldots \quad (2)$$

Subtracting (1) from (2), we eliminate the conductance of the test-circuit itself and obtain

$$R' = \frac{2}{\omega(\Delta C_i - \Delta C_0)} \quad \ldots \quad \ldots \quad (3)$$

Moreover, if C_i denote the reading of the micrometer condenser at resonance with the resistor in, and C_0 denote the corresponding reading with the resistor out, it is obvious that the difference $C_0 - C_i$ is equal to the effective self-capacitance C_m of the resistor at the frequency in question.

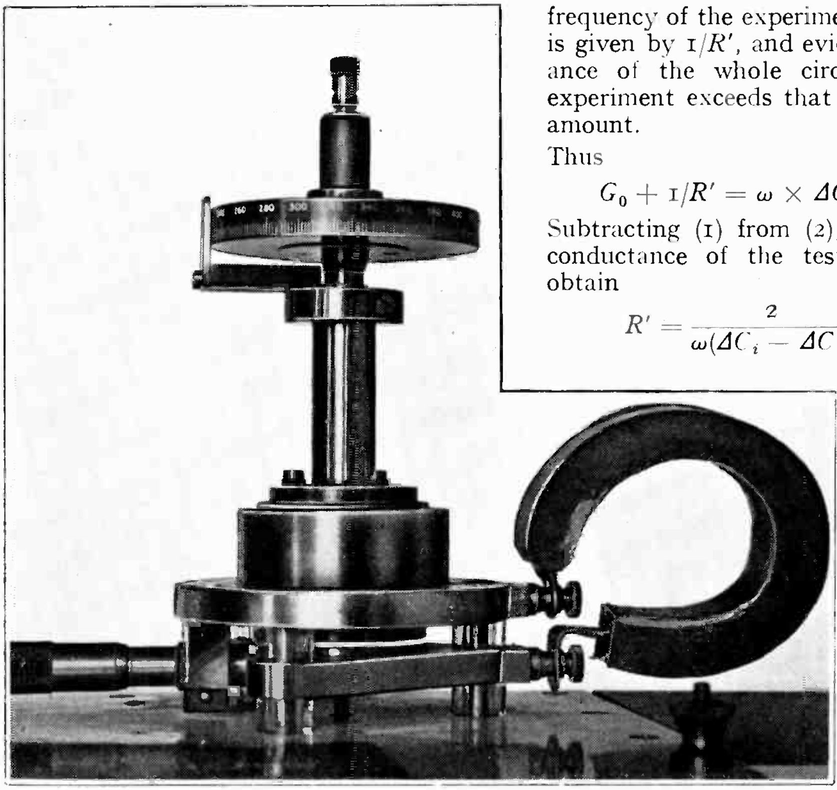

Fig. 2.—Close-up of micrometer condensers and screened tuning coil of one turn used at the very high frequencies.

$$C_m = C_0 - C_i \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

The possible sources of error are discussed in detail in the paper already quoted, but it may be pointed out that the method has the great advantages of simplicity and freedom from troublesome corrections. Moreover it requires no auxiliary standards, and the only change required on changing the frequency is a change of tuning coil.

Results

The apparatus described above may be used for measurements on chokes and condensers as well as resistors, and measurements made on a typical selection of all these components at frequencies up to 100 Mc/s have already been published.[3] The values obtained for the resistors are reproduced in Table 2, together with the additional data required for the purpose of comparing the values with those given by Prof. Howe's calculations.

Adopting Prof. Howe's notation, the length of the resistor (exclusive of terminal caps, etc.) is denoted by $2l$, and its diameter by d. R is its resistance with direct current and R' the effective value at any given high frequency f. The values are recorded by giving the value of R'/R corresponding to various frequencies. The effective self capacitance of the resistor measured as described above is denoted by C_m. Prof. Howe calculated the equivalent terminal capacitance of the resistor and denoted this quantity by C'. It is, however, important to remember that the measured C_m must exceed the calculated C' by the capacitance of the terminal caps C_t and connecting leads C_l. Thus

$$C_m = C' + C_t + C_l \quad \ldots \quad \ldots \quad (5)$$

Moreover, the calculated value of C' refers to an isolated rod. Actually, neighbouring apparatus and leads will distort the electric field of the rod and thereby affect the value of C' by an amount which it is almost impossible to calculate. In order to minimise this effect, one might be tempted to place the resistor at a considerable distance from the remainder of the apparatus, but this would necessitate the use of long leads which would not only increase the value of C_l, but would introduce inductance which would be very troublesome at high frequencies. The leads to the resistor were actually made as short as possible on this account, and we are therefore faced with the difficulty that the calculated value of C' must be modified to an unknown extent by the proximity of the measuring circuit. This difficulty was dealt with in the following way. Let C_d denote the total distributed capacitance of the resistor including that between the various elements of the resistor and neighbouring apparatus as well as the quantity lC calculated by Prof. Howe. Let us further assume that this additional capacitance is also uniformly distributed. Then if we replace lC in Prof. Howe's calculations by C_d they will take into account the proximity effect. In order to evaluate C_d we notice from Prof. Howe's calculations that although C' diminishes with rise of frequency at high frequencies, it approaches a constant value C'_0 at low frequencies, and this constant value is equal to $C_d/3$. Thus

$$C_d = 3C'_0 \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

Now C' may be determined from (5), for C_m is observed, the terminal capacitance C_t may be approximately calculated from

[3] L. Hartshorn and W. H. Ward, *Journ. Scient. Instr.*, 1937, Vol. 14, p. 132.

TABLE 1.

LINEAR DIMENSIONS AND VALUES OF CAPACITANCE.

Resistor No.	Type	$2l$ cm	d cm	C_t μμF.	C_l μμF.	C_{m0} μμF.	C'_0 μμF.	C_d μμF.	C_d/l μμF/cm.
1	A	1.5	0.5	0.03	0.05	0.43	0.35	1.05	1.4
2	B	4.5	0.1	0.10	0.04	0.29	0.15	0.45	0.20
3	A	4.5	1.0	0.03	0.04	0.59	0.52	1.56	0.69
4	A	1.5	0.5					1.0	1.4
5	A	3.0	0.8					1.4	0.9
6	B	4.5	0.1	0.10	0.04	0.22	0.08	0.24	0.11
7	A	1.5	0.5					1.0	1.4
8	A	3.0	0.8					1.4	0.9
9	A	1.5	0.5	0.03	0.05	0.32	0.24	0.72	0.96
10	B	4.5	0.1	0.10	0.04	0.32	0.18	0.54	0.24
11	C	3.0	0.5	0.03	0.04	0.48	0.41	1.23	0.82

A = Solid rod without terminal caps. Leads encircle ends.
B = Film on glass rod, enclosed by porcelain tube. Terminals : metal caps of diameter 0.8 cm.
C = Spiral film on porcelain tube. Terminals : metal caps of diameter 0.6 cm.

the dimensions of the terminals and resistor, and the leads capacitance C_l may be measured separately. In this way Prof. Howe's parameter $flCR = fC_dR$ becomes known for the conditions of the experiment and the corresponding value of R'/R may be read from the curve in his Fig. 8. The calculated values of R'/R given in Table 2 were obtained in this way.

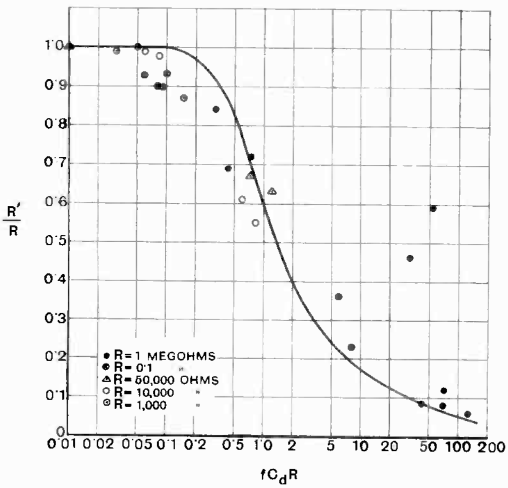

Fig. 3.—*Howe's curve and the observed values.*

Table 1 gives the auxiliary data. The capacity of the terminals of the resistor C_t was in each case approximately calculated from the dimensions, the formula for two spheres in air being applied. The calculated value for type B was doubled in order to allow for the effect of the porcelain cylinder. The leads-capacity C_l was estimated from the results of separate measurements made on short lengths of wire similar to those used with the resistors. The measured values of self-capacity C_m are given in Table 2. It is to be noted that they diminish with rise of frequency in accordance with Howe's Fig. 7. The limiting value of this quantity at low frequencies, C_{m0} given in Table 1, is deduced from the observed values in Table 2. In some cases the value given is slightly greater than the largest value actually observed. In these cases the necessary correction has been deduced from Howe's Figs. 7 and 8 considered in relation to the observed value of R'/R. The correction is, however, small. C'_0 is obtained from C_{m0} by means of equation (5) and C_d is then obtained by (6). Howe's parameter fC_dR and the calculated value of R'/R are then immediately obtained, as previously explained.

Inspection of Table 2 shows that, except for resistor No. 10 at frequencies of 60 and 100 Mc/s, Howe's calculation accounts for all the results within the probable errors of calculation and experiment. The results are plotted in Fig. 3, together with Howe's calculated curve. This diagram brings out clearly the very wide range of conditions covered by the experiments, and leaves no doubt that the observed diminution of resistance is almost entirely due to the distributed self-capacity of the rod. It is possible that the variations of resistors of low value, 1 and 3, are due to inhomogeneity

TABLE 2.

Resistor No.	R.	Frequency f.	C_m.	fC_dR.	R'/R Observed.	R'/R Calculated.
	ohms.	Mc/s.	$\mu\mu$F.			
1	1,000	0.6		0.00	0.98	1.00
		60	0.43	0.06	0.93	1.00
		100	0.40	0.10	0.93	1.00
2	1,000	0.6	—	0.00	0.98	1.00
		60	0.29	0.03	0.99	1.00
		100	0.22	0.05	1.00	1.00
3	1,000	0.6	—	0.00	0.98	1.00
		60	—	0.09	0.90	1.00
		100	0.59	0.15	0.87	0.98
4	10,000	0.6	—	0.01	0.99	1.00
		60	—	0.6	0.61	0.77
5	10,000	0.6	—	0.01	0.98	1.00
		60	—	0.84	0.55	0.65
6	50,000	0.6	—	0.01	1.00	1.00
		60	0.22	0.72	0.67	0.71
		100	0.21	1.2	0.63	0.55
	megohms					
7	0.1	0.6	—	0.06	0.93	1.00
		60	—	6.0	0.36	0.22
8	0.1	0.6	—	0.08	0.90	1.00
		60	—	8.4	0.23	0.19
9	1.0	0.6	0.26	0.43	0.69	0.86
		60	0.13	43	0.094	0.09
		100	0.10	72	0.070	0.06
10	1.0	0.6	0.29	0.32	0.84	0.91
		60	0.21	32	0.46	0.10
		100	0.17	54	0.59	0.08
11	1.0	0.6	0.44	0.74	0.72	0.70
		60	0.28	74	0.120	0.06
		100	0.21	120	0.060	0.05

NOTE.—Some of the values of R, the D.C. resistance, differed from the nominal values given by as much as 5 per cent., but the actual values were used in the derivation of R'/R.

of the material, as suggested by Puckle, but the effect is very small compared with those observed with the resistors of higher value. The behaviour of resistor No. 10 is anomalous. It agrees with the calculations at 0.6Mc/s, but at the high frequencies the values of resistance are unexpectedly high. Skin effect immediately suggests itself, but it is difficult to substantiate such an explanation. Possibly this resistor was imperfect in construction—the conducting film may be very uneven or there may be a bad contact at a terminal.

The last column of Table 1 gives the distributed capacity per unit length of rod for each resistor. The observed and calculated values of this quantity are as follows :—

$2l/d$.	Capacity per unit length : $\mu\mu$F. per cm.	
45	0.18	Deduced from observations.
6	0.82	
3	1.0	
20	0.12	Howe's calculated values.
10	0.17	

The experimental and calculated values are of the same order but the calculated values are definitely low. As previously explained, this is due to the fact that in practice the leads and neighbouring apparatus also contribute to the distributed capacitance. The present experiments give an idea of the magnitude of this effect, and it is suggested that the above values, together with Howe's curves, will enable the performance of any resistor to be calculated with all the accuracy that is likely to be required in ordinary practice.

With regard to the accuracy, it should be noticed that the mean deviation of the observed values of R'/R from those calculated amounts to 8 per cent. of the low frequency value (R) if resistor No. 10 is included, and 6 per cent. if No. 10 is excluded. Since the calculations assume a uniform distribution of capacitance, which cannot be strictly true, a closer agreement could not be expected. On the whole, the observed values tend to be the smaller, and if the signs of the deviations are taken into account, the observed values are on the average 3 per cent. lower than the calculated ones. Thus the effect of inhomogeneities of the conducting film is not likely to be greater than this, while the effect of distributed self-capacity may be as large as 94 per cent.

Not only do the comparisons strengthen our knowledge of the behaviour of resistors at high frequencies, but they also afford valuable confirmation of the accuracy of the method of measurement and apparatus employed.

The measurements recorded were made by Mr. W. H. Ward, and it will be clear that the accuracy obtained at the very high frequencies could not have been achieved without the exercise of considerable skill on his part.

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

Binaural Reproduction

To the Editor, The Wireless Engineer.

SIR,—I have recently been conducting some experiments on binaural reproduction by means of earphones and have obtained some results which do not seem to tally with the accepted explanation.

The system used consists of two moving coil microphones, two amplifiers and a pair of moving coil headphones, the two channels being identical in characteristic and sensitivity.

The reproduction was of course very fine indeed and can easily be mistaken for the original, but although direction was accurately reproduced, sense was entirely lacking. Further to this, all sense appeared in the hemisphere behind the head and no amount of changing of phases and amplitude of the two channels could make a sound appear in the front hemisphere.

On considering this, it seems that a two-phase system is insufficient to reproduce sound in amplitude, direction and sense, and that a three-phase system is necessary to convey this information. Where, then, does this third sense exist and what form does it take ?

Resulting from a few simple tests on myself and others, it seems that unless there is very good reason to suppose that the sound originates from the front hemisphere, such as touch, sight or experience, then the brain interprets the sound as originating from behind.

I have not seen in any of the literature a satis-

factory explanation of this point and I should be interested to hear the suggestions and comments from your readers. HAROLD K. ROBIN.
London, S.W.16.

Spherical Circuits

To the Editor, The Wireless Engineer.

SIR,—In the March editorial you point out "that the wavelength will be proportional to the linear dimensions if spherical circuits are constructed of exactly the same geometrical proportions, since both the inductance and the capacitance will be strictly proportional to the linear dimensions."

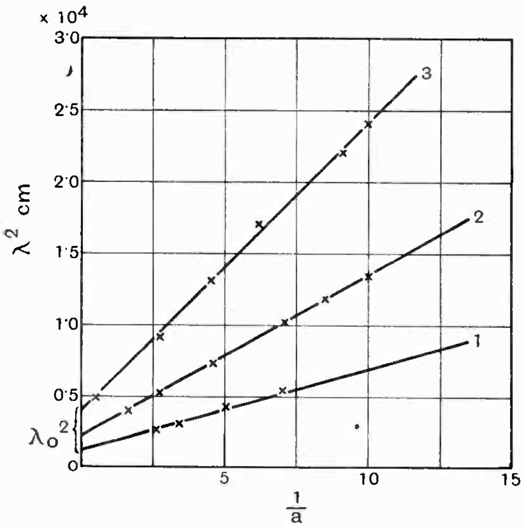

Fig. 1.

In my experiments I did not find that this condition was fulfilled, probably due to various disturbing influences, *e.g.* the limited capacitance of the blocking condenser in the axial tube, various stray capacitances, and, at very high frequencies, the appreciable effects of even the shortest leads.

In order to investigate the relation between the dimensions of the spherical circuit and its natural frequency I have made a number of measurements on five circuits with no blocking condenser in the axial tube, the circuits being separately excited and thus free from valve connections and leads. Their dimensions in cm. were as follows :

Circuit No.	1	2	3	4	5
D_s	3	4	5	10	15.5
D_f	5.4	7.2	9	18	28
d	0.4	0.5	0.6	1.3	1.3

D_s and D_f are the diameters of the spheres and flanges respectively, and d that of the axial tube. $D_f/D_s = 1.8$ in all cases. These circuits cover a range of wavelengths from 50 to 400 cm. In Fig. 1 the square of the natural wavelength is plotted against the reciprocal of the distance a between the flanges. Assuming L to remain constant and C_f, the capacitance between the flanges, to be proportional to $1/a$, both very nearly true for small values of a, these results may be represented by the formula $\lambda^2 = 4\pi^2 LC_f + \lambda_0^2$, where

$$C_f = \frac{A}{4\pi a} = \frac{1}{16}\frac{D_f^2 - D_s^2}{a} = \frac{1}{16}\cdot\frac{D_s^2}{a}(f^2 - 1)$$

where $f = D_f/D_s$.

Knowing that the magnetic flux is confined within the sphere, it can be shown that

$$L = \frac{\pi}{2}\cdot D_s \cdot \text{logn}\frac{D_s}{d}.$$

λ_0 in Fig. 1 is approximately equal to $4\pi D_s$. Substituting these expressions in the above formula for λ gives

$$\lambda = 4\pi D_s\sqrt{\frac{2.45}{100}\cdot\frac{D_s}{a}\cdot(f^2 - 1)\,\text{logn}\frac{D_s}{d} + 1}\ \text{cm}.$$

Thus if one enlarges a spherical circuit, keeping its geometrical proportions D_s/a, D_s/d and f constant,

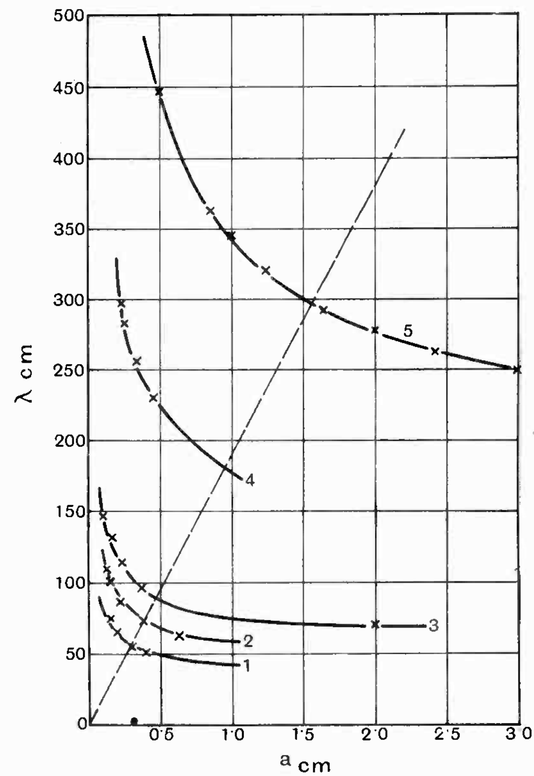

Fig. 2.

the quantity under the root remains constant and the natural frequency is proportional to D_s. For example, if $f = 1.8$, $D_s/d = 10$ and $D_s/a = 10$, $\lambda = 19D_s = 190\ a$.

In Fig. 2 the results are plotted as wavelengths to a base a. The curves are calculated from the above formula and the points are experimental; they lie very well on the curves. The straight line through the origin corresponds to the factor 190 in the above example; it cuts the various curves for values of a approximately proportional to the corresponding values of D_s.

I hope that I have thus provided a more detailed discussion of the resonance conditions in spherical circuits. H. E. HOLLMANN.

Ultra-Short and Decimetre-Wave Valves

To the Editor, The Wireless Engineer

SIR,—In his article on "Ultra-short and Decimetre Wave Valves" in *The Wireless Engineer* of April, p. 198, Mr. F. M. Colebrook develops a formula for the equivalent input shunt resistance which is fundamentally equivalent to Benner's formula[1] for the high-frequency conductance of a condenser through which a stream of electrons passes. After we had for the first time generalised the laws governing the ultra-dynamic longitudinal control of any stream of electrons[2] we considered the dynatron and magnetron and finally the cathode-ray tube in which the control is purely transverse, and developed for this the function which Bakker and de Vries[3] had originally obtained for longitudinal control, viz.:

$$\Theta_{(4)} = \frac{6}{(j\omega\tau)^3}[j\omega t - 2 + (j\omega t + 2)e^{-j\omega t}]$$

With this we obtain for the plate resistance

$$R = -\frac{6\,md^2}{Iq\omega^3}\cdot\frac{1}{\text{Imag. part of }\Theta_{(4)}}$$

$$= -\frac{m\omega^2 d^2}{Iq}\cdot\frac{1}{2\cos\omega\tau + \omega\tau\sin\omega\tau - 2}$$

$$= \frac{m\omega^2 d^2}{4Iq}\cdot\frac{1}{\sin\frac{\omega\tau}{2}\left(\sin\frac{\omega\tau}{2} - \frac{\omega\tau}{2}\cos\frac{\omega\tau}{2}\right)}$$

Here, m, q = mass and charge of an electron.
I = beam current.
τ = transit time between plates.
$= l/u$ = length of plates/velocity.
$\omega\tau$ = "transit angle."
d = distance between plates.

This expression is fundamentally different from that of Mr. Colebrook in that it gives both positive and negative values of resistance, so that the electron beam may not only abstract energy from the condenser field, *i.e.*, damp it, but also give energy to it, whereby the cathode-ray tube may act as a generator of ultra-short waves. Our formula for R has an infinite upper limit when ω tends to zero;

$$\underset{\omega\to 0}{Lt.}\ R = Lt.\frac{3\,md^2}{Iq\omega^3\{1 + \omega^2(\ldots\ldots)\}}$$
$$= \text{infinity}.$$

In the meantime our theory has been substantiated by Recknagel[4] notwithstanding the objections raised by Gundlach and others.[5] (See the Abstract No. 1353, *Wireless Engineer*, April, 1938.) Recknagel gives the following formula for the complex plate capacitance:

$$C' = \frac{1}{2}\cdot\frac{1}{\frac{m}{2q}u^3}\cdot\frac{l^3}{d^2}\cdot\frac{1}{(j\omega t)^3}[j\omega t - 2 + (j\omega t + 2)e^{-j\omega t}]$$

which also contains the function $\Theta_{(4)}$, and the real part of which also gives the above expression for the input shunt resistance R. Whereas we, in order to link up the longitudinal and transverse control, adopted a method based on the introduction of the alternating transit time τ_a, Recknagel adds to the current integral $\frac{I}{d}\int \dot{y}d\tau$ the integral $-\frac{I}{d}y_A$ where y_A is the transverse displacement of the beam on emergence from the condenser field and which takes into account the return of the electron to the zero potential existing outside the condenser.

The advantage of the smaller load on the control voltage with transverse as compared with longitudinal control which Colebrook mentions, is consequently greater than he assumes, because the working conditions can be easily so adjusted that the input shunt resistance is infinitely high or even negative.

H. E. HOLLMANN.
Berlin-Lichterfelde. A. THOMA.

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[2] Hollmann and Thoma: *Zeit. f. Hochfr. u. Elek Akus.*, 49 (1937), pp. 109 and 145.
[3] Bakker and de Vries: *Physica*, 7 (1935), p. 683.
[4] Recknagel: *Zeit. für Tech. Physik*, 19 (1938), p. 74.
[5] Brüche, Gundlach and Recknagel: *Z.f. Hochf. u. El. Akus*, 50 (1937), p. 205.

N.P.L. Director

THE Lord President of the Council has appointed Professor R. H. Fowler, O.B.E., M.A., F.R.S., at present Plummer Professor of Applied Mathematics in the University of Cambridge, to be Director of the National Physical Laboratory with effect as from 1st October, 1938. Professor Fowler will succeed Dr. W. H. Bragg, who has been elected to the Cavendish Professorship of Experimental Physics in the University of Cambridge.

Institute of Physics

THE Annual General Meeting of the Institute of Physics was held on Wednesday, May 25th last. The following were elected to take office on October 1st, 1938: *President*, Dr. C. C. Paterson; *Vice-President*, Mr. T. Smith; *Honorary Treasurer*, Major C. E. S. Phillips; *Honorary Secretary*, Professor J. A. Crowther; *New Members of the Board*, Dr. J. D. Cockcroft and Mr. E. B. Wedmore.

The Response of a Valve Generator to a Modulating Voltage*

The Approximate Solution of a Non-linear Problem

By E. B. Moullin, M.A.

SUMMARY.—This paper contains an approximate solution of the problem of the response of a valve generator to modulation at high acoustic frequencies: it is an approximate solution of a certain non-linear problem.

The effects discussed can be appreciable only when the generator circuit has a very small power factor. In such circumstances it is shown that each radio-frequency cycle of anode potential cannot differ appreciably from a sine curve, even though the curvature of the valve characteristic produces large harmonic components of anode current.

The solution depends on the use of the fundamental component of valve resistance; this resistance is a function of the sinusoidal radio-frequency fluctuations of anode potential, in given operating conditions.

A method of measuring the fundamental component of valve resistance is given and also a typical curve obtained experimentally. An appendix shows that the general form of this curve follows readily from the known shape of the valve characteristic.

It is shown that the circuit behaves as a non-inductive resistance whose magnitude fluctuates at the modulation frequency and by an amount depending on the fractional depth of the modulation. The condition of oscillation is that the resistance of the circuit should at all times be equal and opposite to the fundamental component of resistance of the valve. Given the resistance-amplitude curves of the valve and the resistance-modulation curve of the circuit, the solution can be found by a graphical process. To illustrate the method the resistance-amplitude curves are treated as straight lines, which is justifiable as a first approximation. This leads to a simple algebraic expression for the depth of modulation in terms of that which would obtain if the modulation were very slow. Thus is found the amount of *side band cutting* produced by the valve.

1. Introduction

WHEN a modulated electromotive force acts in a lightly damped resonant circuit it produces a current whose modulation is less than that of the E.M.F. This effect is well-known to all communication engineers, and is due to the inertia or *persistence* of the system; it is analysed by decomposing the E.M.F. into a carrier frequency and two side bands. An effect of the same character must be present in a valve generator whose output is being modulated by any method. Thus if the unmodulated output current of such a generator is proportional to the mean anode potential, then if this potential fluctuates harmonically by, say, ± 50 per cent. from some mean value, the fluctuations of output current will be less than 50 per cent. This paper attempts to express the modulation of current in terms of the frequency of the modulating voltage. An exact analytical solution is impossible because the curvature of the tube characteristic involves a non-linear differential equation whose explicit solution is not known. This problem is one of a large class which tends to become increasingly important in electro-technics. Since the mathematical tool available at present cannot cope with the essential operations, it is necessary to moderate our demands to something which can be dealt with. If, however, the final result is to be a helpful solution of some real problem, considerable thought and knowledge is required in order to choose which concessions to make. Here our first concession is to consider the circuit and the tube as two separate entities: to examine the behaviour of each in given circumstances and attempt therefrom to predict how they will behave when they form a self-contained system.

* MS. accepted by the Editor, December, 1937.

The circuit diagram of a simple valve generator is shown in Fig. 1. In this the battery B_a represents the main supply of energy and the alternator V_m represents the means of modulating the output: the *anode tap* is simulated by dividing the inductance into two parts L and l, having resistances R and r. Various well-known second-order effects will be ignored to the extent of expressing the carrier frequency $p_0/2\pi$ by the equation $p_0^2C(L + l) = 1$: the power factor F is defined by the relation $F = (R + r)p_0C$.

2. Behaviour of the Circuit

We shall impose the restriction that the circuit power factor is small. This important restriction will not curtail the usefulness of our solution appreciably, because in practice F will always be small and if it were not the effect we are examining would be small.

The current entering the circuit can be written as the Fourier series

$$i = I_1 \cos p_0t + I_2 \cos (2p_0t + \lambda_2) + I_3 \cos (3p_0t + \lambda_3) \ldots,$$

where I_1, and no doubt I_2, etc., are modulated. Consider first the case where modulation is not present and a circuit in which l is zero. If V_1, V_2, V_3, etc., are the amplitudes of the harmonic components of P.D. across the circuit due to I_1, etc., then it is well known that

$$V_1 = \frac{pL}{F} I_1,$$

$$V_2 \doteqdot \frac{2}{3} pLI_2,$$

$$V_3 \doteqdot \frac{3}{8} pLI_3,$$

$$V_n \doteqdot \frac{1}{n} pLI_n.$$

Hence $$\frac{V_n}{V_1} \doteqdot \frac{F}{n} \frac{I_n}{I_1} \quad \ldots \quad (1)$$

In our problem it is safe to say that I_n/I_1 is always less than unity (and if n is greater than, say, 4 then $I_n/I_1 \ll 1$). Then if F is of the order of 1 per cent., it follows that V_n/V_1 cannot be larger than about 0.5 per cent. and is likely to be much less. This fortunate result must never be forgotten; it is this property of the circuit which allows an approximate solution to be substantially correct. If l is not zero, the value of V_n/V_1 will be less than that given by (1), provided that $\frac{l}{L + l} < \frac{1}{n^2}$: in particular V_2 will be sensibly zero if $l/L = 1/3$ and $V_3 = 0$ if $l/L = 1/10$. It is easy to devise a network (see for example Bibliography 1, p. 193) in which any number of harmonic voltages are reduced to zero. Thus the existence of l in series with C, in other words the position of the anode tap, does not restrict the conclusion that harmonic voltages are probably less than 1 per cent. of the fundamental. When the fundamental component of current is modulated, so that

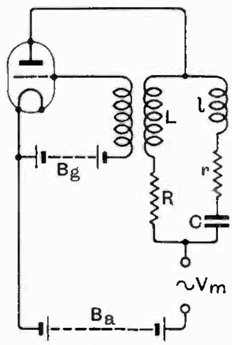


Fig. 1.

$$i = I_1(1 + M \cos \omega t) \cos p_0t, \quad \ldots \quad (2)$$

then the carrier and two side band frequencies are present. Denote ω/p, the fractional modulation frequency, by α: in practice we are concerned only with values of α which are much less than unity, and probably less than 1/10. If Z is the impedance of the circuit to frequency $p/2\pi$, where $p/p_0 \doteqdot 1$, it is well known that

$$Z \doteqdot \frac{\frac{L}{L + l} \cdot p_0L}{F + 2j\alpha}, \text{ if } \frac{R}{L} \doteqdot \frac{r}{l}, \quad \ldots \quad (3)$$

$$\text{and } |Z| = \frac{\frac{L}{L + l} \cdot p_0L}{\sqrt{F^2 + 4\alpha^2}}. \quad \ldots \quad \ldots \quad (3a)$$

It follows from (3) that the voltage across the circuit is expressed by the equation

$$v = \frac{L}{L + l} \frac{p_0LI_1}{F} \left\{ 1 + \frac{MF}{\sqrt{F^2 + 4\alpha^2}} \cos (\omega t - \beta) \right\} \cos p_0t \quad \ldots \quad (4)$$

$$= \frac{L}{L + l} \frac{p_0LI_1}{F} \{1 + m \cos (\omega t - \beta)\} \cos p_0t \quad (4a)$$

$$\text{where } m = \frac{MF}{\sqrt{F^2 + 4\alpha^2}}$$

It follows from (2) and (4) that

$$\frac{v}{i} = R' = \frac{L}{L+l}\,\frac{p_0 L}{F}\,\frac{\left\{1 + \frac{MF}{\sqrt{F^2+4\alpha^2}}(\cos\omega t - \beta)\right\}}{1 + M\cos\omega t} \quad \ldots \quad (5)$$

which shows that the circuit behaves as though it were a non-inductive resistance R', which varies cyclically with fundamental frequency $\omega/2\pi$. We may now drop the complication of the anode tap by putting $l = 0$, having introduced it only to show that its existence has no essential bearing on the problem. In this problem it is more convenient to work in terms of modulation of anode potential, rather than of anode current. Also our problem is of interest only when $2\alpha/F \gg 1$, for otherwise the effect we wish to study will certainly be negligible. Hence omitting l and substituting for M in terms of m from (4) and (4a), we then have

$$R' \doteqdot \frac{p_0 L}{F}\,\frac{1 + m\sin\omega t}{1 + \frac{2\alpha m}{F}\cos\omega t} \quad \ldots \quad (6)$$

$$\doteqdot \frac{p_0 L}{F}\left(1 - \frac{2\alpha m}{F}\cos\omega t\right), \text{ when } M \ll 1 \quad (6a)$$

3. Behaviour of the Tube

It follows from the last section and equation (1) that the radio-frequency component

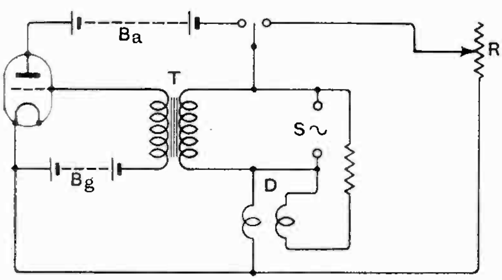


Fig. 2.

of anode potential must be sensibly simple harmonic; this simple harmonic amplitude being modulated at an acoustic rate. Provided the periodic time of the circuit is considerably greater than the transit time of electrons from cathode to anode, a thermionic tube has no inherent phase angle: the anode current at any instant depends only on the value at that instant of the lumped voltage ($V_l = V_a + \mu V_g$), and not on its rate of change.

Since the fluctuations of grid voltage are sensibly (and can readily be made precisely) in antiphase with fluctuations of anode voltage, it follows that the instantaneous value of anode current depends only on the instantaneous value of anode potential, for a given value of B_g and grid coupling. The anode current can be analysed into a Fourier series, each term of which is modulated; the second, third, fourth, and, say, fifth harmonic of current are not necessarily very small compared with the fundamental.

First consider the generator working steadily without modulation: there will be a fundamental component of anode current, but I_1 is not proportional to V_1, since the tube characteristic is not straight. But for a given value of V_1 (in given conditions of B_a, B_g, etc.), the ratio $V_1/I_1 = R_1$ is unique and is the fundamental component of effective resistance of the tube and is negative. Since there is no applied alternating voltage, the condition for maintenance of oscillation is that

$$R_1 + R' = 0 \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

The concept of fundamental component of tube resistance is essential to this solution: however, it does not remain an analytical abstraction for it is a quantity readily measured by the help of a dynamometer ammeter. Thus, referring to Fig. 2, T is a transformer with a closed iron core having a suitable variety of turns-ratio. S is a sensibly sinusoidal source of voltage at, say, 50 c/s. This is connected to the input winding of T and also supplies current to one winding of a dynamometer ammeter D. The suspended coil of the dynamometer carries the anode current of the tube. This system superposes a sinusoidal fluctuation of voltage on the mean anode potential provided by B_a: the transformer T superposes a suitable fraction of this alternating voltage on the mean grid potential provided by B_g, the sense of the winding being such as to make the two voltages in antiphase with one another. The deflection of the dynamometer D is produced only by the fundamental component of anode current, since the harmonic components give no net effect. For any given value of alternating voltage, the deflection of D is noted: then the two-way switch is turned to the right and R_1 is adjusted until the same deflection results. (*Note:* Since the tube has a negative resistance, one deflection will be to the right and one to the left; it is convenient to arrange the switch so that its motion also reverses the sense of either coil of D.) When the two deflections have been matched, the value of R_1 is equal to the fundamental component of tube resistance, appropriate to the alternating voltage in use. By this means it is a simple process to obtain a curve connecting R_1 with *anode swing* for the given conditions of B_a, B_g, and grid coupling ratio. (*Note:* This method was used previously by D. A. Bell, see Bibliography 3, Figs. 2 and 4.) Such a curve is typified by Fig. 3, which was obtained experimentally from a small triode (Osram R5V). The general trend of these curves follows readily from the characteristic and an elementary Fourier analysis; such as that outlined in the appendix. The very sudden rise of resistance when the *anode swing* exceeds a certain value is due to the instantaneous potential of the anode becoming less than that of the grid: the resulting secondary emission causes a marked decrease of anode current. The inception of this condition imposes a sharp maximum on the output obtainable from the tube. Suppose this tube were functioning as an oscillator with a circuit whose *rejector* resistance was 20 $k\,\Omega$. Then with the given grid coupling and bias, reference to the figure will show that the R.M.S. anode voltage would be 105 with $B_a = 220$ V, or 80 with $B_a = 160$: thus the output voltage would be sensibly proportional to B_a. When a radio-frequency generator is being modulated at an acoustic rate, we may regard the mean anode potential as sensibly constant during many radio-frequency cycles, but changing slowly at the acoustic rate. Thus if the generator to which Fig. 3 refers had an anode battery of 190 V and a very slow modulation of $\pm$ 30 V peak, the output voltage would change slowly by $\pm$ 12.5 V from its mean value of 92.5; the fractional modulation thus being 12.5 per cent. If, however, the modulation frequency ω, though much less than p_0, is sufficient to make $2\omega/p_0 > |F|$, then by equation (6) the apparent *rejector* resistance of the circuit will change appreciably during the cycle of ω. Hence the *swing* of anode voltage must now be found from the intersections with the curves of horizontal lines,

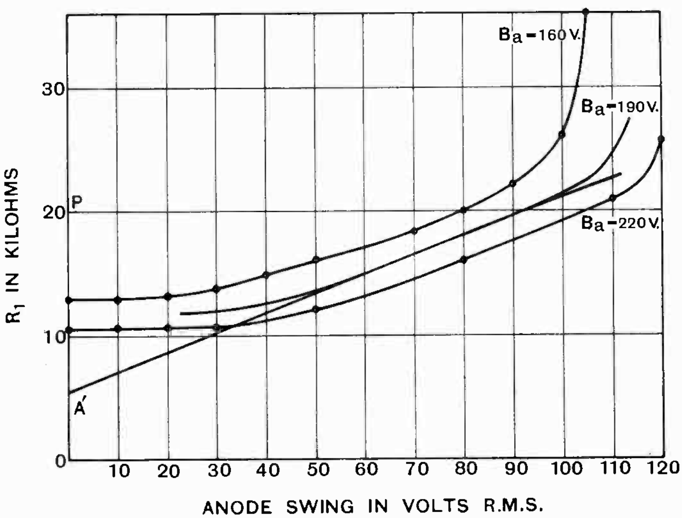


Fig. 3.

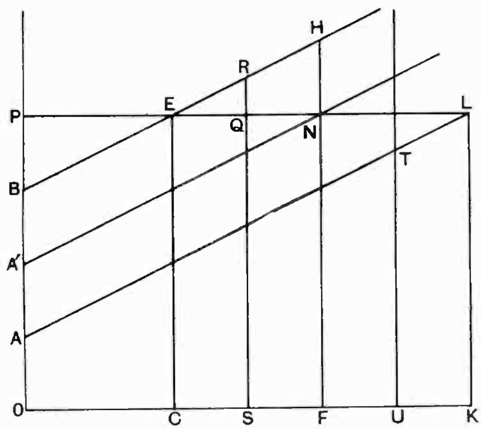


Fig. 4.

above and below that for the mean resistance, namely 20 $k\Omega$ in Fig. 3. Since, however, the value of m which will obtain in these circumstances is not known, these lines cannot yet be drawn.

4. Approximate Value of the Resulting Modulation

If the relevant family of resistance curves is available, the solution can be found graphically. It is, however, simpler to illustrate the process by taking the resistance curves as straight lines. This yields a simple algebraic expression which is a limiting value for small amplitudes. Thus let BH and AL in Fig. 4 represent the curves connecting R_1 and V (for given B_a, B_g and coupling) for the two extremes of slowly changing anode potential. Thus if the modulating voltage in series with B_a be $V_M \sin \omega t$, then AL is the curve connecting R_1 and V for steady anode potential $B_a + V_M$, and BH for $B_a - V_M$. Let $PENL$ be the *rejector* resistance line of the circuit when not modulated. Then if $2\omega/p_0 \ll F$, the output voltage will fluctuate between OC and OK and for such slow modulation.

$$m = \frac{CF}{OF} = \frac{EN}{PN}.$$

If the modulation frequency is such that $2\omega/p_0 \gg F$, the modulation of output will have a smaller value m', such that

$$m' = \frac{SF}{OF} = \frac{QN}{PN}.$$

In other words, the rejector resistance R' has fluctuated between RS and TU about its mean value NF.

$$\text{Since } R' \doteqdot \frac{p_0 L}{F}\left(1 - \frac{2\alpha m}{F}\cos\omega t\right) \quad \ldots \quad (6a)$$

$$\text{it follows that } \frac{QR}{QS} = \frac{2\alpha m'}{F} \equiv xm'$$

$$= x\frac{QN}{PN} \quad \ldots \quad (8)$$

It is now necessary to ascertain the position of the point Q to satisfy the condition (8) for an assigned value of x.

To do this, take a point V on OP, such that $\frac{VP}{OP} = x$: join VN cutting BH in R (see Fig. 5). Then

$$\frac{QN}{QR} = \frac{PN}{PV} = \frac{PN}{PO} \times \frac{1}{x}$$

$$\therefore \quad x\frac{QN}{PN} = \frac{QR}{PO} = \frac{QR}{QS} \quad \ldots \quad \ldots \quad (9)$$

hence Q is determined according to (8).

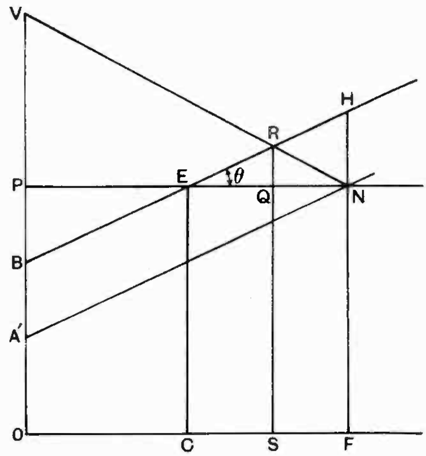


Fig. 5.

$$\text{Now } QR = EQ \tan\theta$$

$$= (EN - QN)\tan\theta$$

$$= \left(EN - \frac{1}{x}\cdot\frac{QR}{QS}.PN\right)\tan\theta, \text{ from (9)},$$

$$\therefore \quad QR\left(1 + \frac{1}{x}\frac{PN}{QS}\tan\theta\right) = EN\tan\theta,$$

$$\therefore \quad \frac{QR}{QS} = \frac{EN}{QS}\,\frac{\tan\theta}{1 + \frac{1}{x}\frac{PN}{QS}\tan\theta}$$

$$= \frac{EN}{PN}\cdot\frac{PN}{PO}\cdot\frac{\tan\theta}{1 + \frac{1}{x}\frac{PN}{QS}\tan\theta}$$

$$\therefore \quad xm' = m\frac{PN}{PO}\cdot\frac{\tan\theta}{1 + \frac{1}{x}\frac{PN}{PO}\tan\theta}$$

$$\therefore \quad \frac{m'}{m} = \frac{A'P}{OP}\cdot\frac{1}{x + \frac{A'P}{OP}}, \quad \text{since } \tan\theta = \frac{A'P}{NP} \quad \ldots \quad \ldots \quad (10)$$

Equation (10) reduces, as it should do,

to unity when x is small and to $\frac{1}{x}\frac{A'P}{OP}$ when x is large.

To illustrate the use of (10), refer to Fig. 3. Take the rejector resistance of the circuit as $20k\Omega$, the mean anode voltage as 190 and the modulating voltage as $\pm$ 30 V: suppose $x = 2\alpha/F = 2$ (for example, $F = 2$ per cent., $\omega/2\pi = 10$ kc/s, and $p_0/2\pi = 500$ kc/s). From Fig. 3 we have $m = \frac{12.5}{92.5} = 13.5$ per cent.; this also shows that $\frac{A'P}{OP} = \frac{3}{4}$. Hence by (10) $\frac{m'}{m} = \frac{3}{11}$, or $m' = 3.7$ per cent.

Equation (10) must not be used indiscriminately, since in its derivation the curves connecting R_1 and V are treated as straight lines and $m'x$ is supposed small enough to permit of the approximation

$$R' = p_0L/F\ (1 - m'x \cos \omega t):$$

it is certainly true, however, as a lower limit when $x \gg 1$. When the validity of (10) is doubtful, graphical solution is available if the three relevant curves connecting R_1 and V are available. Thus first it is necessary to assign a definite value to x and then to derive from (6) the maximum and minimum values of R' for various values of m'. Horizontal lines should then be drawn, on the curve corresponding to Fig. 3, at these values of R' and marked with their appropriate values of m': also vertical lines should be drawn on each side of the point corresponding to N in Fig. 4 for the same assigned values of m'. There will be some value of m' at which the intersection of the horizontal and vertical lines will lie on the curve connecting R_1 and V: this value of m' is the required solution.

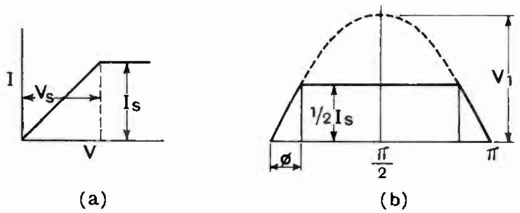
It is not likely, however, that any practical case would merit the labour of this graphical process. Nevertheless, the solution described in this paper must surely be extremely close provided only that $F \ll 1$ and this is the only case of practical interest: it therefore deals effectively with a certain non-linear problem: The solution shows that the difficulty of wide modulation considerably enhances the characteristic of the valve.

The writer has been told that these difficulties are met with in practice occasionally, and, indeed, they must be present in quartz-controlled generators. He understands that the difficulty can often be overcome by changing the rejector resistance of the circuit, for example by adjustment of the anode tap. Thus consider the numerical example used in conjunction with Fig. 3. When the rejector resistance was 20 $k\Omega$, $A'P/OP$ was approximately equal to 3/4. If, however, the rejector resistance had been 12 $k\Omega$, then $A'P/OP$ would have been only about 1/3 and then m'/m would have been 1/7 instead of 3/11. If the rejector resistance had been 25 $k\Omega$, then $A'P/OP$ would have been greater than unity and the high frequency modulation would be accentuated by the valve. It seems clear from this analysis that a steep bend in the curve connecting R_1 and V, be it due to secondary emission or to excessive bias of the grid, is capable of producing a "note correcting" effect. This, however, can obtain only for small modulation depths.

It should also be understood that this analysis applies only to undistorted modulation. Any given amplitude of modulation can be obtained by sufficient increase of the acoustic frequency modulating voltage, but it will not be undistorted modulation: there will be epochs in the modulation cycle when the input to the circuit is insufficent to permit the radio-frequency current to change at the desired rate. This analysis does not apply to such overdriven systems, though no doubt it could be extended to deal with them if it were worth while to do so.

It is known and understood that the main effect of the high frequency harmonics of anode current is to influence slightly the fundamental frequency of the generator (see Bibliography 1, 2, 5). This harmonic content is a function of the high frequency swing of anode voltage and of the mean anode voltage; it is thus different at the peak and the trough of the modulation cycle. Thus it would seem that the modulation of a generator must tend to produce a small fluctuation in the carrier frequency; this can be reduced by circuit devices mentioned in section 2 (see Bibliography 1, p. 193, and 4). Since the modulation produced by a given modulating voltage decreases as ω/p_0 increases, there may be some tendency for the fluctuation of carrier frequency to be less pronounced when ω/p_0 is large.

Should it ever be deemed worth while to



$V_s/I_s = \rho$. Fig. 6.

measure the reduction of modulation predicted in this paper, then it may be best to record the change in the modulation of anode current due to a modulating voltage of constant amplitude and variable frequency; for the enhanced reduction of anode swing due to the persistence of the circuit is inherent to the circuit, and to include this in the measurement would be redundant and increase the experimental difficulties. Thus it would be desirable to include in the anode lead a circuit of small rejector resistance and not very small power factor; and to observe the modulation of the P.D. across this by means of a cathode-ray oscillograph. The writer and Mr. A. W. G. Birch started to make such measurements; the effect described in this paper were readily apparent, but the time at our disposal did not permit us to arrive at quantitative results.

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(4) D. A. Bell, *Wireless Engineer*, 1935, Vol. 12, p. 535.
(5) D. A. Bell, *Wireless Engineer*, 1936, Vol. 13, p. 539.

Appendix

Fourier Analysis of a Simple Case.

Suppose the lumped characteristic of the tube were as shown in Fig. 6 (*a*), the anode current reaching saturation value I_s at anode potential V_s. Let B_a and B_g be such that when the system is not oscillating the anode current is $\frac{1}{2}I_s$: that is, $B_a - \mu B_g = \frac{1}{2}V_s$. Then if the lumped voltage fluctuates harmonically with the amplitude V_1, a half cycle of anode current and potential (shown dotted) would be as shown in Fig. 6 (*b*). Straightforward Fourier analysis of the current curve shows that the fundamental component is

$$I_1 = \frac{2}{\pi}\frac{V_1}{\rho}(\phi + \tfrac{1}{2}\sin 2\phi), \text{ where } \sin\phi = V_s/2V_1$$

$$\therefore R_1 = \frac{\pi\rho}{(2\phi + \sin 2\phi)} \qquad \qquad (11)$$

then $R_1 = \rho$, when $V_1 < \frac{1}{2}V_s$,

and $R_1 \doteqdot \frac{\pi\rho}{2}\frac{V_1}{V_s}$, when $V_1 \geqslant \frac{1}{2}V_s$

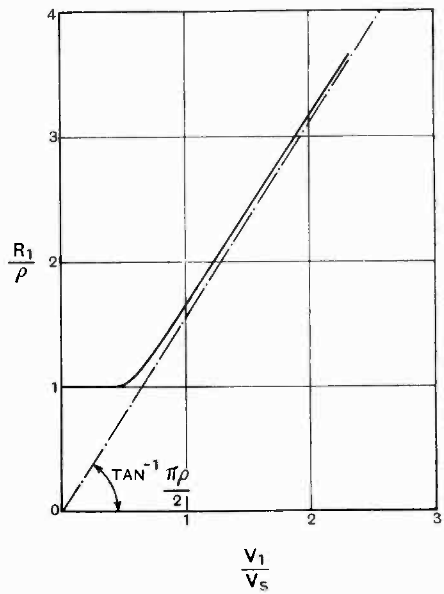

Fig. 7.

Equation (11) is exhibited graphically in Fig. 7, in which R_1/ρ is plotted as a function of V_1/V_s. Fig. 7 is of the same character as Fig. 3 and is sensibly straight over a long range. There is also the limitation on the characteristic of Fig. 6(*a*), that the anode must be positive and also positive to the grid. When the second condition is not fulfilled the curve of Fig. 7 would rise almost vertically, as in fact occurs in Fig. 3.

This brief analysis serves to show that the relation between R_1 and V, obtained experimentally, has the expected character.

The Industry

CUSTOMERS of the British Rola Company are asked to note that the company's Park Royal factory will be closed for holidays from Friday evening, July 22nd, to Monday morning, August 8th.

An illustrated catalogue of laboratory equipment recently issued by the Furzehill Laboratories, Boreham Wood, Herts, deals with cathode-ray gear, oscillators and other test apparatus.

Change of address: Miniature Bearings, Ltd., (suppliers of small ball bearings from 1.5 mm. overall dia.) to 2/3, Duke Street, St. James's, London, S.W.1.

Book Reviews

Magnetism

Magnetism. Pp. 102 + VI. The Institute of Physics, 1, Lowther Gardens, London, S.W.7. Price 4/6.

A two-days' Conference was held in Manchester in July, 1937, under the auspices of the Manchester and District Branch of the Institute of Physics. The subject chosen was "Magnetism" and six lectures were delivered on various branches of the subject, each by a recognised authority in the respective branch. These lectures have been brought together and a foreword added by Prof. W. L. Bragg, to form a very attractive little volume.

Three of the lectures may be classified as practical and three as theoretical. The former include "Electrical sheet steel," by G. C. Richer, of Messrs. Lysaght; "The influence of the properties of available magnetic materials on engineering design," by C. Dannatt, of the Metropolitan-Vickers Co.; and "Permanent magnets," by D. A. Oliver, of Sheffield. The more theoretical papers are "Magnetism and the electron theory of metals," by N. F. Mott, of Bristol University; "Magnetisation curves of ferromagnetics" by E. C. Stoner, of Leeds University; and "X-ray studies on permanent magnets of iron, nickel and aluminium," by A. J. Bradley, of the N.P.L. and A. Taylor, of Manchester University.

It is very convenient to have brought together in a single volume of a hundred pages these six authoritative papers approaching the subject of magnetism from such widely divergent points of view. Each paper is well illustrated and in several cases very extensive bibliographies are appended. It is interesting to note the consistency of the nomenclature and symbolism throughout the volume, the only blot being in the permanent magnet paper where the abscissae of Fig. 7 are stated to be "alternating magnetic field in ampere-turns per inch." G. W. O. H.

The National Physical Laboratory

Report for the Year 1937, pp. 150. Published by H.M. Stationery Office, Adastral House, Kingsway, London, W.C.2. Price, 2s. 6d.

This Report gives a summarised account of the activities of the various departments: Physics, Electricity, Radio, Metrology Engineering, Metallurgy, Aerodynamics, and Ship-model tank.

In the Radio Section the work of a fundamental nature is mainly concerned with researches on the propagation of waves, their reflection at the earth's surface under different angles of incidence and states of polarisation, the relative intensities of direct waves and those reflected from the ionosphere, and the phase velocity of waves along the ground. In the field of direction-finding further progress has been made in the design and calibration of the Adcock or spaced aerial type of finder. Progress has also been made in the application of the cathode-ray tube to a short-wave visual direction-finder of the Adcock type.

An interesting account is given of comparative measurements of field strength by seven sets of equipment, involving five different types, in order to form some estimate of the accuracy of such measurements. Between wave-lengths of 6 and 100 metres the divergences were about $\pm$ 20 per cent., but, strange to say, larger discrepancies up to $\pm$ 45 per cent. occurred in the range between 100 and 500 metres. These measurements clearly indicated the need for further work on the design of such equipment.

New frequency measuring equipment for the range 1 to 70 Mc. per sec. ($\lambda = 300$ to 4 metres) has been installed. This is based upon a 1 kc. per sec. fork controlling a multivibrator, harmonics of which control an oscillator, the output of which is distorted to give harmonics which are then received selectively in a receiver. This equipment was described in our pages (1937, p. 299).

In the Electricity Section a new type of clock has been devised and constructed which has an error of only a small fraction of a second per year. In order to get a more robust construction the quartz ring, upon the electrically-maintained vibration of which the clock depends, is not suspended by fine wires as in the previous model, but is supported on three fixed points. Mechanical vibration and change of level are found to have very little effect on the operation. To obtain the best result the clock is sealed in an evacuated enclosure provided with temperature control. Several clocks of this type are now under construction, one for Greenwich Observatory. Other subjects dealt with in sections other than the Radio Section, but of interest to radio engineers, are high-frequency measurements, dielectrics, and acoustics. The Report, which has a very complete index, shows the diversity and importance of the work being carried out at the National Physical Laboratory.

G.W.O.H.

Principles of Radio

By Keith Henney. Third Edition. Pp. 495 + xii. Chapman and Hall, Ltd., 11, Henrietta Street, London, W.C.2. Price 17s. 6d.

In this, the third edition of Henney's "Principles of Radio," a certain amount of revision has been effected and some new material added, although the revision is perhaps less extensive than one would have expected in view of the continued progress of the science. But apart from developments in television, fundamental principles have not changed and the treatment of the subject of radio communication itself is very complete and thorough. The book retains its high position as a thoroughly sound textbook for the student with limited mathematical knowledge.

The matter relating to television in the last short chapter could, in our opinion, have been deleted altogether with advantage as the small amount of new material added on the subject is totally inadequate. O. P.

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is generally no indication of the importance of the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

PROPAGATION OF WAVES

2660. FURTHER INVESTIGATIONS ON A PROPAGATION EFFECT OF ULTRA-SHORT WAVES (6–11 M) TO DISTANCES OF SOME HUNDREDS OF KILOMETRES [Sporadic Summer-Months "Effect" of New Type].—H. A. G. Hess. (*Funktech. Monatshefte*, April 1938, No. 4, pp. 107–111.) For the first report *see* 1736 (Section B) of May.

2661. DIRECT DETERMINATION OF THE ELECTRICAL CONSTANTS OF SOIL AT ULTRA-HIGH RADIO-FREQUENCIES [73 to 89 Mc/s: by Determination of Attenuation Constant of Lecher-Wire System immersed in Soil].—M. K. Chakravarty & S. R. Khastgir. (*Phil. Mag.*, May 1938, Vol. 25, No. 170, pp. 793–801.)

The dielectric constant varies from 3.95 e.s.u. at 8% moisture content to 29.4 at 41%, and diminishes with increasing frequency: the electrical conductivity is of the order of 10^{-14} e.m.u., first increasing and subsequently decreasing with rising frequency. *Cf.* Banerjee & Joshi, 2870 of 1937.

2662. REFLECTION AT A STRATIFIED MEDIUM [Theoretical and Experimental Investigation].—Pfister & Roth. (*See* 2805.)

2663. EXPERIMENTAL INVESTIGATIONS ON ELECTRON KINETICS [where H.F. Field Cycle is comparable with Transit Time].—Müller. (*See* 2710.)

2664. STYCTOGRAPHIC COHERERS.—D. I. Penner. (*Journ. of Tech. Phys.* [in Russian], No. 23, Vol. 7, 1937, pp. 2227–2230.)

In previous papers (372 of 1935 and back references) Arkadiew described a method for the direct recording of the presence of a radio-frequency field, in which the detecting element consists of a number of coherers resting on a slip of chemically sensitised paper across which a d.c. voltage is applied. The particular coherer whose axis is correctly oriented with respect to the wave becomes conductive, and the passage of direct current between the coherer terminals and the paper marks the latter by chemical action. The present article is concerned with the method of manufacture and the details of operation of the coherers.

2665. RECEPTION OF "RADIO-NORMANDIE" ON ITS SEVENTH HARMONIC—30.37 M: BETTER THAN FUNDAMENTAL IN SOME ENGLISH LOCALITIES, POOR IN OTHERS.—(*World-Radio*, 20th May 1938, Vol. 26, p. 8.) Discussion of a correspondence: *see* also p. 7.

2666. ON THE PROPAGATION OF WAVES, *and* A NEW CONCEPTION OF THE EXPONENTIAL FUNCTION OF THE DIFFERENTIAL OPERATOR, AND ITS APPLICATION TO PHYSICAL PROBLEMS [Heat Flow, Potential Theory, and Propagation of Waves].—T. Sakurai. (*Jap. Journ. of Phys.*, Transactions & Abstracts, No. 2, Vol. 12, 1938, Abstracts p. 35: p. 36: in English.)

2667. RECENT SOLAR ERUPTIONS, AURORAS, AND MAGNETIC STORMS.—A. J. Higgs & R. G. Giovanelli. (*Nature*, 23rd April 1938, Vol. 141, p. 746.)

An exceptionally large eruption was observed at Canberra on 24th Jan. 1938 and was associated with an exceptionally severe radio fade-out. The interval (38 hours) between the solar eruption and the associated auroral display appears to be larger than usual (26 hours). Observations on 16th & 20th/21st Jan. are also described.

2668. ABNORMAL PHENOMENA IN THE IONOSPHERE WITH OCCURRENCE OF THE AURORA BOREALIS.—W. Dieminger & H. Plendl. (*Hochf:tech. u. Elek:akus.*, April 1938, Vol. 51, No. 4, pp. 117–120.)

Photographs of reflected echoes on 30th Sept. 1937, 3rd Oct. 1937, & 25th Jan. 1938 during auroral displays show very diffuse reflecting layers at great heights. Simultaneous reception of echoes from transmitters at two different locations enable the position of the reflecting patches to be estimated, and a measurement on 3.10.37 indicates a position some 350 km North of the receiver (receiver at 53° 15′ N, 13° E).

2669. ON PROCESSES IN THE IONOSPHERE WHICH WERE ESTABLISHED DURING THE AURORAL DISPLAY OF 25TH JAN. 1938 IN MIDDLE LATITUDES (52°).—F. Vilbig, B. Beckmann, & W. Menzel. (*TFT*, March 1938, Vol. 27, No. 3, pp. 73–81.)

The following are the conclusions reached :—(1) Echo measurements show that the display in these latitudes is characterised by the appearance (before the luminous effect is visible) of a diffuse reflection region in the ionosphere above the F layer : this is probably due to a corpuscular radiation coming from the direction of the Pole. Later, the interesting effect occurs of the interpenetration of two regions which obviously have two different origins : the newly formed, diffuse layer penetrates into the F layer, with a simultaneous decrease of the ionisation there. This moment is distinguished by a violent surge in the magnetic disturbance, and a particularly interesting point is that immediately after this penetration the E layer sets in, showing that the radiation has now reached the lower regions and is ionising there.

(2) In contrast to the usual E-layer heights in the Polar zone, this E layer begins at abnormally great heights, 180–200 km : on the assumption of the arrival of the radiation from the direction of the Pole, this may be regarded as a latitude effect. (3) During the luminous phenomena the layers in the E and F regions, produced by the corpuscular radiation, are destroyed, the charge carriers being no doubt mixed up by thermal processes, so that not until a certain time after the luminous effect can the stratification be re-established. After-effects are still apparent on the following night.

(4) Short-wave reception observations at Beelitz confirm the propagation of this disturbance from the Pole. A latitude effect is clearly seen in the time of onset and the magnitude of the fading, which is due to a decrease of ionisation in the F region.

(5) In strong magnetic disturbances not accompanied, in our latitudes, by aurora, similar processes are observed : diffuse stratification above the F region occurs, and sinks slowly with accompanying decrease of F ionisation. But there is no appreciable increase in E ionisation, which suggests that the radiation cannot reach the E levels.

2670. A SHORT SURVEY OF THE MOST IMPORTANT PROBLEMS OF IONOSPHERIC RESEARCH.—Vilbig, Beckmann, & Menzel. (*TFT*, March 1938, Vol. 27, No. 3, pp. 112–115.)

2671. SOLAR ACTIVITY AND RADIO RECEPTION IN 1937.—J. H. C. Lisman. (*Tijdschr. Nederlandsch Radiogenoot.*, April 1938, Vol. 7, No. 6, pp. 220–230.) With Dutch results and a bibliography of over 30 items.

2672. SEASONAL VARIATION IN F_2 IONISATION [Observations at Washington and Watheroo support Goodall's Portrayal of F_2 Variations].—E. O. Hulburt. (*Phys. Review*, 15th April 1938, Vol. 53, No. 8, pp. 670–671.) For Goodall's paper *see* 811 of March.

2673. CHARACTERISTICS OF THE IONOSPHERE AT WASHINGTON, D.C., FEB. 1938.—Gilliland & others. (*Proc. Inst. Rad. Eng.*, April 1938, Vol. 26, No. 4, pp. 482–485.)

2674. STUDY OF TEMPERATURE OF ATMOSPHERE AT HEIGHTS UP TO 35 MILES BY OBSERVATIONS OF RAYS OF RISING AND SETTING SUN.—Hulburt. (*Science*, 6th May 1938, Vol. 87, Supp. p. 10.)

2675. "LATE" ARTILLERY REPORTS GIVE CLUES TO STRATOSPHERE : MINUTE SLOW IN ARRIVING, SOUND TRAVELLED VERY HIGH AND WAS REFLECTED FROM WARMER STRATOSPHERIC LAYER.—B. Gutenberg. (*Sci. News Letter*, 7th May 1938, Vol. 33, p. 296.)

2676. ON THE PROPERTIES OF GEOLOGICAL CONDUCTORS AND THEIR DETERMINATION [with Special Reference to Geological Exploration by Radio Methods].—V. Fritsch. (*Hochf:tech. u. Elek:akus.*, April 1938, Vol. 51, No. 4, pp. 138–146.)

2677. REFRACTIVE INDEX AND DISPERSION OF DISTILLED WATER FOR VISIBLE RADIATION, AT TEMPERATURES 0 TO 60° C.—Tilton & Taylor. (*Journ. of Res. of Nat. Bur. of Stds.*, April 1938, Vol. 20, No. 4, pp. 419–477.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2678. THE REDUCTION OF INTERFERENCE FROM ATMOSPHERICS IN THE AURAL RECEPTION OF MORSE SIGNALS.—K. Dannehl & P. Kotowski. (*Telefunken*, March 1938, Vol. 19, No. 78, pp. 22–38.)

A previous paper (3292 of 1937) dealt with "amplitude selection," *i.e.* the use of limiting devices. The present paper considers frequency selection ("resonance" selection), alone and in conjunction with amplitude selection. The other two main methods of reducing interference are not considered : namely, "compensating" circuits, where interference on a neighbouring channel, received on a second receiver, cancels out the interference on the signal wavelength (this plan involves rather elaborate equipment, and the necessary neighbouring channel, free from all signals, is rarely available) ; and directional selection, depending on suitable directive aerials and independent of the receiver.

Section B deals with the band width and signal intelligibility of "coherently" keyed transmitters for interference-free reception : a "coherently" keyed transmitter is one in which the master-oscillator stage remains oscillating even during the spaces, so that the signals do not vanish during these spaces and there need be no sudden change of phase between signals. With "incoherently" keyed transmitters, dealt with similarly in Section C, the master-oscillator stage itself is keyed.

Section D deals with the relation between the amount of interference and the receiver band width, Section E with the intelligibility of Morse signals in the presence of atmospheric "clicks." Here, new measurements on band widths ranging from 100 to 5000 c/s, using gramophone records to provide the interference, gave the points marked by crosses on curve A of Fig. 37 (taken from the previously cited paper) and confirmed that errors of 2% occur if the peaks of the "clicks" are three times as high as the signal peaks. Section F considers the working of a combination of amplitude limitation and frequency selection on the intelligibility of Morse telegrams suffering from interference.

Section G deals with "steepness magnifying" circuits, giving a type of contrast expansion. The previous tests having shown that the use of selective circuits with very low damping is limited by the decrease in contrast between signal and space produced by "nachklingen" (signal persistence or "ringing" effect) the circuit of Fig. 41 was used to magnify the amplitude differences. Results are seen in Figs. 42 and 43. The final conclusions are that there is an optimum narrowing of receiver band width for the elimination of interference, depending chiefly on the signalling speed. For a speed of 100 letters per minute this optimum width is 6 c/s, but departures up to 36 c/s have little ill effect on reception. A limiting of the high interference peaks before resonance selection is advantageous. Contrast magnification after resonance selection does not actually decrease the errors, but is welcomed by operators as giving more comfortable reception.

2679. LIGHTNING AND ATMOSPHERICS [Short Summary of Present Knowledge].—(*Naturwiss.*, 18th March 1938, Vol. 26, No. 11, p. 173.)

2680. THE MECHANISM OF THE LONG SPARK [Pre-Discharge is "Leader Stroke" as in Lightning: Direction of Branching of Discharge gives Criterion for Direction of Propagation of Leader Stroke: etc.].—T. E. Allibone. (*Journ. I.E.E.*, May 1938, Vol. 82, No. 497, pp. 513–521.)

2681. CURIOUS EFFECTS OF GLOBULAR LIGHTNING.—(*Nature*, 23rd April 1938, Vol. 141, p. 722.)

2682. A METHOD FOR THE INVESTIGATION OF UPPER-AIR PHENOMENA, AND ITS APPLICATION TO RADIO METEOROGRAPHY [U.S. Navy Work with Exploring Balloons: Details of Equipment and Procedure].—Diamond, Hinman, & Dunmore. (*Journ. of Res. of Nat. Bur. of Stds.*, March 1938, Vol. 20, No. 3, pp. 369–392.)

PROPERTIES OF CIRCUITS

2683. THEORY OF THE RECTIFYING ACTION IN A CIRCUIT CONTAINING A DISSIPATIVE IMPEDANCE AND A [Smoothing] CONDENSER [leading also to Valve-Generator Relations].—S. Zilitinkewitsch. (*Tech. Phys. of USSR*, No. 2, Vol. 5, 1938, pp. 96–124: in German.)

For the original Russian paper see *Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 8, 1938, pp. 316–339. Author's summary:—"The author has developed the theory of the rectifying action on to a dissipative impedance R and a smoothing capacity C; it holds good for various circuit arrangements and for an arbitrary number of phases of rectification. For the first time the dependence of the rectified voltage not only on the peak value of the applied voltage but also on the value of the product RC (forming the predominant characteristic of the load circuit of the rectifier) is established. The most general formulae for the rectified current, the apparent power, and other electrical quantities are derived, from which the commonly used relations evolve as special cases.

"A very interesting and important point in the author's theory is that in spite of the complete concreteness of all its laws and conclusions it not only gives the general relations for the rectification process in question, but also allows all the chief relations of the theory of the valve generator, *i.e.* the theory of the transformation of direct current into alternating current by means of thermionic valves, to be derived as special cases.

"In a particular example the author demonstrates the technical method for the use of the theory for the solution of concrete problems, and investigates the effect on the rectification process of changes in the characteristic product RC."

2684. THE GLOW-DISCHARGE LAMP AS A REGULABLE A.C. RESISTANCE [and Its Use as Low-Pass Filter with Variable Pass Band: as A.F. Band Filter for Broadcast Receiver, giving Automatic Decrease of Band Width for Weaker Stations].—E. Eisele. (*Funktech. Monatshefte*, April 1938, No. 4, pp. 102–107.)

The writer's experiments and measurements on the use of a glow-discharge tube as coupling element in an a.f. amplifier (on the lines described by Miram, 613 of 1936) have shown the occurrence, at the higher frequencies, of a marked fall in amplification which could not be explained entirely by the internal-capacity effects in the valves. Its amount could only be accounted for by the supposition that the a.c. resistance of the glow-discharge tube increased with increasing frequency. This result led the writer to make an investigation into the nature and magnitude of the a.c. resistance of such a tube, by a combination of theoretical treatment and exact measurements over the frequency range 20–10 000 c/s.

Various types of tube were tried (Fig. 4), but preliminary tests showed that most of them were unstable under measurement. The best was No. 10 (used for "thermometer" tuning indication in broadcast receivers) with a rod cathode and two anodes—these were paralleled during the a.c. resistance measurements. This type was therefore adopted for the investigation. Only the region of the normal cathode drop was dealt with: in this type of tube it extended from 100 to 1000 μA. It was found that for frequencies above 100 c/s the a.c. resistance increased with frequency; that for a fixed frequency the absolute value of the resistance depended on the constant d.c. current—at 500 c/s the resistance was 3500 ohms for a d.c. value of 1000 μA, whereas for 100 μA it jumped to 60 000 ohms (Fig. 6); for frequencies below 100 c/s the frequency-dependence vanished, but the variation with the d.c. value remained (Fig. 9). Fig. 7, taken at 2000 c/s, shows how the a.c. resistance could be varied between 160 000 and 13 000 ohms by adjusting the d.c. value between 100 and 1000 μA. This behaviour is examined closely in section 4. In section 5 the equivalent circuit of the tube as an a.c. resistance is discussed: Fig. 8 represents it, sufficiently accurately for practical purposes, as made up of a frequency-independent ohmic resistance in series with an inductance. The latter can be calculated (section 6) from the measured magnitudes, for various d.c. values, of the a.c. resistance and the frequency-independent resistance (seen in Fig. 9): Fig. 10 shows such calculated inductances for d.c. values between 100 and 1000 μA, the range of inductance variation coming out as from 0.6 to 12.5 henry. Section 7 deals with the application of this to the formation of a low-pass filter with regulable band width. In Fig. 11 the d.c. current through the two tubes, measured by the meter I_g, can be adjusted by applying suitable control voltages to the grid of the triode: the consequent variation of the attenuation for a fixed frequency of 1000 c/s is shown in Fig. 12.

2685. Circuits for Piezoelectric Quartz Oscillators and Resonators for Frequency Stabilisation and for Selectivity Devices.—Bechmann. (*See* 2926.)

2686. "Einführung in der Vierpoltheorie der elektrischen Nachrichtentechnik" [Book Review].—R. Feldtkeller. (*E.T.Z.*, 21st April 1938, Vol. 59, No. 16, p. 430.) Being Vol. 2 of Fassbender's series "Physics & Technique of the Present Day."

2687. Investigations on the Time of Transit in Four-Terminal Networks and the Use of the Gliding-Frequency Method [especially to measure Least Perceptible Differences in Time of Transit].—W. Bürck & H. Lichte. (*E.N.T.*, March 1938, Vol. 15, No. 3, pp. 78–101.)

2688. Capacities and Inductances as Distorting Elements.—C. Budeanu. (*Arch. f. Elektrot.*, 28th April 1938, Vol. 32, No. 4, pp. 251–259.)

2689. Variable Equalisers [Investigation on Structures by which an Arbitrary Multiple of a Given Attenuation Characteristic can be introduced into a Circuit by Changes of a Single Element: the Difficulty of Distortion: Some Useful Circuits, and Their Characteristics].—H. W. Bode. (*Bell S. Tech. Journ.*, April 1938, Vol. 17, No. 2, pp. 229–244.)

2690. Study of the Principles of Retroaction [particularly Negative Retroaction: Discussion of Black's Theory: Feldtkeller's Treatment by Inverse Series Method, showing Black's Conclusions on Reduction of Non-Linear Distortion to be Not Rigorous].—F. Bedeau & J. de Mare. (*L'Onde Élec.*, April 1938, Vol. 17, No. 196, pp. 153–173: to be contd.)

2691. Methods for the Stabilisation of Negative-Feedback Highly Linear Amplifiers [for Multiple Telephony, etc.].—H. Werrmann. (*Siemens Veröff. a.d.G.d. Nachricht.*, No. 5, Vol. 7, 1937, pp. 861–863.)

2692. The Optimum Value of the Angle Φ [in H.F. Power Amplifiers].—V. Olsson: Kósa. (*Wireless Engineer*, May 1938, Vol. 15, No. 176, p. 269.) The approximate formulae used in Kósa's paper (870 of March) "may sometimes lead to considerable errors."

2693. Current Circuits with Iron-Cored Inductances [Mathematical Analysis of Circuits containing Inductances whose Value varies with Current].—W. Taeger. (*Arch. f. Elektrot.*, 28th April 1938, Vol. 32, No. 4, pp. 233–250.)

2694. Oscillations in a Non-Linear System which is Approximately Equivalent to a Linear System with Periodically Varying Parameters.—G. Gorelik. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 8, 1938, pp. 453–460.)

In the theory of oscillations equations are often encountered of the form $\ddot{x} = X(x, \dot{x}, t)$, where $\dot{x}$ and $\ddot{x}$ are derivative with respect to t and X is a non-linear function with respect to x and $\dot{x}$, and periodical (or nearly periodical) with respect to t. It is difficult to analyse and solve this equation unless it can be reduced to a system of two equations. In a particular case represented by equation (3) a method was proposed for such reduction by van der Pol (*Phil. Mag.*, 1927, Vol. 3, No. 13, p. 65) and from a different standpoint by Mandelstam & Papalexi (*Journ. of Tech. Phys.* [in Russian], Vol. 4, 1934, No. 2, p. 118). In the present paper this method is further extended and applied to a non-linear system having one degree of freedom and approximately equivalent to a linear system with periodically varying parameters and having zero average damping. This system can be represented by equation (4), and an approximate method is indicated for reducing it to two equations (16). An analysis of these two equations is given and, as an example, the results obtained are applied to the case of a super-regenerative receiver.

2695. On Single and Coupled Tuned Circuits having Constant Response-Band Characteristics [Two-Stage Amplifier, One Stage working into Coupled Tuned Circuits, the Other into a Single Tuned Circuit, gives Satisfactory Flat Response Curve].—Ho-Shou Loh. (*Proc. Inst. Rad. Eng.*, April 1938, Vol. 26, No. 4, pp. 469–474.) The required circuit constants are, moreover, easily computed. A quantity termed "transmutational coupling" is employed.

2696. A Method of Neutralising the Hum and Feedback caused by Variations in the Plate Supply [by using Screen Grid of Multi-Grid Valve to produce a Variation upon Succeeding Grid neutralising the Variation arriving Directly through Plate-Circuit Resistor].—K. B. Gonser. (*Proc. Inst. Rad. Eng.*, April 1938, Vol. 26, No. 4, pp. 442–448.)

2697. HIGH-MU TUBES IN RESISTANCE-COUPLED AMPLIFIERS [High and More Uniform Gain, and Less Distortion, obtained with 15 Megohm Grid Leak than with Conventional 1 Megohm Leak in conjunction with Biasing Cell].—Nat. Union Laboratories. (*Electronics*, April 1938, Vol. 11, No. 4, p. 53.)

2698. A SIMPLE METHOD FOR CALCULATING THE HARMONIC DISTORTION OF A VACUUM TUBE AMPLIFIER [Class A].—Y. Fukuta. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts p. 17.)

2699. "Q" *versus* "Z": WHICH IS THE REAL "FIGURE OF MERIT"? [Resonant Impedance *Z* is Only True Indication of Efficiency of Tuned Circuit when operating in Conjunction with a Valve: Greater Attention should be paid to Design of Inter-Stage Couplers].—(*Rad. Review of Australia*, April 1938, Vol. 6, No. 4, pp. 102–104.)

2700. RELAXATION OSCILLATIONS OF DIRECT-CURRENT REGENERATIVE AMPLIFIERS [of Considerably Long Period, although Little Inductance or Capacity exists in Circuit: Experimental Investigation].—Awaya, Emi, & Hasegawa. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts pp. 22–23.) "This oscillation seems to differ from other oscillation mechanisms, for example the multivibrator."

2701. PRODUCTION OF RELAXATION OSCILLATIONS: SOME EXPERIMENTS WITH A SOFT TRIODE [War-Time R2A Detector, containing Helium, with Discontinuity due to Cumulative Ionisation: Sudden Deionisation by Increase in Negative Grid Bias (unlike Thyratron): Production and Selection of Sub-Harmonics: Maintenance of Oscillations in an *LR* Circuit: etc.].—S. Byard. (*Wireless Engineer*, May 1938, Vol. 15, No. 176, pp. 252–256.) *Cf.* Eck, 946 of 1937.

2702. HARMONIC GENERATION.—H. J. Scott & L. J. Black. (*Proc. Inst. Rad. Eng.*, April 1938, Vol. 26, No. 4, pp. 449–468.)

For screen-grid and similar valves, where the plate current is substantially independent of plate voltage and hence of load impedance, the analysis has been made by Terman & Ferns (1934 Abstracts, p. 325). With valves having a plate resistance comparable with the plate load impedance, the effect of the harmonic voltage developed across this impedance must be considered (in practical operation the impedance is a resonant circuit tuned to the desired harmonic). The analysis of this condition of operation is here given, with experimental verification up to and including the 9th harmonic.

2703. THE EQUIVALENT CIRCUIT OF THE TRANSFORMER [from the Simplest 1 : 1 Transformer without Leakage to the Transformer with Leakage and Arbitrary Ratio: including H.F. Transformers].—H. Pitsch. (*Funktech. Monatshefte*, April 1938, No. 4, pp. 111–118.)

2704. THE SWITCHING ON OF A CIRCUIT [On the Instantaneous Conditions when a D.C. Voltage is applied to a Circuit].—B. D. Lapkin. (*Journ. of Tech. Phys.* [in Russian], No. 2, Vol. 8, 1938, pp. 187–189.)

In studying dielectrics it is often necessary to consider circuits consisting of two series resistances each shunted by a condenser. In the present paper formulae are derived for determining the currents in various parts of the circuit at the moment when a d.c. voltage is applied. One of the conclusions reached is that the currents through the two condensers flow in opposite directions.

2705. SOME ELECTRONIC SWITCHING CIRCUITS [particularly for Observation of Multiple Recurrent Patterns on Screen of Cathode-ray Oscillograph].—C. C. Shumard. (*Elec. Engineering*, May 1938, Vol. 57, No. 5, pp. 209–220.)

2706. PARALLEL IMPEDANCE CHART [giving Amplitude and Phase of Equivalent Impedance, for Tuned Circuits, Grid-Bias Filters, etc.]—D. G. Fink. (*Electronics*, May 1938, Vol. 11, No. 5, pp. 31, 32.)

2707. MUTUAL INDUCTANCE AND FORCE BETWEEN TWO LINEAR ELEMENTS, AND THE SELF INDUCTANCE OF REGULAR POLYGONS.—J. Hak. (*Arch. f. Elektrot*, 28th April 1938, Vol. 32, No. 4, pp. 267–274.)

2708. PRACTICAL NOMOGRAMS [Alignment Diagrams] FOR WIRELESS TECHNIQUE, AND THEIR PREPARATION.—J. G. Lang. (*Funktech. Monatshefte*, April 1938, No. 4, pp. 119–124.)

TRANSMISSION

2709. THE OPERATION OF A RETARDING-FIELD VALVE.—V. F. Kovalenkov. (*Journ. of Tech. Phys.* [in Russian), No. 5, Vol. 8, 1938, pp. 425–433.)

An experimental investigation on the operation of spiral-grid triodes in the retarding-field connection and having both ends of the grid brought out and connected to a Lecher system (Fig. 1). The experiments showed that each valve can only be excited on a number of definite wavelengths, and a certain relationship was established between these wavelengths and the dimensions of the grid circuit. The necessary electrical conditions for self-excitation of the valve were also determined experimentally, and the results obtained are shown in a number of graphs. It appears from these results that oscillations at each frequency can be obtained with two different sets of operating conditions. The conclusions reached in this investigation are discussed, but a mathematical theory of the operation of the valve is deferred until a later paper.

2710. EXPERIMENTAL INVESTIGATIONS ON ELECTRON KINETICS [Transit across a Plane Condenser in Oscillating Field at Frequency such that Cycle is comparable with Electron Transit Time: Results generally in accordance with Theory: Oscillations obtained in condition of Saturation: Inertia Effects of Electrons also observable in Gaseous Atmosphere at Comparatively High Pressures].—J. Müller. (*Hochf:tech. u. Elek:akus.*, April 1938, Vol. 51, No. 4, pp. 121–127.)

2711. Armstrong's Frequency Modulator [using 90° Shift of Side-Bands or Carrier of Amplitude-Modulated Carrier followed by Recombination of the Translated Components: Analysis to determine Distortion Components, assuming Idealised Receiver: practically All due to Third Harmonic of Modulating Voltage: Negligible after Frequency Multiplication to obtain Desired Carrier].—D. L. Jaffe. (*Proc. Inst. Rad. Eng.*, April 1938, Vol. 26, No. 4, pp. 475–481.)

2712. Carrier Suppression in Modulation Circuits [for Carrier-Current Systems: Investigation of Sources of Error and Their Effects].—V. Aschoff. (*TFT*, March 1938, Vol. 27, No. 3, pp. 102–105.)

2713. A New Modulation Meter [Earlier Meters fail to fulfil List of Requirements for Successful Meter (*e.g.* they measure Peak Depths for Known Wave-Form only): Defects of Gaudernack's Meter: a New Patent].—F. C. Williams & A. E. Chester. (*Wireless Engineer*, May 1938, Vol. 15, No. 176, pp. 257–262.)

2714. Production of Relaxation Oscillations: Some Experiments with a Soft Triode.—Byard. (*See* 2701.)

2715. The Anode Current in the Class B Amplifier, taking into Account the Bottom Bend of the Characteristic.—Gürtler. (*See* 2789.)

2716. Internal Inductance of Coils, and Its Influence on the Temperature Coefficient of the Coil [Butterworth's H.F. Resistance Formulae supplemented by Similar Formulae for Internal Inductance, yielding Formulae for T.C. of Resistance and Internal Inductance, etc.]—Tj. Douma. (*Philips Transmitting News*, April 1938, Vol. 5, No. 1, pp. 20–32: to be continued: in German and English concurrently.) For Groszkowski's work (here mentioned) *see* 678 of 1936: *also* 2695 of 1937.

2717. Practical Experience with the Ultra-Rapid-Action Safety Device for Rectifier Equipments, incorporating Mercury-Vapour Valves [on the Hilversum Transmitter].—(*Philips Transmitting News*, April 1938, Vol. 5, No. 1, pp. 16–19: in German and English concurrently.) The device was dealt with in 1168 of 1937.

2718. A 200-Kilowatt [Short-Wave] Radio-Telegraph Transmitter.—C. W. Hansell & G. L. Usselman. (*RCA Review*, April 1938, Vol. 2, No. 4, pp. 442–458.) Used since 1936 for service with N. Europe.

2719. A Multi-Frequency Transmitter for the Private Plane.—E. A. Bescherer. (*Bell Lab. Record*, April 1938, Vol. 16, No. 8, pp. 271–274.)

2720. Intra-Band Quick Frequency Change for Transmitters: combining Band-Pass action with Relay-Controlled Padders for Frequency Shift without Manual Retuning.—B. Goodman. (*QST*, May 1938, Vol. 22, No. 5, pp. 23–26 and 84, 86.)

2721. Applying Band-Pass Couplers to Amateur Transmitters: a Continuous-Coverage Transmitter with 100 Watts Output on Four Bands.—C. B. De Soto. (*QST*, May 1938, Vol. 22, No. 5, pp. 12–16 and 110 . . 122.)

RECEPTION

2722. On the Amplification of the Super-Regenerative Circuit [Analysis and Deductions: Increased Sensitivity by reducing the Decreasing-Time of Oscillation Amplitude, as well as by Optimum Values of Quenching Frequency & Voltage: etc.].—H. Maeda. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts pp. 18–19.)

2723. Oscillations in a Non-Linear System which is Approximately Equivalent to a Linear System with Periodically Varying Parameters [with Application to the Super-RegenerativeReceiver].—Gorelik. (*See* 2694.)

2724. A Frequency Converter heterodyned by Crystal Oscillator Harmonics, and Its Application to Commercial Short-Wave Receivers [giving Increased Stability even at Ultra-High Frequencies].—H. Seki. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts p. 22.)

2725. Design Trends in Mobile Receivers in America [particularly Ultra-Short-Wave Receivers for Police (Motor-Cycle and Car), and Aircraft Receivers].—L. M. Clement & F. X. Rettenmeyer. (*RCA Review*, April 1938, Vol. 2, No. 4, pp. 459–482.)

2726. The Present Position in the Development of Coils for Communication Engineering [including H.F. Iron Cores, and the "X" Shaped Core giving Very Small Losses and Simple Inductance Alignment: also H.F. Coil with 9:1 Inductance Variation by D.C. Biasing Current].—Kiessling & Wolff. (*AEG-Mitteilungen*, April 1938, No. 4, pp. 221–226 [pages before 225 missing in some copies].)

2727. The Variation in the High-Frequency Resistance and Permeability of Ferromagnetic Materials due to a Superimposed Magnetic Field [Theory and Experimental Investigation: Applications, including Remote Tuning of Radio Circuits ("Incremental Permeability Tuning"), Geophysical Exploration, etc.].—J. S. Webb. (*Proc. Inst. Rad. Eng.*, April 1938, Vol. 26, No. 4, pp. 433–441.) For hydrogenised iron the h.f. resistance can be changed from 30 to 3 ohms by a field change of one oersted.

2728. PERMEABILITY-TUNED PUSH-BUTTON SYSTEMS.—F. N. Jacob. (*Communications*, April 1938, Vol. 18, No. 4, pp. 15 and 38, 39.)

2729. A PERMEABILITY-TUNED PUSH-BUTTON SYSTEM.—J. P. Tucker. (*Electronics*, May 1938, Vol. 11, No. 5, pp. 12–13 and 34.)

2730. A HIGH-FIDELITY LOCAL RECEIVER [Model HF-1: for Stations within about 100 Miles: with Push-Button Selection of 8 Stations, 6-Position Selectivity/Fidelity/Gramophone Switch, etc.].—RCA Victor. (*Communications*, April 1938, Vol. 18, No. 4, p. 28.)

In the full-range position, reproduction is claimed to be faithful from 50 to 7000 c/s.

2731. THE GLOW-DISCHARGE LAMP AS A REGULABLE A.C. RESISTANCE [and Its Possible Use in Broadcast Receivers].—Eisele. (*See* 2684.)

2732. THE INDIRECTLY HEATED "URDOX" RESISTANCE DESIGNED AS A NOISE-FREE AND REMOTELY CONTROLLABLE VOLUME CONTROL.—Osram Company. (*Telefunken-Röhre*, April 1938, No. 12, p. 72.) A note by Wolf & Tillmann on their paper dealt with in 1433 of April.

2733. ON "REGULATING CHARACTERISTICS" [of Variable-Mu Valves for AVC].—Kleen & Wilhelm. (*See* 2786.)

2734. THERMAL STABILITY OF CONDENSERS: CERAMIC DIELECTRICS AND THEIR USE AT LOW TEMPERATURES [Preliminary Investigations showing Peculiarities of Dielectric Behaviour when used at Low Temperatures and Very Low Frequencies: Need for Much Further Research].—P. R. Coursey. (*Wireless Engineer*, May 1938, Vol. 15, No. 176, pp. 247–251.)

2735. DATA CHARTS FOR SINGLE CONTROL OF SUPERHETERODYNE RECEIVERS [and Method of R.F. Circuit Design by Their Use].—H. Wada. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts p. 18.)

2736. ON THE HUM OF INDIRECTLY HEATED AMPLIFIER VALVES.—Graffunder. (*See* 2785.)

2737. NEUTRALISING THE HUM AND FEEDBACK DUE TO PLATE-SUPPLY VARIATIONS IN RESISTANCE-COUPLED AMPLIFIERS.—Gonser. (*See* 2696.)

2738. ELECTROLYTIC CAPACITORS IN FILTER DESIGN [Pros and Cons of Low Power Factors for Receiver Smoothing Circuit].—P. M. Deeley. (*Communications*, April 1938, Vol. 18, No. 4, pp. 19–20 and 41.)

"The fact remains that ultimate user satisfaction will be increased if radio-receiver engineers use electrolytic capacitors with power factors that have not been lowered at the cost of lowered breakdown voltages, shortened life, and poor shelf-life characteristics."

2739. THEORY OF THE RECTIFYING ACTION IN A CIRCUIT CONTAINING A DISSIPATIVE IMPEDANCE AND A [Smoothing] CONDENSER.—Zilitinkewitsch. (*See* 2683.)

2740. THE REDUCTION OF INTERFERENCE FROM ATMOSPHERICS IN THE AURAL RECEPTION OF MORSE SIGNALS.—Dannehl & Kotowski. (*See* 2678.)

2741. THE COMPENSATION OF INTERFERENCE IN RECEIVERS [Experiments on Revival of Old "Opposition" Method (Signal *plus* interference *versus* Interference alone) with Modern Technique: Importance in the Rivalry between Wireless and Wired Broadcasting].—W. Menzel. (*Funktech. Monatshefte*, April 1938, No. 4, pp. 124–128.)

2742. ELECTRICAL INTERFERENCE WITH RADIO RECEPTION.—A. Gill & S. Whitehead. (*Engineer*, 8th April 1938, Vol. 165, p. 392: long summary of I.E.E. paper.)

2743. BROADCAST INTERFERENCE CAUSED BY ELECTRIC RAILWAYS [Trams and Trolleybuses] AND WAYS OF COMBATING IT.—E. Trechsel. (*Bull. Assoc. suisse de Élec.*, No. 8, Vol. 29, 1938, pp. 166–171: in French.)

2744. THE INTERFERENCE SUPPRESSION OF AEG SMALL MOTORS AND HOUSEHOLD APPLIANCES.—H. Krätz. (*AEG-Mitteilungen*, March 1938, No. 3, pp. 171–174.)

2745. AN ANALYTICAL STUDY OF SHOCK EXCITATION OF [the R.F. Stages of] RADIO RECEIVERS, AND NOTES ON THE FIELD-STRENGTH MEASUREMENT OF ELECTROMAGNETIC WAVE IMPULSES.—H. Iinuma. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts pp. 21–22.)

2746. THE BACKGROUND NOISE OF VALVE AMPLIFIERS, WITH PARTICULAR REGARD TO THOSE OF THE RESISTANCE-CAPACITY TYPE [Review followed by Author's Theoretical Investigation of *RC* Amplifier].—M. Mandò. (*La Ricerca Scient.*, 15th/31st March 1938, Series 2, 9th Year, Vol. 1, No. 5/6, pp. 217–234.)

In the *RC* amplifier the noise is made up of four components, due respectively to (i) Johnson (thermal agitation) effect in the grid resistance, (ii) granular (shot) effect of the grid current, (iii) Johnson effect in the amplifying resistance in the plate circuit, and (iv) granular effect of the plate current. It is shown that the Johnson effect is subject to precise calculation, but that the shot effect in the space-charge régime (the normal case) cannot be predicted quantitatively owing to the difficulties and complications inherent in the phenomenon (for example, the choice between various valves or the optimum working point for a given valve is decided experimentally). Nevertheless, even for the shot effect it is possible, when secondary actions such as flicker effect are eliminated, to determine for any particular problem the optimum conditions for the input circuit and amplifier. The writer refers to a previous paper (795 of February).

2747. THE NECESSARY FIELD STRENGTH FOR A SHORT-WAVE COMMERCIAL TELEGRAPH RECEIVER.—M. Morita & K. Tobiyama. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts p. 19.) For a similar paper on the frequency band *see* 951 of March.

2748. Corrections to Footnote in "Minimum Noise Levels obtained on Short-Wave Radio Receiving Systems."—K. G. Jansky. (*Proc. Inst. Rad. Eng.*, April 1938, Vol. 26, No. 4, p. 400.) *See* 948 of March.

2749. Effect of Interference on "Real" Station Coverage.—Haskins & Metcalf. (*See* 3028.)

2750. 9.6 Million Broadcast Listeners [German Data].—(*E.T.Z.*, 12th May 1938, Vol. 59, No. 19, p. 508.)

AERIALS AND AERIAL SYSTEMS

2751. Effect of the Receiving Antenna on Television Reception Fidelity [Interference between Direct and Reflected Signals, Its Results and Its Prevention].—S. W. Seeley. (*RCA Review*, April 1938, Vol. 2, No. 4, pp. 433–441.)

2752. An Aerial for Long-Distance Television [Excellent Results at 97 Miles from Alexandra Palace: Vertical Dipole with Reflector and Two Directors].—S. West. (*Television*, May 1938, Vol. 11, No. 123, pp. 271–272.)

2753. On the Electromagnetic Field from a Vertical Half-Wave Aerial above a Plane Earth.—P. Ryazin [Rjasin].—(*Tech. Phys. of USSR*, No. 1, Vol. 5, 1938, pp. 29–40: in English.) The original Russian paper was dealt with in 962 of March.

2754. The Effect of the Earth [Its Nature and Condition] on the Radiation Impedances of Short-Wave Antennas.—Y. Kato. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts pp. 15–16.)

2755. Measurements of Directional Characteristics and the Gain of a [Receiving] Beam Antenna [and a Comparison with Theoretical Results].—Morita, Nakagami, & Miya. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts p. 16.) The test signals were from a crystal-controlled oscillator in an aeroplane.

2756. On the Spacing between the Projector and the [Fed or Free] Reflector of a Short-Wave Beam Antenna.—H. Takeuti. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts p. 16.)

2757. Vertical Directivities of Short-Wave Beam Antennas [and the Design Calculations to give Any Desired Pattern].—Y. Kato. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts p. 17.)

2758. "V" and Rhombic Antennas fed with Travelling Current [Theory & Experiment show that Good Characteristic Figures are given even for Frequency Changes ± 30% away from Designed Frequency].—Y. Kato. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts p. 17.)

2759. A Method of Measuring the Field Intensity of Short Waves with a Half-Wave Antenna [using New Formula for Relation between Exciting Field Strength and Output Voltage of Half-Wave Dipole: Elimination of Loop Aerial with Its Disadvantages].—M. Nakagami & K. Miya. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts p. 20.)

2760. Constants of Fixed Antennas on Aircraft [Measurements of Various Aerials on Two Types of Modern Aircraft].—G. L. Haller. (*Proc. Inst. Rad. Eng.*, April 1938, Vol. 26, No. 4, pp. 415–420.)

2761. Vertical Radiators [Some Photographs], *and* Table for Broadcast Tower Heights.—(*Communications*, April 1938, Vol. 18, No. 4, pp. 16–17: p. 18.)

2762. Simple Directional Arrays using Half-Wave Elements: a Résumé of Data on Gain Variation with Spacing.—N. C. Stavrou. (*QST*, May 1938, Vol. 22, No. 5, pp. 17–19 and 108, 110.)

2763. New Ideas in Rotatable Antenna Construction: Improved Feeder Contacts for Continuous Rotation.—L. H. & G. W. Whitney. (*QST*, May 1938, Vol. 22, No. 5, pp. 20–21 and 92, 96.)

2764. H.F. Feeder for 100 Kilowatts, 556 Kilocycles/Second, 7000 Volts, using Calite Insulation: for 1600 m Length.—Câbleries de Brougg. (*Bull. Assoc. suisse des Élec.*, No. 10, Vol. 29, pp. 225–226: in French.)

2765. Correspondence on the Resistance to Earth of Water-Pipe Systems.—Krohne: Böninger. (*E.T.Z.*, 12th May 1938, Vol. 59, No. 19, pp. 510–511.)

VALVES AND THERMIONICS

2766. The Developmental Problems and Operating Characteristics of Two New Ultra-High-Frequency Triodes [RCA-888 (and -887, with Amplification Factor 10 instead of 30) and RCA-833].—W. G. Wagener. (*Proc. Inst. Rad. Eng.*, April 1938, Vol. 26, No. 4, pp. 401–414.)

2767. Research on the Magnetrons: S.F.R. Magnetrons for Ultra-Short Waves [Negative-Resistance, Transit-Time, and Multiple-Segment Types, and Their Efficiencies: Development of S.F.R. Magnetrons with Multi-Segment Prismatic Anodes, such that the Segments resonate Longitudinally like Lecher Wires.]—H. Gutton & S. Berline. (*Bull. de la S.F.R.*, No. 2, Vol. 12, 2nd Quarter 1938, pp. 30–46: in French and English concurrently.) *See* also 1354 of April. In the near future it is hoped to extend the wave-range down to 3 or 4 cm.

2768. THE MAGNETRON AND THE GENERATION OF ULTRA-SHORT WAVES [Objection to Suggested Use of a Cathode at Each End of Cylindrical Anode—Excessive Bombardment] —A. Helbig: G.W.O.H. (*Wireless Engineer*, May 1938, Vol. 15, No. 176, p. 268.) Prompted by the Editorial dealt with in 902 of March.

2769. "DAS VERHALTEN DER HABANNRÖHRE ALS NEGATIVER WIDERSTAND" [Behaviour of Habann (Magnetron) Valve as Negative Resistance: Berlin Thesis, 1938: 96 pp.].—F. S. Gundlach. (At Patent Office Library, London: Cat. No. 78 564.)

2770. FUNDAMENTALS OF THE MAGNETRON VALVE [Survey, with Particular Attention to the Electron Paths in the "Negative-Resistance" (Dynatron), "Rotating-Field," and "Transit-Time" Régimes].—H. Berger. (*Funktech. Monatshefte*, April 1938, No. 4, pp. 97–101.)

2771. THE INFLUENCE OF A HOMOGENEOUS MAGNETIC FIELD ON THE MOTION OF ELECTRONS BETWEEN COAXIAL CYLINDRICAL ELECTRODES.—Grünberg & Wolkenstein. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 8, 1938, pp. 19–36.) A German version was dealt with in 3308 of 1937.

2772. ON THE NEW VACUUM TUBE "SENTRON" FOR ULTRA-SHORT WAVES.—Uda, Uchida, & Sekimoto. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts pp. 21–22.) *See* also 2262 of June and back reference. A special type with an electron lens focusing the electrons into the anode cylinder (and giving good modulation characteristics) is mentioned.

2773. ON THE MOTION OF ELECTRONS IN AN ALTERNATING ELECTRIC FIELD [Theoretical and Experimental Investigation in connection with Multi-Grid Valves: Some Electrons can attain Greater Kinetic Energy than corresponds to Instantaneous Local Field: leading to a Special "Transit-Time" Rectifier].—K. S. Knol, M. J. O. Strutt, & A. van der Ziel. (*Physica*, May 1938, Vol. 5, No. 5, pp. 325–334: in English.)

So called because it will only work if the transit time in the second-grid/anode space is comparable with the period of the alternating voltage applied to the anode. The rectified current flows to the first grid, in pulses.

2774. EXPERIMENTAL INVESTIGATIONS ON ELECTRON KINETICS [where H.F. Field Cycle is comparable with Transit Time].—Müller. (*See* 2710.)

2775. SUPPLEMENTARY NOTE ON PAPER ON POWER AMPLIFICATION AT ULTRA-HIGH FREQUENCIES, AND THE LIMIT OF RETROACTIVE OSCILLATIONS [Explanation of Disagreement between Author's Expression for Input Resistance of Screen-Grid Valves and Llewellyn's Expression].—H. Zuhrt. (*Hochf: tech. u. Elek:akus.*, April 1938, Vol. 51, No. 4, pp. 135–138.)

For the paper in question *see* 2166 of 1937. There, the writer's formula was compared with those of Llewellyn (552 of 1936) and North (1450 of 1936), and with the measurements made by Ferris (1449 of 1936). It was found to agree well with the two latter but to disagree seriously with Llewellyn's expression. Correspondence has cleared up this discrepancy and showed that although the two treatments differ as to the introduction of the modulating voltage, and although this would, theoretically, produce a difference in results, in actual practice this difference is so small that it may be neglected if the electrode spacing is not extremely large; the discrepancy in question was due to inserting numerical values which were inapplicable to Llewellyn's formula.

2776. VARIATIONS OF THE AMPLIFICATION FACTOR AND PLATE RESISTANCE OF THERMIONIC VALVES AT HIGH FREQUENCIES [Experimental Investigation, with Curves: Factor increases from 20 to 45 for Frequency Increase from 120 kc/s to 2750 kc/s: Filament/Plate Resistance nearly Steady at 18 000 Ohms up to 1250 kc/s, rises to 42 500 Ohms at 5000 kc/s].—R. D. Joshi & R. G. Saxena. (*Sci. & Culture*, Calcutta, April 1938, Vol. 3, No. 10, pp. 569–570.)

2777. ON THE MODE OF ACTION OF A CYLINDRICAL DIODE ON THE APPLICATION OF A HIGH-FREQUENCY ANODE VOLTAGE.—G. Grünberg & A. Bliznjuk. (*Tech. Phys. of USSR*, No. 1, Vol. 5, 1938, pp. 3–18: in German.)

Continuation of the work dealt with in 1790 of 1936, which led also to the papers dealt with in 2196 of 1936 and 4115 of 1937. The present paper is the "Part II" referred to in the first abstract, and completes the treatment of the cylindrical diode. In Section 3 the case of a vanishingly thin cathode is considered: here all the relations become simplified and the solution is given by simple integrals. Among other results, it is shown that the negative real resistance component, which (as in the plane-parallel diode) can occur in certain conditions, rapidly decreases as the ratio anode-radius/cathode-radius increases, and becomes infinitely small when this ratio is sufficiently large.

2778. CURRENT CONDUCTION BY CONVECTION & DIFFUSION IN CYLINDRICAL ARRANGEMENTS.—Borgnis. (*See* 3039.)

2779. A NEW COLD-CATHODE GAS-TRIODE [Type OA4-G: a Starter-Anode Type Tube particularly for "Stand-Bi" of Remote Control System described by Kimball].—W. E. Bahls & C. H. Thomas. (*Electronics*, May 1938, Vol. 11, No. 5, pp. 14–16 and 72, 74.) *See* 1389 of April.

2780. A THEORY OF FLUCTUATION NOISE [Shot Effect and Thermal Agitation in Space-Charge-Limited Valve].—D. A. Bell. (*Journ. I.E.E.*, May 1938, Vol. 82, No. 497, pp. 522–532: Discussion pp. 532–536.)

"It is deduced that the noise . . . is best expressed as a thermal noise, and it is shown that a small correction must be applied to the valve slope resistance to give the value of resistance effective as a noise source. The theoretical temperature of this resistance is then shown to be approximately half the cathode temperature [*cf.* Rothe & Engbert, 1427 of April] . . . Shot noise and thermal noise in the valve's internal resistance are essentially the same phenomenon, but are modified by the differing conditions of electron transit . . ."

2781. FLUCTUATION NOISE IN THERMIONIC VALVES [made up of Thermal Noise in the Measured Resistance, *plus* Simple Shot Noise arising from Residual Current which is Temperature-Limited].—D. A. Bell. (*Nature*, 7th May 1938, Vol. 141, p. 833.)

2782. BACKGROUND NOISE PRODUCED BY VALVES AND CIRCUITS: Part I.—Percival & Horwood: Bell. (*Wireless Engineer*, May 1938, Vol. 15, No. 176, pp. 268–269.) Reply to Bell's criticisms (2336 of June).

2783. ON THE THEORY OF ELECTRON NOISE IN MULTIPLE-GRID VALVES.—W. Schottky. (*Ann. der Physik*, May 1938, Vol. 32, No. 1/2, pp. 195–204.)

Extending the theory of shot effect to include electron sharing between the anode and a positively charged grid. In the absence of a space change between cathode and control grid, anode noise is determined only by the anode current. When such a space change exists, conditions are intermediate between this condition and a second limiting condition, but in practice closely approach the latter, the full theory for which is given. The factor F characteristic of a space-change-limited triode is replaced by $\sqrt{F^2 + \alpha(1 - F^2)}$, where α is the proportion of the total current flowing to the screen grid.

2784. THE BACKGROUND NOISE OF VALVE AMPLIFIERS, PARTICULARLY OF THE RESISTANCE-CAPACITY TYPE.—Mandò. (*See* 2746.)

2785. ON THE HUM OF INDIRECTLY HEATED AMPLIFIER VALVES [and the Seriousness of the Component due to Leakage through Filament/Cathode Insulation].—W. Graffunder. (*Telefunken-Röhre*, April 1938, No. 12, pp. 46–63.)

Valve hum may be more troublesome than the combined noises of shot effect and thermal agitation, especially in narrow-band amplifiers liable to pick out the mains frequency and its harmonics. The writer describes his experimental (c-r oscillographic) investigation of the various causes of valve hum: these are (a) static grid hum, chiefly due to the capacity of the filament-ends to the grid: occasionally (chiefly in valves with grids led out at the bottom) due to inadequate filament/grid insulation; (b) static anode hum, analogous to (a); (c) induction hum, due to the action of the heating-current leads on the various electrode connections; (d) magnetic hum, due to the filament stray field acting on the electrons; and (e) insulation hum, due to the conductivity of the insulating layer between filament and cathode.

In a valve with grid led out at the top, (c) and (e) are the predominant components. The induction hum cannot be dealt with by the anti-hum potentiometer: it can be reduced by careful disposition and twisting of the heating-current leads. If the heating-current frequency is increased (500 c/s or "chopper" current) the effect of induction hum predominates: anode and grid hums also increase with the frequency, but are eliminated by the potentiometer, leaving the induction hum. All these three components have their phase at right angles to the filament-current phase, and therefore appear on the screen as ellipses with horizontal axes.

Insulation hum gives a completely irregular trace on the screen, owing to the non-linearity of the current/voltage characteristic of the filament/cathode insulating layer (Figs. 16 & 17). It cannot be eliminated by the potentiometer, though a more or less sharp minimum can be obtained. The leakage current producing the hum can be reduced considerably by the use of a lower cathode temperature, and by the introduction of a d.c. biasing voltage between filament and cathode such that the horizontal part of the current/voltage curve of the insulation resistance is involved (*cf.* German patents Nos. 620 770 & 641 001): the best value seems to be +80 v on the filament. Even valves with unsatisfactory insulation can be freed almost completely from insulation hum by this device.

2786. ON "REGULATING CHARACTERISTICS" [of Variable-Mu Valves for AVC: the Question of the Best Shape of Curve].—W. Kleen & K. Wilhelm. (*Telefunken-Röhre*, April 1938, No. 12, pp. 1–6.)

The three qualitative properties to be demanded of a valve used for a.v.c. are: (1) small non-linear r.f. distortion, (2) as steep as possible an initial slope, in the un-regulated régime, with not too large a standing current, and (3) a high regulating activity with low requirements in regulating voltage. If definite conditions are laid down as to the magnitude or amplitude-dependence of the r.f. distortion, the shape of the curve follows analytically, except for constants. In such r.f. distortion two types must be distinguished: "modulation-distortion," occurring for a signal on the grid, and "cross-modulation" (Wilhelm, 152 of 1936) depending on the presence of an interfering signal: a measure for the former is given by the modulation factor (or "modulation deepening"), for the latter by the "cross-modulation factor." Both these factors are proportional to the ratio of the third to the first derivative of the current with respect to the grid voltage.

If it is demanded that both modulation-distortion and cross-modulation should be zero, independent of the working point, this requirement is satisfied by a quadratic characteristic of the form

$$I_a = I_0 + a(V_g - V_{g0}) + b(V_g - V_{g0})^2,$$

of which the third derivative is always zero. Such a characteristic, however, fails to satisfy condition (3), as is seen in Fig. 1: a curve must be chosen whose slope changes more quickly than linearly with grid voltage, although at the cost of some distortion.

The logarithmic characteristic (curve 1 of Fig. 2), of Ballantine & Snow's original equation, gives a modulation-distortion which is independent of the working point *provided the anode alternating voltage depends only on the depth of modulation* of the signal and not at all on the carrier amplitude. This can only happen if a separate amplifier is provided to give the regulating voltage ("parallel" a.v.c.):

in all other cases the curve must be modified as in curve 2 of Fig. 2 if the modulation-distortion is to remain constant whatever the working point (but *see* also Footnote 7).

On the other hand, among the various phenomena due to the non-linearity of the valve characteristic perhaps the most unpleasant is cross-modulation, and it is very desirable that this should be constant whatever the working point. This is attained by the exponential characteristic of Fig. 3 (curve 1) given by $I_a = I_{a0}\epsilon^{V_g/V_T}$. The magnitude of V_T determines the absolute value of the cross-modulation, but unfortunately as V_T increases (thus reducing the cross-modulation) the necessary regulating voltage increases also and the initial slope decreases. Conditions (2) and (3) are therefore in opposition, and a compromise is necessary: this can be accomplished by making V_T smaller at the top end of the curve, increasing the initial slope as shown at "2" in Fig. 3. This has also the effect of rendering the modulation-distortion (which for a true exponential characteristic would increase as the square of the grid alternating voltage) less dependent on the input voltage. The fact that in practice the curve is found to depart from the exponential shape at the bottom end also ("3" in Fig. 3) is not deliberate but an unavoidable result of construction: this branch causes great modulation-distortion and should be kept out of action.

2787. ON THE THEORY OF VALVES WHOSE GRID/CATHODE SPACING IS SMALLER THAN THE PITCH OF THE GRID [as in Variable-Mu Valves]. — L. Oertel. (*Telefunken-Röhre*, April 1938, No. 12, pp. 7–17.)

The calculation of the characteristic of a triode whose grid has a constant pitch is easily accomplished by replacing it by an "equivalent" diode. The coefficients of the linear relation between the control-voltage of the diode and the electrode-voltages of the triode are functions of the "durchgriff." But this replacement is only valid if the field-strength distribution at the cathode of each valve (triode and equivalent diode) is practically identical, and this is only the case when the grid/cathode distance is large compared with the grid pitch. In the design of modern valves, and particularly of variable-mu valves, it is often essential to go below this minimum distance; it is therefore necessary to extend the calculation to cover this case.

The writer, dealing first with a plane-electrode arrangement and then with cylindrical electrodes, derives in each case an extended formula for the "durchgriff" which is valid for all conditions likely to be encountered, and which passes, for large grid/cathode spacing, into the older formulae of Ollendorf and Elias respectively. These results, utilised in the "sub-dividing" way described by Scheel & Marguere (1934 Abstracts, pp. 324–325), enable the characteristic curves to be calculated with sufficient accuracy for practical purposes. Incidentally, the calculated curves given at the end of the paper give clear indication of the advantages brought by the use of a thin wire for the grid: the thinner the wire, the more homogeneous the field for the same grid/cathode spacing and the same "durchgriff," and the less the effect of a displacement of the grid by ± 20% (such as by a crooked fixing of the cathode in assembling).

2788. "DER KENNLINIENVERLAUF BEI VERSTÄRKERRÖHREN MIT VERÄNDERLICHEM DURCHGRIFF" [The Shape of the Characteristic Curves of Variable-Mu Amplifier Valves: Charlottenburg Thesis, 1938: 34 pp.].—H. E. W. Richard. (At Patent Office Library, London: Cat. No. 78 557.)

2789. THE ANODE CURRENT IN THE CLASS B AMPLIFIER, TAKING INTO ACCOUNT THE BOTTOM BEND OF THE CHARACTERISTIC.—R. Gürtler. (*Telefunken*, March 1938, Vol. 19, No. 78, pp. 15–22.)

If the bottom bend is parabolic and merges tangentially into straight lines (as in Fig. 20), amplification will be linear: only even higher harmonics will occur, and these will be eliminated in push-pull Class B amplifiers with transformer output, and cause no distortion. The water-cooled Telefunken amplifiers for powers ranging from 10 to 200 kw, such as the 10 kw Type RS 261, have something very near to this characteristic: *see* Fig. 18, in which the anode current up to 1.2 A is plotted on a scale of squares, but above 1.2 A on a linear scale: both parts of the curve come out as straight lines, the two scales being so chosen that these lines have the same slope and thus make one continuous straight line. The case of the RS 261 is dealt with fully.

2790. INVESTIGATIONS ON THE SELECTING OF AMPLIFYING VALVES [and the Estimation of Distortion].—M. Harnisch & W. Raudorf. (*E.N.T.*, March 1938, Vol. 15, No. 3, pp. 65–70.)

Development of a simple method for estimating distortion produced by a triode amplifier by inspection of the characteristics, and the introduction of a numerical "factor of merit" as a criterion for selecting individual valve types. Equations 7a, 8 & 8a express the "distortion factor" in terms of known valve constants and a quantity b, where $D = a + b \, . \, u_g/u_a$ (D = "durchgriff"). For an ideal triode, $b = 0$ and the "durchgriff" is constant. For any practical valve, the value of b may be taken as a guide to its value as a distortionless amplifier. The theory applies also to screen-grid valves with low load resistances.

2791. CALCULATION OF THE WORKING DATA FOR PENTODE TRANSMITTING VALVES [to give Maximum Anode Power Output].—V. Babits. (*Elektrot. u. Masch:bau*, 24th April 1938, Vol. 56, No. 17, pp. 220–223.)

2792. CATHODE-RAY OSCILLOGRAPH APPLICATIONS: THE TRACING OF VALVE CHARACTERISTICS.—H. F. Mayer. (*Electronics*, April 1938, Vol. 11, No. 4, pp. 14–16.)

2793. NEW MEASURING METHODS FOR OUTPUT VALVES [made necessary by Failure of "Klirr"-Factor Method to give Results corresponding to Practical Experience].—P. Wolf. (*Telefunken-Röhre*, April 1938, No. 12, pp. 64–71.)

(i) Static characteristic recorder (with c-r oscillograph) without damage to valve, by intermittent (1 : 15) loading by rotating commutator, the spare 14/15ths of the time being utilised to eliminate various c-r-tube errors (zero-point anomalies, sensitivity varying with deflection, etc.) by superposing a fixed system of axes giving current and voltage, and also a second system in which each axis can be displaced by directly-read biasing voltages, calibrated to give current and voltage. The instrument is illustrated in Figs. 1, 2, & 3.

(ii) Delineation and measurement of linear distortion by the method of Wilhelm & Kettel (2686 of 1936): this method has proved exceptionally useful, and some results are described.

(iii) The use of the Siemens note-frequency spectrometer (Freystedt, 1474 of 1936).

(iv) The automatic test-bench "klirr"-factor bridge embodying the indirectly-heated Urdox resistance (1433 of April).

2794. Heat Transfer by Radiation, and the Calculation of Grid Temperatures in Wireless Valves [Analysis, with "Idealised" Grid replacing Practical Grid: Calculated and Measured Values differ by Less than 4%].—S. Wagner. (*Forschung auf dem Geb. des Ingenieurwesens*, Nov./Dec. 1937, Vol. 8, No. 6, pp. 314–315.)

2795. The Dissipation of Energy from Receiving Valves [and Its Effect in Heating the Components in a Receiver Chassis: Metal *versus* Glass Valves: etc.].—K. Mie. (*Telefunken-Röhre*, April 1938, No. 12, pp. 18–45.)

The heat dissipation of the modern power output valve and rectifier is an important question in a receiver whose complicated components—band filters and so on—have a marked temperature dependence. If frequency disturbances, excess damping effects, etc., are to be avoided, these sensitive components must be kept away from the heat sources; the space requirements of such valves are therefore not merely dependent on their geometrical dimensions. The thermometric and radiometric investigations here described lead to the conclusion, "at first sight surprising," that for equally heavy loading, in an ordinary design of chassis, the geometrically small "metal" valve has a larger space requirement than the geometrically bigger glass-bulb valve: this is because the latter dissipates its energy losses more "favourably"—more upwards and less sideways. This radiation distribution is elaborately investigated for various valves and various conditions of loading.

The main conclusion reached is that while "metal" construction has its distinct advantages for r.f. valves, where the special possibilities of metal technique can be used to give greater stability of construction, there is no justification for departing from the glass bulb for highly loaded output valves and rectifiers, now that the present investigation has destroyed the last argument in favour of metal envelopes for such valves—the fiction of smaller space requirement.

2796. The Assumption of Constant Capacity in the Estimation of the Amplification attainable with a Valve in Wide-Band Amplifiers.—Pieplow: Kleen. (*See* 2896.)

2797. Harmonic Generation.—Scott & Black. (*See* 2702.)

2798. A Thyratron Impulse Generator [4–200 per Second, Duration 3–100% of Time of Complete Cycle: up to 1000 Volts: primarily for Research on Thermionic Emission].—B. G. Pressey. (*Journ. Scient. Instr.*, May 1938, Vol. 15, No. 5, pp. 163–171.)

2799. Drift of Adsorbed Thorium on Tungsten Filaments heated with D.C. [Suggestion that Thorium Ions drift along the Wire Surface towards the Negative End].—R. P. Johnson. (*Phys. Review*, 1st May 1938, Vol. 53, No. 9, p. 766.)

2800. Photoelectric and Thermionic Investigations of Thoriated Tungsten Surfaces [Photoelectric and Thermionic Work Functions Not Equal for a Non-Uniform Surface].—A. King. (*Phys. Review*, 1st April 1938, Vol. 53, No. 7, pp. 570–577.)

2801. Oxide-Coated Cathodes: I—Particle Size and Thermionic Emission [Emission increases as Particle Size decreases: Size of Particles is determined by Method of Preparation of Carbonates from which Oxide is derived].—M. Benjamin, R. J. Huck, & R. O. Jenkins. (*Proc. Phys. Soc.*, 2nd May 1938, Vol. 50, Part 3, pp. 345–357.)

2802. On "Field Electron Emission" from Thin Insulating Layers of the Type Al—Al_2O_3—Cs_2O [Secondary Emission from a Cathode of This Type produced by Positive Ion Bombardment].—J. Mühlenpfordt. (*Zeitschr. f. Physik*, April 1938, Vol. 108, No. 11/12, pp. 698–713.)

2803. Electron-Optical Observation of the Ionic and Electronic Emission from Wire-Shaped Sources [Electron Emission studied normally, on Electron Microscope Principle: Ionic Emission similarly, after Transformation to Electronic Emission at a Secondary-Emitting Metal Surface, in order to prevent Damage of Viewing Screen by Prolonged Ionic Bombardment.].—Mahl. (*Zeitschr. f. Physik*, April 1938, Vol. 108, No. 11/12, pp. 771–776.)

2804. Electron Emission by Positive Ion Bombardment of the Cathode of a Glow Discharge [Cathode coated with Layers of Various Oxides: always increases Emission: Application to Study of Building-Up and Disintegration of Oxide Layers].—Güntherschulze & Betz. (*Zeitschr. f. Physik*, April 1938, Vol. 108, No. 11/12, pp. 780–785.)

DIRECTIONAL WIRELESS

2805. Reflection at a Stratified Medium [in connection with Echo-Sounding Altimeter Devices for Aircraft, using Ultra-Short Waves].—W. Pfister & O. H. Roth. (*Hochf: tech. u. Elek:akus.*, May 1938, Vol. 51, No. 5, pp. 156–162.)

"The various methods of altitude measurement with electric waves all use the earth's surface as reflector, in order to make use of either the amplitude or phase of the reflected energy for measuring purposes. It is clear that this is only possible if the reflected component never sinks below a certain minimum value corresponding to the sensitivity of the receiver. Practical tests made with such apparatus have shown, however, that this requirement is by no means always fulfilled, and that, under otherwise similar conditions as regard place and time, widely differing results may be obtained. The same sort of thing is found in other fields: thus in propagation measurements certain localities are repeatedly found where the field strength shows abnormally small values, so that in some cases radio communication is impossible with certain stations. Both these occurrences show clearly that only the composition of the earth can be answerable for the results. In the following pages this problem will be dealt with, first theoretically, and then by a report on some investigations, with a wave of 14 cm, on reflection at a stratified medium, which show a new possibility of determining the electrical constants ϵ and σ of the earth. Finally some practical examples, of particular importance for altitude measurement, are worked out."

The general equations obtained with the help of optical methods in section II (the agreement with the results of Dallenbach & Kleinsteuber—*ibid.*, pp. 152–156—is mentioned) are applied in section III to the simplified condition encountered in the experimental work, namely a third medium consisting of sheet iron, for which eqn. 12 becomes further simplified, since now, for horizontal polarisation, $C = +1$ and $\gamma = 180°$. Figs. 3–6 are thus calculated: they are all for vertical incidence, and show, for various values of ϵ and as functions of d/λ (where d is the thickness of the second layer), the course of the "boundary curves" enveloping, with sufficient accuracy, the building-up and the decaying interference lines. Each diagram shows a family of such curves, for various values of $S(=60\sigma\lambda)$. Fig 7, also for vertical incidence, takes a definite medium ($\epsilon = 2$, $S = 1.5$) and shows the calculated course of the field-strength fluctuation for 8, 14, and 20 cm waves. It makes clear that a minimum of the field-strength curve need by no means coincide with a minimum of the lower "boundary curve": the two minima coincide only for definite wavelengths (*e.g.* 14 cm). "Thus it is necessary, after calculating the boundary curve, to construct also the actual course of the field-strength curve, in order to deduce from its position the maximum fluctuation of field strength. Conversely, a known course of field-strength curve gives the possibility of determining the electrical constants ϵ and σ" (last paragraph of section III: practical examples on p. 160). Fig. 8 shows the course of the "boundary curves" as a function of the angle of incidence, for a particular medium.

The 14 cm-wave tests were carried out on water (in a metal bath) and on sand (in a metal tray). Figs. 9–13 show the results, for various angles of incidence: curve 1 in each case gives the measured values, curves 2 & 3 the calculated. Finally, in section V, "since it has been shown that the theory gives a good agreement with the experiments," some practical cases of interest for altitude determination are calculated, for vertical incidence only and for a wavelength of 1.5 m: these are dry-ground/water, dry-ground/wet-ground, ice/water, and water/asphalt. The last case (Fig. 18) is of special interest, representing as it does the conditions often occurring on aerodromes after heavy rain. Since $\epsilon_3 < \epsilon_2$, this diagram, unlike the others, has no minimum in the lower boundary curve. Since the reflecting power of the water is high, the absorption of the penetrating component great, and the reflecting power of the asphalt very small, very little energy returns to the first medium, so that the amplitude of the interference curve is very small (broken line: the dotted interference curve is for a wave of 15 cm).

2806. Results with Pulse and Adcock Ground Direction-Finders.—F. Böttcher. (*Luftwissen*, Aug. 1937, Vol. 4, No. 8, pp. 243–247.)

Exhaustive comparisons are described of frame direction-finders using pulse transmission from aircraft, with visual indication on a cathode-ray tube, and an **H** Adcock system using normal transmission and aural reception. It is concluded that the Adcock system is much superior, definitely overcoming night and twilight effects and being suitable for 24-hour operation at aerodromes. The Adcock system was also much less disturbed by interference: the percentage of test transmissions on which bearings could not be taken owing to interference was for either system in daylight 3%, for the Adcock at night 0.5%, and for the frame-and-pulse system at night 20%.

2807. Comparison of Modulated Transmissions with and without Carrier Wave for the Service of Maritime Radio-Beacons [where Frequency Band is Limited: Theoretical Treatment with Experimental Verification: Suppressed Carrier System has No Advantages, the Decreased Band Width occupied being countered by the Greater Strength necessarily given to the Two Components to obtain Equal Signal Strength after Detection].—J. Marique. (*L'Onde Élec.*, April 1938, Vol. 17, No. 196, pp. 174–194.)

2808. The Santucci Radio Course Indicator [with Double Rotating Frames, One acting as Radio Compass, the Other responding to Earth's Magnetic Field: combining so that Constant Indicator Reading shows Aircraft to be following Given Ground Course].—Santucci. (*Journ. des Télécommunications*, Nov. 1937, Vol. 4, No. 11.) In a paper (pp. 301–307) on the Application of Wireless to Aerial Navigation.

2809. Aircraft Radio Compass [with 30 cm Ring Aerial rotating 5 r.p.s. and Synchronised Generator].—H. Colberg. (*Zeitschr. f. Fernmeldetech.*, No. 3, Vol. 19, 1938, pp. 38–40: with photographs.) *Cf.* Busignies, 549 of 1937.

2810. The Simon Static-Free Radio Direction Finder, *and* The Simon Radio Guide.—Simon. (*American Aviation*, 15th March 1938, Vol. 1, No. 20, p. 16: *Aero Digest*, April 1938, Vol. 32, No. 4, p. 72.)

2811. Radio Emergency Procedure [Suggestions based on Experience of Air Liner which lost Its Bearings].—H. W. Roberts. (*Aero Digest*, March 1938, Vol. 32, No. 3, pp. 27 and 160, 161.)

2812. From the Early History of Wireless Directional Telegraphy, especially as regards Direction Finding.—F. Kiebitz. (*Telefunken*, March 1938, Vol. 19, No. 78, pp. 5–15.)

ACOUSTICS AND AUDIO-FREQUENCIES

2813. Negative-Feedback Loudspeaker [High Fidelity easier to obtain in Microphone than in Loudspeaker (because of Latter's Large Output): therefore Special High-Fidelity Microphone picks up Part of Loudspeaker Output and feeds back through Inverse-Feedback Circuit (Transfer Factor much Greater than Unity): Final Output determined by Characteristics of Feedback Circuit and Microphone, instead of by Loudspeaker Characteristic].—Y. Otuka. (*Electrot. Journ.*, Tokyo, May 1938, Vol. 2, No. 5, p. 120.)

2814. On the Relaxation Time in Seignette [Rochelle] Salt Crystals: II [Piezoelectric Modulus, Not the Dielectric Constant, follows Debye Function of Frequency].—R. D. Schulwas-Sorokin. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 12, 1937, pp. 685–700: in English.) Continuation of the work dealt with in 1482 of 1935.

2815. The Effect of Hydrostatic Pressure on the Susceptibility of Rochelle Salt.—Bancroft. (*See* 2927.)

2816. Ribbon Microphones: the Underlying Principles of Their Design.—F. W. Alexander. (*World-Radio*, 13th May 1938, Vol. 26, pp. 10–11.)

2817. On the Distortion of an Acoustic Field by a Solid Sphere.—H. Stenzel. (*E.N.T.*, March 1938, Vol. 15, No. 3, pp. 71–78.)

2818. The Indicial Functions of the Simplest Sound Sources.—A. Kharkevich. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 8, 1938, pp. 83–91.)

2819. Undertones [Sub-Harmonics: Experimental Study of Their Generation in Telephones, Microphones, Strings, etc., with Approximate Theory].—E. Waetzmann & R. Kurtz. (*Ann. der Physik*, April 1938, Vol. 31, No. 7, pp. 661–680.)

2820. Demonstration of Sub-Harmonics [and a Refutal of the Old Idea of Their Practical Unimportance].—E. Waetzmann. (*Akust. Zeitschr.*, May 1938, Vol. 3, No. 3, pp. 130–131.)

2821. Improvement in the Applications of the Gramophone to the Study of Foreign Languages (Routin System).—Routin. (*Recherches et Inventions*, April 1938, No. 275, pp. 86–89.) *See* also 1467 of April.

2822. A Method of Periodical Sound Reproduction [for Several Million Repetitions—"Speaking Clocks," etc.].—T. Korn. (*Electronics*, May 1938, Vol. 11, No. 5, pp. 38, 40.) For the full German paper *see* 4144 of 1937.

2823. Testing Ribbon Microphones.—D. E. L. Shorter. (*World-Radio*, 20th May 1938, Vol. 26, pp. 12–13.)

2824. New Magnetic Telephone [alternately as Transmitter and Receiver: Pivoted Armature: Magnet of Remalloy].—G. E. Atkins. (*Bell Lab. Record*, April 1938, Vol. 16, No. 8, pp. 282–284.)

2825. Characteristic Time Intervals in Telephonic Conversation.—A. C. Norwine & O. J. Murphy. (*Bell S. Tech. Journ.*, April 1938, Vol. 17, No. 2, pp. 281–291.)

2826. Selecting Speech-Input Units [for Broadcasting Equipment].—J. P. Taylor. (*Communications*, April 1938, Vol. 18, No. 4, pp. 7–10 and 32 . . 38.)

2827. Correcting Line Distortion [with Some Typical Line Characteristics and Equaliser Circuits].—H. B. Rantzen. (*World-Radio*, 22nd April 1938, Vol. 26, pp. 14–15.) By the Head of Lines Department, B.B.C.

2828. Investigations on the Time of Transit in Four-Terminal Networks and the Use of the Gliding-Frequency Method [especially to measure Least Perceptible Differences in Time of Transit].—W. Bürck & H. Lichte. (*E.N.T.*, March 1938, Vol. 15, No. 3, pp. 78–101.)

2829. The Disturbing Effect of Non-Linear Distortion.—von Braunmühl & Weber. (*World-Radio*, 29th April 1938, Vol. 26, pp. 10–11.) Abridged translation of the paper dealt with in 1483 of April and back reference.

2830. On the Binaural Effect in Broadcasting and Sound Films (Stereosound).—M. Z. Vysotski & V. N. Konoplev. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 8, 1938, pp. 399–407.)

A survey of literature on the subject is given and also an account of experiments carried out in the U.S.S.R., particularly with sound films. It is stated that in a cinema very realistic stereophonic effects are obtained using two sound tracks each feeding a separate loudspeaker. This compares with American experience for wire transmission from Philadelphia to Washington, where, in the absence of vision, three sound channels were found desirable.

2831. Reverberation Control in Broadcasting [and the Columbia Use of a Labyrinth-Type Reverberation Chamber].—H. A. Chinn. (*Electronics*, May 1938, Vol. 11, No. 5, pp. 28–29.)

2832. Control-Room Switching.—J. G. Sperling. (*Communications*, April 1938, Vol. 18, No. 4, pp. 11–14.)

2833. The Acoustics of the New Théatre du Trocadéro.—Ch. Ed. Sée. (*Génie Civil*, 21st May 1938, Vol. 112, No. 21, pp. 428–430.)

2834. The Electrical Equipment of the Broadcasting Studios of the Poste-Parisien Station.—M. Adam. (*Rev. Gén. de l'Élec.*, 30th April 1938, Vol. 43, No. 18, pp. 557–567.)

2835. Acoustical Measurements on Concert Halls [Various Swiss Halls: including Use of Orchestra itself as Sound Source: Measurements for Empty and Full Hall: Estimation of Equivalent Absorption per Person: etc.].—W. Furrer. (*Elektrot. u. Masch:bau*, 1st May 1938, Vol. 56, No. 18, pp. 241–242: summary only.)

2836. The Acoustical Design of Broadcasting Studios.—J. McLaren. (*World-Radio*, 6th May 1938, Vol. 26, pp. 14–15.)

2837. The Prevention of the Transmission of Sound along Water Pipes [by Insulating Rubber Sections], *and* The Transmission of Sound in a Building by Indirect Paths.—J. E. R. Constable. (*Proc. Phys. Soc.*, 2nd May 1938, Vol. 50, Part 3, pp. 360–367: pp. 368–373.)

2838. The Insulation of Buildings against Noise.—(*Génie Civil*, 21st May 1938, Vol. 112, No. 21, p. 442: notice of a 7-chapter article in the journal *Acier*.)

2839. [Expanded] Mica Pellets for Insulation.—Schundler Company. (*Scient. American*, May 1938, Vol. 158, No. 5, pp. 298–299.)

2840. Cornstalk Acoustical Board [Absorption 21–36% at 512 c/s, increased to 95% by boring 225 Holes per Sq.Foot].—(*Electronics*, April 1938, Vol. 11, No. 4, pp. 52–53.)

2841. The Determination of the Absorption Factor for Oblique Incidence [including Special Advantage of Use of 45° or 54° 44′].—K. Schuster. (*Akust. Zeitschr.*, May 1938, Vol. 3, No. 3, pp. 137–140.)

2842. A Recording System for Transmission Measurements [High Recording Speed by Absence of Contact with Paper: Electrically Heated Wire moving near Heat-Sensitive Paper].—P. F. Jones. (*Bell Lab. Record*, April 1938, Vol. 16, No. 8, pp. 289–294.)

2843. Modern Measuring Methods in Communication Technique.—Tamm. (*See* 2935.)

2844. New Methods and Apparatus for the Measurement of Industrial Noises.—Navjazhskij & Suponin. (*Journ. of Tech. Phys.* [in Russian], No. 3, Vol. 8, 1938, pp. 243–251.)

2845. Investigations on the Noise of Aircraft Propellers.—W. Ernsthausen. (*Akust. Zeitschr.*, May 1938, Vol. 3, No. 3, pp. 141–146.)

2846. Noise Interference in the Transmission of Speech over Lines [External, including Power Lines and Wireless Stations: Internal, including Microphone and Thermal-Agitation Noises].—W. Wild. (*E.T.Z.*, 14th April 1938, Vol. 59, No. 15, pp. 385–388: Discussion pp. 405, 407.)

2847. The AEG Heterodyne Oscillation Generator [1 Watt Output, 20 c/s to 20 kc/s].—E. Furbach. (*AEG-Mitteilungen*, March 1938, No. 3, pp. 125–127.)

2848. Experiments with a Sound-Wave Generator of High Power [Frequencies 300–600 c/s].—F. Bruns. (*Akust. Zeitschr.*, May 1938, Vol. 3, No. 3, pp. 147–153.)

2849. Sustaining Longitudinal Vibrations in Rods [by Air Jet, using Bernoulli Effect: Deafening Volume of Sound obtainable].—E. H. Johnson. (*Science*, 15th April 1938, Vol. 87, p. 351.)

2850. Recent Problems in Sound Research [Short Survey of Sound-Analysis Methods, and Results on Speech and Musical (particularly Organ) Sounds].—F. Trendelenburg. (*E.T.Z.*, 5th May 1938, Vol. 59, No. 18, pp. 475–480.)

2851. "Science and Music," *and* "Music and Sound" [Book Reviews].—J. Jeans: Ll. S. Lloyd. (*Review Scient. Instr.*, April 1938, Vol. 9, No. 4, pp. 116–117: p. 118.)

2852. On the Problem of Stroke Excitation of a Piano String.—N. Jakovlev. (*Journ. of Tech. Phys.* [in Russian], No. 3, Vol. 8, 1938, pp. 271–274.)

2853. Investigation of Wave Phenomena on Models using Ultrasonic Waves [Wave Pictures of Diffraction, Interference, Reflection from Surfaces of Complicated Shape, etc., by Töpler's Method of Striae, with Stroboscopic Viewing by Kerr Cell].—S. Kretschmer & S. Rschevkin. (*Tech. Phys. of USSR*, No. 11/12, Vol. 4, 1937, pp. 1004–1019: in English.)

2854. An Investigation of Complex Supersonic Fields by an Optical Method using a Point Light Source.—I. T. Sokolov. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 8, 1938, pp. 408–409.)

In this investigation the optical system proposed by Debye & Sears (1932 Abstracts, p. 576) was used, but the beam of light was passed through a small circular aperture (0.3 mm diam.) instead of a slot. The oscillating crystal was immersed in a transparent bath containing vaseline oil, and in order to obtain complex fields various reflectors and absorbers were also immersed in the bath. A number of photographs are shown obtained for different conditions and frequencies ranging from 424 to 1205.35 kc/s.

2855. On the Transparency of Solid Plates [of Iron & Steel] to Supersonic Waves.—E. Baumgardt. (*Comptes Rendus*, 2nd May 1938, Vol. 206, No. 18, pp. 1284–1286.)

2856. The Production of Damage to Materials [*e.g.* for Turbines] through Cavitation by Rapid Oscillations of Solid Bodies in Liquids [produced by Magnetostriction].—Peters, Kerr, & others. (*Zeitschr. V.D.I.*, 7th May 1938, Vol. 82, No. 19, pp. 557–558.)

2857. Simple Material Testing with Magnetostrictive Supersonic-Wave Apparatus [Investigation of Cracks in Concrete Beams; Setting of Cement Mixtures; Sound Fields parallel to Surface of Absorbing Materials].—E. Meyer & G. Buchmann. (*Akust. Zeitschr.*, May 1938, Vol. 3, No. 3, pp. 132–136.)

2858. Absorption of Ultrasonic Waves by Organic Liquids [Experiments on 21 Liquids, in Range 3–16 Mc/s: Conclusions].—S. Parthasarathy. (*Current Science*, Bangalore, April 1938, Vol. 6, No. 10, pp. 501–502.)

2859. The Determination of the Absorption of Ultrasonic Vibrations in Solid and Liquid Media [Improved Method based on Sokolov's Procedure for detecting Internal Defects in Metals: Results disagree with Theoretical Formula].—N. F. Otpushtshennikov. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 12, 1937, pp. 736–744: in English.)

2860. Absorption of Supersonic Waves in Liquids by an Optical Method [Study of Absorption as a Function of Frequency in the Range 6 to 75 Mc/s for Benzol: Absorption at the Higher Frequencies for Certain Other Liquids].—H. Grobe. (*Physik. Zeitschr.*, 15th April 1938, Vol. 39, No. 8, pp. 333–338.)

2861. A Precision Method of High Absolute Accuracy for the Determination of Velocity of Supersonic Waves in Liquids [by Optical method: Accuracy of Frequency Measurement 5×10^{-6}, of Velocity Measurement 6 to 7×10^{-5}: Temperature Coefficients of Velocity in Various Organic Liquids measured over Range 23 to 27°C].—N. Leifen. (*Zeitschr. f. Physik.*, April 1938, Vol. 108, No. 11/12, pp. 681–697.)

2862. Sound Absorption in Gases for Frequencies between 20 and 100 kc/s.—N. Schmidtmüller. (*Akust. Zeitschr.*, May 1938, Vol. 3, No. 3, pp. 115–129.)

PHOTOTELEGRAPHY AND TELEVISION

2863. Equipment and Methods developed for Broadcast Facsimile Service ["Home Newspaper"], *and* Home Newspapers by Radio.—C. J. Young: F. C. Ehlert. (*RCA Review*, April 1938, Vol. 2, No. 4, pp. 379–395: *Communications*, May 1938, Vol. 18, No. 5, pp. 7–9 and 35.)

2864. Effect of the Receiving Antenna on Television Reception Fidelity [Interference between Direct and Reflected Signals, Its Results and Its Prevention].—S. W. Seeley. (*RCA Review*, April 1938, Vol. 2, No. 4, pp. 433–441.)

2865. The Monoscope.—C. E. Burnett. (*RCA Review*, April 1938, Vol. 2, No. 4, pp. 414–420.) A summary was referred to in 1097 of March.

2866. The Monotron *and* The Phasmajector [for Generation of Test Image Signals for Servicing, etc.].—National Union: DuMont. (*Communications*, April 1938, Vol. 18, No. 4, p. 26: p. 30 and 35.) *See* also 2448 of June and back reference.

2867. Directly-Viewed Large Pictures: Details of the World's Largest Cathode-Ray Tube [Screen Diameter 31": Picture 18" × 24"].—RCA. (*Television*, May 1938, Vol. 11, No. 123, pp. 265–266.) Referred to in 2446 of June.

2868. Television in U.S.S.R. [including Project of Relaying by Land-Line to 500 Subscribers from Each Relay Point].—(*World-Radio*, 13th May 1938, Vol. 26, p. 9.) *Cf.* 2453 of June.

2869. "High Definition" [Five Photographic Reproductions of Television Images].—(*Electronics*, April 1938, Vol. 11, No. 4, p. 32.)

2870. The London Television Service, *and* The Marconi-E.M.I. Television System [with Reasons for Adoption of Present Standards].—Macnamara & Birkinshaw: Blumlein, Browne, & others. (*Electrician*, 22nd April 1938, Vol. 120, pp. 509 and 508: summaries of I.E.E. papers.) For Discussion see *ibid.*, 29th April, p. 534. A long summary of the second paper is given in *Television*, May 1938, Vol. 11, No. 123, pp. 284–287; a similar summary of the first is begun in the June number.

2871. The New Television Transmitting Centre of the Eiffel Tower, Paris.—M. Adam. (*Génie Civil*, 14th May 1938, Vol. 112, No. 20, pp. 413–416.) *See* also *Television*, May 1938, Vol. 11, No. 123, pp. 261–264, and Editorial on p. 259.

2872. The Standardisation of the German Television Service: the New Standard Synchronising Signal.—F. Banneitz. (*Funktech. Monatshefte*, April 1938, No. 4, Supp. p. 27.) For a previous paper *see* 612 of February.

2873. Television Standards [Two New Items and Two Changes of Wording].—R.M.A. Television Committee. (*Communications*, April 1938, Vol. 18, No. 4, pp. 14 and 35.) *See* A. F. Murray's article, 1061 of March.

2874. Present-Day Television Technique [Lecture to E.V. in Vienna].—F. Schröter. (*Elektrot. u. Masch:bau*, 1st May 1938, Vol. 56, No. 18, pp. 229–238.)

2875. Television Transmission Technique: I—Fundamental Conceptions and Definitions.—F. Ring. (*Funktech. Monatshefte*, April 1938, No. 4, Supp. pp. 28–30.) First of a series.

2876. TELEVISION RECEIVERS: FUNDAMENTAL FACTORS OF DESIGN AND OPERATION.—E. W. Engstrom & R. S. Holmes. (*Electronics*, April 1938, Vol. 11, No. 4, pp. 28–31 and 63 . . 66.) The first of a new series from the RCA Manufacturing Company.

2877. "LA TÉLÉVISION" [Book Review].—M. Chauvièrre. (*Rev. Gén. de l'Élec.*, 30th April 1938, Vol. 43, No. 18, pp. 545–546.)

2878. "FERNSEHEN" [Book Review].—F. Schröter & others. (*Electronics*, May 1938, Vol. 11, No. 5, p. 30.) Collection of 8 lectures given in 1936 and dealt with in previous abstracts (*e.g.* 1473 of 1937).

2879. QUANTITATIVE CONSIDERATIONS ON PROJECTED TELEVISION RECEPTION WITH CATHODE-RAY TUBES.—K. Diels & G. Wendt. (*Telefunken*, March 1938, Vol. 19, No. 78, pp. 38–45.)

Authors' summary:—"The brightness of the screen image of a cathode-ray tube depends chiefly on three factors: the luminous output of the fluorescent material, the ray current, and the ray voltage. It is shown that an increase of the ray current is limited particularly by the mutual repulsion of the electrons [causing spot enlargement—Fig. 51] and lens error [spherical aberration, increasing as the cube of the ray diameter]. Increase of voltage, on the other hand, brings with it, electron-optically, nothing but advantages; it is limited only by the loading capacity of the fluorescent material. On the assumption that the luminous outputs of 2 Hefner candles per watt measured at low loading [Schnabel, 815 of 1935] still hold good for higher loading, dimensions and brightness of projected images are given [table on p. 45] for various ray wattages." It is pointed out (p. 40) that the luminous output of 2 Hefner candles per watt will certainly be raised to 3 or more, by further development of screen material, by viewing from the bombarded side of the screen, etc. Footnote 4 mentions Knoll's attainment of the figure of 5.2 (1931 Abstracts, p. 163).

2880. ON THE ANALYSIS AND SYNTHESIS OF A TELEVISION PICTURE.—Köllner: Mertz & Gray. (*Telefunken*, March 1938, Vol. 19, No. 79, pp. 46–60.)

The work of Mertz & Gray (1934 Abstracts, p. 568), which was a great step towards a complete theory of the scanning and recombination processes in television, "has not so far received the attention which it deserves." The present writer therefore begins by a detailed account of this work (sections b to l) and then extends it by applying its methods to the interlaced scanning system and finally to an image with moving content. Of the various interlaced scanning systems which are theoretically possible (Urtel, 1043 of 1937) only the one with an odd number of lines is considered, thus saving unnecessary complication of the analysis. The fundamental difference between ordinary and interlaced scanning is seen clearly from a comparison of their frequency spectra. Both have the property in common that the smallest spacing between two lines of the spectrum corresponds to the image frequency (section d); in ordinary scanning, however, two such lines belong to the same side-band, whereas in interlaced scanning they belong to the side-bands of different principal spectral lines. In the ordinary system the zones corresponding to fine structure in the image lie in the "empty" low-energy regions (section l); in interlaced scanning they are always in the immediate neighbourhood of a new principal line which, at any rate at the beginning of the spectrum, corresponds to a coarse structure: *i.e.*, they are in a high-energy part of the spectrum (a footnote on p. 57 mentions Weiss's suggestion that the improvement in picture quality given by interlaced scanning, for a frequency channel of given width, may be considered as due to the utilisation of those frequency regions which in ordinary scanning remain "empty"). It is this difference in spectrum that gives the interlaced scanning system the greater sensitivity to disturbance by movements in the picture content which is at the back of most of the objections brought by opponents of the system. Such disturbances are, however, greatly reduced by the use of "storage" scanning devices.

2881. DISCUSSION ON "THEORY AND PERFORMANCE OF THE ICONOSCOPE" [particularly the Signal/Noise Ratio: the Advantages of the Use of High R (Coupling Resistance) and Subsequent Correction].—Zworykin & others: Williams. (*Journ. I.E.E.*, May 1938, Vol. 82, No. 497, pp. 561–562.) *See* 1070 of March: *also* 433 of February, for a predecessor to Williams's paper, not yet published.

2882. A NEW FARNSWORTH "PICK-UP" TUBE: INCREASED SENSITIVITY OWING TO IMAGE BEING AMPLIFIED BEFORE BEING SCANNED: THE "IMAGE GRID."—Farnsworth. (*Television*, May 1938, Vol. 11, No. 123, p. 260: *Science*, 15th April 1938, Vol. 87, Supp. p. 12.)

2883. MOSAIC SCREEN FOR CATHODE-RAY SCANNER [with Elements individually Insulated from Common Metallic Base: Method of Preparation].—Telefunken. (French Pat. No. 820 246, pub. 6.11.1937: *Rev. Gén. de l'Élec.*, 30th April 1938, Vol. 43, No. 18, pp. 143–144D.)

2884. ELECTRON MULTIPLIER DESIGN [and the Use of Balls rolling on Tightly Stretched Rubber Sheet to find Best Electrode Arrangement for Electrically-Focused Type].—J. R. Pierce. (*Bell Lab. Record*, May 1938, Vol. 16, No. 9, pp. 305–309.)

2885. THE ELECTRICAL REPRODUCTION OF IMAGES BY THE PHOTOCONDUCTIVE EFFECT [in Zinc Selenide and Other Substances, deposited as Layer on a Conducting Base and scanned by Electron Beam].—H. Miller & J. W. Strange. (*Proc. Phys. Soc.*, 2nd May 1938, Vol. 50, Part 3, pp. 374–384.)

2886. GAS-FILLED ELECTRON-MULTIPLIER PHOTOCELLS.—L. Goncharski. (*Journ. of Tech. Phys.* [in Russian], No. 23, Vol. 7, 1937, pp. 2219–2221.)

A report on experiments carried out with gas-filled photocells with electron-multiplier grids between cathode and anode. An amplification of 10 and more per stage was obtained for a potential difference of 60–80 volts between consecutive grids. Frequency characteristics of cells filled with neon, argon, and helium are shown in Fig. 5.

2887. A CONFERENCE ON THE PHOTOEFFECT AND SECONDARY EMISSION.—(*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 8, 1938, pp. 369–372.) *See* next month's Abstracts.

2888. THE SECONDARY ELECTRON EMISSION FROM RUBIDIUM AND POTASSIUM COMPLEX CATHODES, *and* THE SECONDARY ELECTRON EMISSION FROM GOLD, SILVER, AND PLATINUM COATED WITH THIN ALKALI-METAL FILMS.—Timofeev & Pyatnitski: Afanas'eva & Timofeev. (*Tech. Phys. of USSR*, No. 11/12, Vol. 4, 1937, pp. 945–952: pp. 953–960: in German.) The original Russian papers were dealt with in 1978 & 1979 of May.

2889. THE EFFECT OF DIFFUSION ON THE PHOTO-SENSITIVITY AND SECONDARY EMISSION OF OXYGEN-CAESIUM LAYERS.—A. Dobrolyubski. (*Journ. of Tech. Phys.* [in Russian], No. 3, Vol. 8, 1938, pp. 226–231.)

For previous work *see* 2287 of 1937. An experimental investigation was carried out to determine the effect of introducing additional particles of Ag into layers Cs-Cs_2O, Cs, Ag-Ag_2O and Ag, on the photosensitivity and secondary emission of these layers. A description is given of experiments in which additional Ag particles were deposited by the method proposed by Asao & Suzuki (1932 Abstracts, p. 292). The main conclusions reached on the basis of these experiments are as follows: after the first stage of diffusion (deposition of Ag particles) secondary emission decreases considerably and photosensitivity is reduced practically to zero; after the second stage (heating of the layer to a temperature of 180–200° C) secondary emission increases again but remains below the original value, while photosensitivity exceeds the original value. It has also been established that a maximum secondary emission takes place with fewer Ag particles in the semiconducting layer of Cs_2O than are required for a maximum photosensitivity. A theoretical interpretation of the results obtained is also given.

2890. TIME LAG IN GAS-FILLED PHOTOELECTRIC CELLS [Tests on Special Cell with Small Anode equidistant from All Parts of Cathode].—A. M. Skellett. (*Bell Lab. Record*, May 1938, Vol. 16, No. 9, pp. 321–323.)

2891. THE PREPARATION OF THALLOFIDE PHOTO-CELLS BY MICHELSSEN'S METHOD.—A. A. Sivkov. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 8, 1938, pp. 11–18.)

A description of the apparatus and procedure for obtaining a photosensitive layer by evaporating Tl_2S in an atmosphere of oxygen. The optimum pressure of oxygen (0.45–0.50 mm Hg) was determined, and layers with a photosensitivity $S(=\Delta R/R_0)$ around 50% were so produced. The spectral sensitivity of the layers was also investigated.

2892. ON THE PHOTO-ELECTROMOTIVE FORCE IN SEMICONDUCTORS, *and* THE RECTIFYING ACTION OF SEMICONDUCTORS.—B. Davydov. (*Tech. Phys. of USSR*, No. 2, Vol. 5, 1938, pp. 79–86: pp. 87–95: both in English.)

(i) "If the resistance of the illuminated contact is high, the photo-e.m.f. for weak illumination is proportional to it. A considerable e.m.f. can appear only: (a) when electrons and 'holes' are comparable, or (b) when the light creates free charges opposite in sign to those due to thermal motion. If the contact resistance is not large, the photo-e.m.f. for weak illumination becomes a quadratic effect. The results obtained by Landau & Lifschitz [3513 of 1936] do not always hold good." (ii) "The formulae thus obtained give satisfactory agreement with the known data for the cuprous-oxide rectifier, if it is assumed that the blocking layer possesses normal electronic conductivity. Rectification must be accompanied by a thermal effect, associated with the dissociation and recombination of free electrons and 'holes.' It is shown that the theories of rectification proposed before (tunnel effect, cold emission) cannot explain the observed phenomena." For the original Russian papers see *Journ. of Tech. Phys.* [in Russian], No. 23, Vol. 7, 1937, pp. 2212–2218, & No. 1, Vol. 8, 1938, pp. 3–10.

2893. A BARRIER-LAYER PHOTOCELL WITH SURFACE EXPOSED TO THE AIR.—Zeiss Ikon Company. (*Rev. Gén. de l'Élec.*, 30th April 1938, Vol. 43, No. 18, p. 142D.)

2894. ON THE MODE OF ACTION OF THE "SPARK COUNTER": A MAINS-DRIVEN INSTRUMENT FOR THE COUNTING OF RADIATION QUANTA AND PHOTOELECTRONS.—H. Greinacher. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 19, 1938, pp. 132–134.) For previous work *see* 1205 of 1937.

2895. WIDE-BAND TELEVISION AMPLIFIERS: II—LOW-FREQUENCY RESPONSE: EFFECTS OF CATHODE-BIASING CIRCUITS AND PLATE-IMPEDANCE CORRECTION NETWORKS ON AMPLIFICATION AND PHASE SHIFT.—F. A. Everest. (*Electronics*, May 1938, Vol. 11, No. 5, pp. 24–27.) For I *see* 1533 of April.

2896. REMARKS ON THE PAPER "THE AMPLIFICATION OF [H.F.] WIDE FREQUENCY BANDS."—H. Pieplow: W. Kleen. (*Telefunken-Röhre*, April 1938, No. 12, p. 72.)

In Kleen's paper (1534 of April) it is maintained that Pieplow, in his paper on the same subject (4022 of 1937), evaded the chief point in the problem of wide-band amplification by his assumption of a constant capacity. This statement is here argued.

2897. SOME NOTES ON VIDEO-AMPLIFIER DESIGN [Closer Tolerances required in Multi-Stage Video Amplifiers demand *k*-Factor 1.55 and *m* 0.55 instead of Usual 1.414 and 0.707: Advantages of "Cathode Coupling": etc.].—A. Preisman. (*RCA Review*, April 1938, Vol. 2, No. 4, pp. 421–432.)

2898. THE AMPLIFIER IN TELEVISION [Extracts from Forthcoming Book "Das Fernsehen"].—K. Lipfert. (*Funktech. Monatshefte*, April 1938, No. 4, Supp. pp. 25–27.)

2899. TELEVISION INTERMEDIATE REPEATERS FOR 1.3 Mc/s CARRIER FREQUENCY [and 0.5 Mc/s Band Width].—A. Agricola. (*AEG-Mitteilungen*, April 1938, No. 4, pp. 236–240.)

2900. THE RÔLE OF THE IRREGULARITIES ON CABLES (TELEPHONIC, COAXIAL, AND FOR TELEVISION).—L. Brillouin. (*Ann. des Postes, T. et T.*, April 1938, Vol. 27, No. 4, pp. 271–321.) Introduction: the work of Didlaukis & Kaden (1880 of 1937) and of Mertz & Pfleger (596 of February): author's own treatment, along lines of the former but more general and flexible: experimental evaluation of the tolerable faults in television: etc.

2901. SOME PRACTICALLY IMPORTANT PROPERTIES OF CONCENTRIC CABLES FOR WIDE-BAND TRANSMISSION [and Formulae for Practical Calculation].—E. Müller. (*Zeitschr. f. Fernmeldetech.*, No. 2, Vol. 19, 1938, pp. 17–22.)

2902. THE TECHNIQUE OF THE WIDE-BAND CABLE.—G. Wuckel. (*AEG-Mitteilungen*, April 1938, No. 4, pp. 195–220 [pages after 208 missing in some copies].)

2903. THE POSITION OF WIDE-BAND CABLE TECHNIQUE IN GERMANY.—(*E.T.Z.*, 21st April 1938, Vol. 59, No. 16, pp. 423–424.)

MEASUREMENTS AND STANDARDS

2904. RESISTANCE MEASUREMENTS WITH A LECHER-WIRE SYSTEM.—H. Bruckmann. (*Hochf:tech. u. Elek:akus.*, April 1938, Vol. 51, No. 4, pp. 128–135.)

The magnitude and phase angle of a complex impedance can be measured at high frequencies (50 Mc/s and over) by observing the current distribution in a Lecher-wire system terminated by the impedance. The method is developed to determine loss angles in coils and dielectrics with an accuracy sufficient for technical purposes (tan δ of the order of 0.01). Typical measurements show good agreement with accepted values.

2905. THE ABSOLUTE MEASUREMENT OF RESISTANCE AND REACTANCE AT FREQUENCIES OF THE ORDER OF 300 Mc/s [by using the Unknown Impedance to terminate a Lecher-Wire System: Brief Description and Bibliography].—R. A. Chipman. (*Phys. Review*, 15th April 1938, Vol. 53, No. 8, p. 672.)

2906. IMPROVED THERMO-AMMETER CONSTRUCTION TO INCREASE ACCURACY ON ULTRA-HIGH FREQUENCIES.—J. H. Miller. (*QST*, May 1938, Vol. 22, No. 5, pp. 44–45.) *See* 1907 of 1937 for full *I.R.E.* paper.

2907. REFERENCE TABLES FOR IRON-CONSTANTAN AND COPPER-CONSTANTAN THERMOCOUPLES.—W. F. Roeser & A. I. Dahl. (*Journ. of Res. of Nat. Bur. of Stds.*, March 1938, Vol. 20, No. 3, pp. 337–355.)

2908. NEW MEASURING METHODS FOR OUTPUT VALVES.—Wolf. (*See* 2793.)

2909. A METHOD OF MEASURING THE FIELD INTENSITY OF SHORT WAVES WITH A HALF-WAVE ANTENNA.—Nakagami & Miya. (*See* 2759.)

2910. MEASUREMENT OF BROADCAST COVERAGE AND ANTENNA PERFORMANCE: PART I—COVERAGE.—W. A. Fitch & W. S. Duttera. (*RCA Review*, April 1938, Vol. 2, No. 4, pp. 396–413.)

2911. A NEW METHOD OF MEASUREMENT FOR THE LOSS ANGLE OF CAPACITANCES AT NOTE FREQUENCIES AND HIGH FREQUENCIES [based on Consideration of Loss Angle as a Resistance Shunting the Condenser, altering the Latter's Capacity by Amount Too Small for Direct Measurement: Effect increased by Introduction of a Second Shunt Capacity: Resonance-Bridge Method, in Several Varieties suitable for Different Circumstances].—W. Herzog. (*TFT*, March 1938, Vol. 27, No. 3, pp. 99–102.)

2912. DIRECT MEASUREMENT OF THE LOSS CONDUCTANCE OF CONDENSERS AT HIGH FREQUENCIES [2 & 4.2 Mc/s].—M. Boella. (*Proc. Inst. Rad. Eng.*, April 1938, Vol. 26, No. 4, pp. 421–432.) The original Italian paper was dealt with in 2001 of 1935. Variations of the method to extend its use to still higher frequencies are discussed in the final section.

2913. A BRIDGE METHOD FOR MEASURING POWER FACTOR AND DIELECTRIC CONSTANT OF INSULATORS WITH GUARD RINGS AT H.F. RANGE, *and* HEAT-CYCLE TEST OF SUSPENSION INSULATORS.—Numakura & Tukamoto: Satoh & Kimata. (*Electrot. Journ.*, Tokyo, May 1938, Vol. 2, No. 5, pp. 116–119: p. 120.)

2914. APPARATUS FOR MEASUREMENT OF DIELECTRIC CONSTANTS ["Elmometer," using Quartz-Stabilised Oscillator: for Simple and Accurate Measurements, *e.g.* for determining Moisture Content, etc.].—Henriquez. (*Journ. Scient. Instr.*, May 1938, Vol. 15, No. 5, pp. 180–181.) For Henriquez's work *see* 3176 of 1935.

2915. A METHOD OF MEASURING THE COEFFICIENT OF REFLECTION OF ELECTRONS FROM A DIELECTRIC.—M. S. Kosman, I. R. Plotnikov, & N. N. Fedorova. (*Journ. of Tech. Phys.* [in Russian], No. 23, Vol. 7, 1937, pp. 2231–2236.)

The method proposed for determining the ratio n_2/n_1, where n_1 is the number of electrons leaving the dielectric surface and n_2 the number of electrons falling on it, is based on measuring the potential of the surface subjected to electron bombardment. A circuit employing an electrometer was developed for this purpose (Fig. 1) and an account is given of experiments with a thin lamination of mica.

2916. MEASUREMENTS OF RESISTANCE AND CAPACITY OF MONOFILMS OF BARIUM STEARATE.—Buchwald & others. (*Proc. Nat. Acad. Sci.*, May 1938, Vol. 24, No. 5, pp. 204–208.)

2917. MEASURING APPARATUS FOR TELEPHONE CABLES AT HIGHER FREQUENCIES, *and* FREQUENCY MEASUREMENT IN CARRIER-CURRENT TELEPHONY.—R. Keller: H. A. Wahl. (*AEG-Mitteilungen*, April 1938, No. 4, pp. 267–272: pp. 272–275.)

2918. Measurement of H.F. Lines [Twisted Pair, Coaxial, etc: using the Boonton "Q-Meter"].—Ballantine Laboratories. (*Electronics*, April 1938, Vol. 11, No. 4, pp. 26–27.)

2919. Precise Measurement of Insertion Phase Shift [in Communication Circuits].—J. S. Elliott. (*Bell Lab. Record*, April 1938, Vol. 16, No. 8, pp. 285–288.)

2920. The Alternating-Current Resistance of Hollow, Square Conductors.—A. H. M. Arnold. (*Journ. I.E.E.*, May 1938, Vol. 82, No. 497, pp. 537–545.)

2921. Aluminium and Steel-Cored Aluminium Conductors: the Calculation of Inductance.—L. P. Dudley. (*Electrician*, 29th April 1938, Vol. 120, pp. 535–536 and 538.)

2922. Internal Inductance of Coils, and Its Influence on the Temperature Coefficient of the Coil.—Douma. (*See* 2716.)

2923. Theoretical and Experimental Study of a Direct-Reading Frequency Meter [Independent of Wave Form and Amplitude: Thyratron Relaxation Oscillator synchronised with Frequency to be measured: Milliammeter, traversed by Charging Current, is Graduated in Frequencies, 30–3200 c/s].—R. Legros. (*Rev. Gén. de l'Élec.*, 21st May 1938, Vol. 43, No. 21, pp. 643–651.)

2924. Frequency Measurement by the Summation of Current Pulses produced by the Charging of a Condenser through Valves [Fecker's Method].—A. Wahl: Fecker. (*E.T.Z.*, 14th April 1938, Vol. 59, No. 15, pp. 399–400: summary only.) *See* 648 of February.

2925. A New Form of Frequency and Time Standard [at the N.P.L: Cylindrical Quartz Ring oscillating in an Overtone Longitudinal Mode at 100 kc/s: in Air at Room Temperature, Stability is ± 5 Parts in 10^8 during Periods of 1 Hour and ± 1 in 10^7 during Weekly Periods: when in Continuous Operation in Vacuum at Constant Temperature, ± 4 Parts in 10^{10} during Hourly Periods or 1 in 10^8 during Periods of 1 Month].—L. Essen. (*Proc. Phys. Soc.*, 2nd May 1938, Vol. 50, Part 3, pp. 413–426.)

2926. Circuits for Piezoelectric Quartz Oscillators and Resonators for Frequency Stabilisation and for Selectivity Devices.—R. Bechmann. (*Telefunken*, March 1938, Vol. 19, No. 78, pp. 60–69.)

Author's summary:—"In the development of crystal oscillators the great object is to arrive at circuits possessing one definite frequency which is determined only by the crystal and is independent of the circuit and its construction. Three circuits are described which fulfil this requirement in increasing degree, and allow the best use to be made of the low damping of the crystal. In the use of crystals for selective purposes it is necessary to raise the crystal damping more or less, in order to correspond with the actual requirements of band width. The simplest and most illuminating circuit consisting of a crystal and two oscillatory circuits is examined in detail and the possibilities for the regulation of the band width are discussed." Work by Heegner (1934 Abstracts, p. 47), Bechmann (3283 of 1937), and Kautter (478 of February), and patents by Telefunken, Heegner, and Goering, are mentioned.

2927. The Effect of Hydrostatic Pressure on the [Electric] Susceptibility of Rochelle Salt [studied for Pressures 0 to 10 000 Atmospheres and Temperatures between $-20°$ and $+60°$: No Satisfactory Explanation of Results].—D. Bancroft. (*Phys. Review*, 1st April 1938, Vol. 53, No. 7, pp. 587–590.)

2928. On the Relaxation Time in Rochelle Salt Crystals: II.—Schulwas-Sorokin. (*See* 2814.)

2929. Are Further Improvements possible in the Construction of Electrometers?—E. Perucca. (*Zeitschr. f. Physik*, March 1938, Vol. 108, No. 9/10, pp. 635–639.) The writer concludes that improvements are possible, especially in mechanical details, and describes a new vane-type electrometer as sensitive as any existing instruments and much superior mechanically.

2930. An Absolute Electrometer for the Measurement of High Alternating Voltages [up to 275 Kilovolts], *and* A Transformer Method for measuring High Alternating Voltages, and Its Comparison with an Absolute Electrometer.—Brooks, Defandorf, Silsbee. (*Journ. of Res. of Nat. Bur. of Stds.*, March 1938, Vol. 20, No. 3, pp. 253–316: pp. 317–336.)

2931. An Improved Circuit for the Direct Current Amplifying Valve of a Valve-Voltmeter [Reduction of Calibration Dependence on Anode-Battery Voltage by Correct Choice of Galvanometer Resistance with respect to Valve Characteristics].—R. E. Burgess. (*Journ. Scient. Instr.*, May 1938, Vol. 15, No. 5, pp. 171–174.)

2932. Multiplying the Range of a Vacuum Tube Voltmeter [by Type 845 Triode, connected as Diode, and 2 Megohm Tapped Voltage Divider].—G. R. Chinski. (*Electronics*, May 1938, Vol. 11, No. 5, pp. 42 . . 46.)

2933. An Improved Meter Shunt Circuit [giving Increased Security against Burn-Out].—V. O. Gunsolley. (*Electronics*, April 1938, Vol. 11, No. 4, pp. 36 and 42 . . 46.)

2934. Testing Current Transformers by Means of the Alternating Current Potentiometer.—F. E. J. Ockenden. (*Journ. Scient. Instr.*, May 1938, Vol. 15, No. 5, pp. 149–156.)

2935. MODERN MEASURING METHODS IN COMMUNICATION TECHNIQUE [Measurement of Volume: Testing of Subscribers' Telephone Instruments (including the Falling-Shot Standard Sound Source): Measurement of Non-Linearity: Analysis of Frequency Mixtures: Some Problems of H.F. Measuring Technique].—R. Tamm. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 19, 1938, pp. 134–146.)

2936. A NEW TYPE OF [Quick-Reading] LOOP GALVANOMETER.—A. N. Klokman. (*Journ. of Tech. Phys.* [in Russian], No. 2, Vol. 8, 1928, pp. 190–192.)

A description of a model incorporating a number of improvements over the Deubner type (1930 Abstracts, p. 519, l-h col.). The sensitivity of the model is of the order of 5.10^{-8}A per scale division with a total magnification by microscope of 100 times. The resistance of the loop is around 10 ohms.

2937. A NEW MODULATION METER.—Williams & Chester. (*See* 2713.)

2938. THE AEG SECONDS METER [for Relay Delay Times, etc.].—G. Stark. (*AEG-Mitteilungen*, March 1938, No. 3, pp. 130–132.)

2939. PROVISIONAL REGULATIONS FOR MEASURING INSTRUMENTS.—Verband Deutscher Elektrotechniker. (*E.T.Z.*, 5th May 1938, Vol. 59, No. 18, pp. 481–486.)

SUBSIDIARY APPARATUS AND MATERIALS

2940. A CATHODE-RAY OSCILLOGRAPH WITH AN ELECTRIC SCALE.—Laufer. (*Journ. of Tech. Phys.* [in Russian], No. 23, Vol. 7, 1937, pp. 2222–2226.)

Varying potentials are applied to the plates of the oscillograph by means of a circular motor-driven commutator (Fig. 2), and a scale is thus traced on the screen of the oscillograph tube. Such a scale will show any distortion introduced by the tube, and moreover it enables measurements to be made directly in volts instead of in units of length.

2941. A CATHODE-RAY RECORDER FOR VALVE CHARACTERISTICS, WITH ELECTRICALLY ADJUSTABLE COORDINATE SCALES (GIVING DIRECT METER READINGS) ELIMINATING USUAL SCREEN ERRORS.—Wolf. (*See* 2793.)

2942. IMPROVEMENT TO DEFLECTING CIRCUITS OF CATHODE-RAY OSCILLOGRAPHS [to give as Little Spot Distortion with Electrostatic Deflection as is usual with Magnetic Deflection].—Zeitline. (*Rev. Gén. de l'Élec.*, 30th April 1938, Vol. 43, No. 18, pp. 142–143D.)

2943. THE AUTOMATIC RECORDING OF NON-RECURRENT PHENOMENA WITH THE CATHODE-RAY OSCILLOGRAPH [with Special Combination Circuit (Pentode and Two Grid-Controlled Rectifiers) for Time Base, and a Dynatron Circuit to convert Arriving Pulse into Rectangular Wave-Form to give Full Spot Brightness].—A. Bigalke. (*E.T.Z.*, 14th April 1938, Vol. 59, No. 15, pp. 389–391.)

A c-r tube with post-acceleration of the ray is recommended as giving the highest recording speed (about 50 km/s) of any commercial high-vacuum tube. A dual-ray tube is convenient, since a time scale is particularly useful with non-recurrent processes.

2944. METHOD OF MEASURING AND RECORDING TWO DIFFERENT PROCESSES BY THE CATHODE-RAY TUBE [Length and Voltage of Electric Arc: Voltage by Ordinary Electrostatic Deflection, Length by Simultaneous Optical Projection on to Same C-R Screen, using Cylinder Lens to give a Line Image].—Sedlmayr. (*Bull. Assoc. suisse de Élec.*, No. 9, Vol. 29, pp. 189–194: in German.)

2945. SOME ELECTRONIC SWITCHING CIRCUITS [particularly for Observation of Multiple Recurrent Patterns on Screen of Cathode-Ray Oscillograph].—Shumard. (*Elec. Engineering*, May 1938, Vol. 57, No. 5, pp. 209–220.)

2946. "DIE KATHODENSTRAHLRÖHRE: IHRE VERWENDUNG ZU MESSZWECKEN" [The Cathode-Ray Tube: Its Application to Measuring Purposes: Book Review].—Nentwig. (*Elektrot. u. Masch:bau*, 1st May 1938, Vol. 56, No. 18, p. 244.)

2947. SCATTERING OF AN ELECTRON BEAM BY ITS OWN SPACE CHARGE.—von Borries & Dosse. (*Arch. f. Elektrot.*, 28th April 1938, Vol. 32, No. 4, pp. 221–232.)

Increase of diameter of a beam is calculated for the general case of a convergent or divergent beam issuing from an aperture, and results are given in the form of curves and abacs for easy numerical application.

2948. ELECTRON-OPTICAL OBSERVATION OF THE IONIC AND ELECTRONIC EMISSION FROM WIRE-SHAPED SOURCES.—Mahl. (*See* 2803.)

2949. AN ELECTRON MICROSCOPE FOR HIGH MAGNIFICATIONS [for Imperial College of Science and Technology].—Nuttall. (*Met.-Vickers Gazette*, May 1938, Vol. 17, No. 301, pp. 256–259.)

2950. CATHODE-RAY SCREEN PHOTOGRAPHY [Choice of Film and Development Procedure for Various Screen Materials.]—Morse. (*Electronics*, April 1938, Vol. 11, No. 4, pp. 37–38.)

2951. ON THE LUMINOUS OUTPUT OF ZINC SILICATE LUMINESCENT MATERIAL IN A GASEOUS DISCHARGE [leading to a Law for the Dependence of the Excitation Bands on the Activation: etc.].—Rüttenauer. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 19, 1938, pp. 148–150.)

2952. THE KINETICS OF PHOSPHORESCENCE [Bimolecular Reaction (Recombination of Electrons & Ions in Lenard Phosphors) does not disturb Thermal Equilibrium of Freed Electrons: Law explained by Series of Such Reactions, of Different Velocities: Estimation of Recombination Times: etc.].—Blochinzev. (*Physik. Zeitschr. der Sowjetunion*, No. 5, Vol. 12, 1937, pp. 586–601: in German.)

2953. INFLUENCE OF THE FILTER ACTION OF CRYSTALS WITH HIGH CdS CONTENT ON THE SPECTRAL INTENSITY DISTRIBUTION OF ZnS CdS Ag FLUORESCENT SCREENS WITH SEVERAL COMPONENTS WITH DIFFERENT CdS CONTENT.—von Ardenne. (*TFT*, March 1938, Vol. 27, No. 3, pp. 106–108.)

2954. A MECHANICAL LAG-SCREEN OSCILLOGRAPH.—Hoecker & Asher. (*See* 3048.)

2955. A NEW KIND OF OSCILLOGRAPH LOOP [for Direct Observation of Curve Form of Wattless Current in Non-Sinusoidal Circuits].—Rothlein: Fryze. (*E.T.Z.*, 12th May 1938, Vol. 59, No. 19, pp. 501–502.) In connection with Fryze's work (1932 Abstracts, p. 519.)

2956. AN IMPROVED FORM OF HIGH-VACUUM LEAK [Needle cannot Rotate in Orifice but is Free to Align itself with This].—Bogg. (*Journ. Scient. Instr.*, Dec. 1937, Vol. 14, No. 12, pp. 412–413.)

2957. A SIMPLE KNUDSEN VACUUM GAUGE [Aluminium Leaf alongside Heated Platinum Strip].—Hughes. (*Review Scient. Instr.*, Nov. 1937, Vol. 8, No. 11, pp. 409–412.)

2958. AN APPARATUS FOR THE CLEANING OF THE INERT GASES AND HYDROGEN FROM IMPURITIES.—Weizel. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 19, 1938, pp. 146–148.)

2959. THE EFFECT OF DEIONISATION IN A THYRATRON DURING RELAXATION OSCILLATIONS.—Gabovich. (*Journ. of Tech. Phys.* [in Russian], No. 24, Vol. 7, 1937, pp. 2328–2335.)

In circuits employing thyratrons for producing saw-tooth voltage curves (Fig. 1), non-linear distortion is often introduced owing to residual conductance of the thyratron after the condenser has discharged through it. This effect, due to the deionisation of the gas in the thyratron, is examined theoretically in the present paper, and exact formulae in which the residual conductance is taken into account are derived for determining the charging period, when the thyratron is fed (a) through a valve (eqn. 17) and (b) through a resistance (eqn. 21). The paper concludes with a report on experiments with a neon thyratron.

2960. A HIGH RESOLVING POWER TENFOLD THYRATRON COUNTER [Resolving Time 1/2000th Second].—Kerst. (*Review Scient. Instr.*, April 1938, Vol. 9, No. 4, pp. 131–133.)

2961. A THYRATRON IMPULSE GENERATOR.—Pressey. (*See* 2798.)

2962. THE CONSTANTS OF AN IMPULSE GENERATOR FOR A GIVEN WAVE-FORM.—Höfer. (*Arch. f. Elektrot.*, 28th April 1938, Vol. 32, No. 4, pp. 275–280.)

2963. THE SOURCE OF IONS FOR A VACUUM HIGH-VOLTAGE TUBE, *and* AN IMPULSE GENERATOR.—Papkov. (*Journ. of Tech. Phys.* [in Russian], No. 2, Vol. 8, 1938, pp. 162–168: pp. 169–174.)

2964. AN IMPULSE GENERATOR FOR LARGE CURRENTS [of Order of a Million Amperes].—Solomonov. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 8, 1938, pp. 343–347.)

2965. PRACTICAL EXPERIENCE WITH THE ULTRA-RAPID-ACTION SAFETY DEVICE FOR RECTIFIER EQUIPMENTS, INCORPORATING MERCURY-VAPOUR VALVES [on the Hilversum Transmitter].—(*See* 2717.)

2966. ON DR. SIEMENS'S DISSERTATION, "DIE ERHITZUNG" [Criticism of Siemens's Suggested New Criterion for State of Rectifier as regards Freedom from Back-Firing].—White: Siemens. (*Tech. Phys. of USSR*, No. 2, Vol. 5, 1938, pp. 167–168: in English.) The "erhitzung" (heating) is defined as the amount of heat transferred by the arc to the mercury vapour in the shield during one cycle, per unit mass of vapour.

2967. SOLVING A RECTIFIER PROBLEM [Improving the Regulation from Original 40% to 5%].—Lee. (*Electronics*, April 1938, Vol. 11, No. 4, pp. 39–40.)

2968. THEORY OF THE RECTIFYING ACTION IN A CIRCUIT CONTAINING A DISSIPATIVE IMPEDANCE AND A [Smoothing] CONDENSER.—Zilitinkewitsch. (*See* 2683.)

2969. ELECTROLYTIC CAPACITORS IN [Smoothing] FILTER DESIGN.—Deeley. (*See* 2738.)

2970. THE RECTIFYING EFFECT OF SEMICONDUCTORS.—Davydov. (*See* 2892.)

2971. ON THE AGEING OF COPPER-OXIDE RECTIFIERS.—Renne, Rumyantseva, & Pasynkov. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 8, 1938, pp. 340–342.)

The ageing of copper-oxide rectifiers when not in use was investigated and found to be caused by humidity of the air. Additional experiments have shown that this effect is due to an increase in resistance of the aquadag layer under the influence of humidity.

2972. "TROCKENGLEICHRICHTER" [Dry-Plate Rectifiers: Book Review].—Maier. (*Electrician*, 22nd April 1938, Vol. 120, p. 514.)

2973. THE GLOW-DISCHARGE LAMP AS A REGULABLE A.C. RESISTANCE.—Eisele. (*See* 2684.)

2974. MULTIPLE STATES IN THE HIGH-PRESSURE DISCHARGE [Suggested Existence of at least One Type of Discharge in addition to Normal Arc & Glow Discharges].—Suits. (*Phys. Review*, 1st April 1938, Vol. 53, No. 7, p. 609.)

2975. ELECTRON EMISSION BY POSITIVE ION BOMBARDMENT OF THE CATHODE OF A GLOW DISCHARGE.—Güntherschulze & Betz. (*See* 2804.)

2976. THE INFLUENCE OF ADMIXTURES ON THE BREAKDOWN POTENTIAL OF A DISCHARGE IN ARGON.—Moralew. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 12, 1937, pp. 667–684: in English.)

2977. Variation of the Starting Potential of a Discharge Tube without Internal Electrodes, under the Influence of Ultra-Violet or Visible Light [Curves for Hydrogen: Possible Effect of Containing Walls].—R. Zouckermann. (*Comptes Rendus*, 31st Jan. 1938, Vol. 206, No. 5, pp. 331–333.)

2978. The Experimental Validity of Paschen's Law and of a Similar Relation for the Reignition Potential of an Alternating Current Arc.—Slepian & Mason. (*Journ. of Applied Physics*, Sept. 1937, Vol. 8, No. 9, pp. 619–621.)

2979. On Raising the Temperature in the Plasma of an Electric Arc.—Rukavishnikov & Shishkov. (*Journ. of Tech. Phys.* [in Russian], No. 24, Vol. 7, 1937, pp. 2336–2342.) Desirable in various commerical processes: a survey of methods.

2980. Rôle of Oxidation in Arc Cathodes [Suggestion that Cold Metallic Cathodes cannot supply Sufficient Emission to maintain Arc unless Oxidised].—Suits & Hocker. (*Phys. Review*, 15th April 1938, Vol. 53, No. 8, p. 670.)

2981. The Potential Gradient in the Positive Column.—Klarfeld. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 8, 1938, pp. 410–424.)

2982. The Study of the Gaseous Discharge in the USSR.—Spivak. (*Journ. of Tech. Phys.* [in Russian], No. 3, Vol. 8, 1938, pp. 211–225.)

2983. Internal Inductance of Coils, and Its Influence on the Temperature Coefficient of the Coil.—Douma. (*See* 2716.)

2984. Thermal Stability of Condensers: Ceramic Dielectrics and Their Use at Low Temperatures.—Coursey. (*See* 2734.)

2985. The Initial Current in Abnormal Dielectrics.—Gross. (*Zeitschr. f. Physik*, March 1938, Vol. 108, No. 9/10, pp. 598–608.)

2986. Formation of High-Voltage Polarisation in $NaNO_3$ [in connection with the Decrease, with Time, of the Current passing through Certain Dielectrics].—Hochberg. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 12, 1937, pp. 644–657: in English.)

2987. Thermal Breakdown of Solid Dielectrics at High Frequencies [*e.g.* 10 Mc/s].—Gaylish. (*Tech. Phys. of USSR*, No. 1, Vol. 5, 1938, pp. 19–28: in English.) The original Russian paper was dealt with in 2079 of May.

2988. Fibre Glass—a New Insulation for Electric Apparatus.—Mathes. (*Gen. Elec. Review*, May 1938, Vol. 41, No. 5, pp. 218–219.)

2989. Static Electric Properties of a New Bakelite Plastic [Polystyrene XMS-10023: ranking close to Amber in Insulating Properties, and Easy to Mould].—Landsberg & Ingham. (*Science*, 6th May 1938, Vol. 87, pp. 419–420.)

2990. The Adsorption of Vapours at Plane Surfaces of Mica.—Bangham & Mosallem. (*Proc. Roy. Soc.*, 27th April 1938, Vol. 165, No. 923, pp. 552–567 & p. S 55.)

2991. A Method of Measuring the Coefficient of Reflection of Electrons from a Dielectric.—Kosman & others. (*See* 2915.)

2992. The Present Position in the Development of Coils for Communication Technique.—Kiessling & Wolff. (*See* 2726.)

2993. "Eisenlose Drosselspulen" [Air-Core Choking Coils (with an Appendix on H.F. Powder-Core Coils): Book Review].—Hak. (*Elektrot. u. Masch:bau*, 8th May 1938, Vol. 56, No. 19, p. 256.)

2994. The Best Form of Iron Core for Inductance Coils [giving Minimum Volume for Given Loss Factor at Given Frequency: including "Shielded Shell" Type for Dust Cores].—Nakai. (*Rep. of Rad. Res. in Japan*, Oct. 1937, Vol. 7, No. 2, Abstracts p. 25.)

2995. The Variation in the H.F. Resistance and Permeability of Ferromagnetic Materials due to a Superimposed Magnetic Field.—Webb. (*See* 2727.)

2996. Losses in Ferromagnetic Laminae at Radio Frequencies [Latest Knowledge on Eddy-Current, Hysteresis, and "Residual" Losses].—M. Reed. (*Wireless Engineer*, May 1938, Vol. 15, No. 176, pp. 263–268.)

2997. Sessions of the Commission on Magnetic and Conducting Materials of the Department of Technical Sciences of the Academy of Sciences of the USSR [including a Double-Anode Magnetron for Measurement of Magnetic Fields].—Jegorov. (*Tech. Phys. of USSR*, No. 11/12, Vol. 4, 1937, pp. 1045–1048: in English.)

2998. Direct-Reading Instrument for Measurement of Magnetic Field [by Force exerted on Current-Carrying Pivoted Search Coil].—Servant & Tsaï. (*Comptes Rendus*, 11th April 1938, Vol. 206, No. 15, pp. 1172–1174.)

2999. On the Magnetic Susceptibility of Metallic Cerium [and the Important Dependence of the Effect of Small Quantities of Ferromagnetic Impurities on the Field Strength used].—Jaanus. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 12, 1937, pp. 729–735: in English.)

3000. The Anisotropy of the Magnetic Energy in Single Crystals of Nickel as a Function of Temperature.—Brukhatov & Kirensky. (*Physik. Zeitschr. der Sowjetunion*, No. 5, Vol. 12, 1937, pp. 602–609: in English.)

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3002. On the Hysteresis of Magnetostriction of Iron, Nickel, Cobalt, and Single Crystals of Iron: of Alloys of the Systems Iron-Nickel, Nickel-Cobalt, and Iron-Cobalt.—Masiyama. (*Jap. Journ. of Phys.*, Transactions & Abstracts, No. 2, Vol. 12, 1938, Abstracts p. 79.)

3003. On the Effect of Stretching and Twisting on the Discontinuous Process of Magnetisation in Nickel-Iron Alloys.—Okubo & Takagi. (*Jap. Journ. of Phys.*, Transactions & Abstracts, No. 2, Vol. 12, 1938, Abstracts p. 79.)

3004. Magnetic Alloys [Survey, with a Theory of High Permeability: Theory of High Coercive Force (Pure Iron specially treated Gives 150 Oersteds): etc.].—Honda. (*Jap. Journ. of Phys.*, Transactions & Abstracts, No. 2, Vol. 12, 1938, Abstracts p. 79.)

3005. On the Theory of the Susceptibility of Paramagnetic Alums in A.C. Fields.—Fierz. (*Physica*, May 1938, Vol. 5, No. 5, pp. 433–436: in German.)

3006. Recent Advances in the Theory of Ferromagnetism.—Bozorth. (*Scient. Monthly*, April 1938, pp. 366–371.)

3007. Relays for Tube Circuits [Survey and Hints].—Dudley. (*Electronics*, May 1938, Vol. 11, No. 5, pp. 18–23 and 61 . . 63.)

3008. A Vacuum-Tube Control Circuit for Cloud Chambers [for regulating Timing of Events accompanying Expansion, and Time Intervals between Expansions].—Richardson. (*Review Scient. Instr.*, May 1938, Vol. 9, No. 5, pp. 152–154.)

3009. The "Medicus" Stabiliser [for 1000 Volts: Corona-Discharge Device].—Veksler: Medicus. (*Journ. of Tech. Phys.* [in Russian], No. 1, Vol. 8, 1938, pp. 37–44.) *See* 1933 Abstracts, p. 638.

3010. Styctographic Coherers [for the Recording of H.F. Fields].—Penner: Arkadiew. (*See* 2664.)

3011. High-Speed Recorder with Heat-Sensitive Paper marked by Moving Hot Wire.—Jones. (*See* 2842.)

3012. High-Speed Motion-Picture Photography applied to Design of Telephone Apparatus [and a Camera taking 4000 Pictures/Second].—Herriott. (*Journ. Soc. Motion Pic. Eng.*, Jan. 1938, Vol. 30, pp. 30–36: *Bell T. System Tech. Pub.*, Monograph B-1049.)

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3014. An Extremely Light High-Potential Battery of Long Life [primarily for Exploring Balloons: 1000 Volts, weighing under 2 Pounds].—Ramsey. (*Journ. Franklin Inst.*, April 1938, Vol. 225, No. 4, pp. 401–409.)

3015. H.F. Screened Non-Reactive Resistances and Ratios.—Sullivan Ltd. (*Journ. Scient. Instr.*, May 1938, Vol. 15, No. 5, p. 178.)

3016. On the Mode of Action of the "Spark Counter": a Mains-Driven Instrument for the Counting of Radiation Quanta and Photoelectrons.—Greinacher. (*See* 2894.)

3017. Porcelain-Tube Cables [to save Use of Lead.]—Ziegler. (*E.T.Z.*, 20th Jan. 1938, Vol. 59, No. 3, p. 72.)

3018. Electrical and Thermal Investigations on Manganin [Determination of Thermal Treatment necessary for Optimum Behaviour of Manganin in Standard Resistances].—Schulze. (*Physik. Zeitschr.*, 15th Aug. 1937, Vol. 38, No. 16, pp. 598–601.)

3019. Structural Investigations of Thin, Oriented Metallic Films, produced by Evaporation [of Gold, Silver, Palladium on to Mica, Fluorspar, etc: Electron Diffraction Experiments].—Rüdiger. (*Ann. der Physik*, Series 5, No. 6, Vol. 30, 1937, pp. 505–526.) Higher temperatures were used than in the work referred to in 3199 of 1936 (Brück).

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3021. Polarimetric Studies of Oxide Film Formation on Metals [Optical Study of Early Growth of Films on Copper].—Winterbottom. (*Nature*, 28th Aug. 1937, Vol. 140, pp. 364–365.)

3022. The Deposit of Films of Uniform Thickness for Interferometer Mirrors.—Fisher & Platt. (*Review Scient. Instr.*, Dec. 1937, Vol. 8, No. 12, pp. 505–507.)

3023. Structure and Resistance of Thin Metal Films [Sharp Transition Temperature may be associated with Gas Desorption].—Wright. (*Nature*, 17th July 1937, Vol. 140, pp. 107–108.)

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3025. Production of Thin Gold Films [by Decomposition of Organo-Gold Compounds].—Gibson. (*Nature*, 14th Aug. 1937, Vol. 140, pp. 279–280.)

STATIONS, DESIGN AND OPERATION

3026. THE CAIRO CONFERENCE AND BROADCASTING.—Ashbridge. (*World-Radio*, 6th May 1938, Vol. 26, pp. 6–7.)

3027. THE WAVELENGTH PROBLEM [Editorial on Cairo Results].—(*Electrician*, 6th May 1938, Vol. 120, pp. 569–570.)

3028. STATION COVERAGE [Useful or "Real" Coverage compared with "Apparent" (Nominal) Coverage: Some Measuring Methods and Results: Effect of Man-Made Noise, especially when using "Antenna Eliminator" (Mains Aerial): etc.].—Haskins & Metcalf. (*Communications*, April 1938, Vol. 18, No. 4, pp. 23–24 and 26.)

3029. MEASUREMENT OF BROADCAST COVERAGE AND ANTENNA PERFORMANCE: PART I—COVERAGE.—Fitch & Duttera. (*RCA Review*, April 1938, Vol. 2, No. 4, pp. 396–413.)

3030. REPORT ON FIELD MEASUREMENTS ON TWO TEST TRANSMITTERS AT DOLLARD AND MAASTRICHT [to find, by Reciprocity Theorem, Best Situation for a Single Central Broadcasting Station for Holland, using a 300 m Wave].—van der Pol. (*Tijdschr. Nederlandsch Radiogenoot.*, April 1938, Vol. 7, No. 6, pp. 173–185.) For supplementary papers see *ibid.*, pp. 186–195 and 196–219.

3031. THE NEW BROADCASTING STATION "RADIO-MONDIAL," ESSARTS-LE-ROI, NEAR RAMBOUILLET.—Adam. (*Génie Civil*, 16th April 1938, Vol. 112, pp. 325–329.)

3032. CBS BUILDS NEW HOME FOR KNX [Los Angeles].—(*Electronics*, April 1938, Vol. 11, No. 4, pp. 20–25.)

3033. THE INTRODUCTION OF HIGH-FREQUENCY WIRED BROADCASTING IN TELEPHONE SYSTEMS [and the Necessary Changes and Additions].—W. Waldow. (*TFT*, March 1938, Vol. 27, No. 3, pp. 108–111.)

3034. CARRIER-FREQUENCY TRANSMISSION OF BROADCAST PROGRAMMES OVER LINES AND CABLES [for Distribution to Several Stations: AEG Equipment for 30 km Cable or 260 km Overhead Lines].—Kluge. (*AEG-Mitteilungen*, April 1938, No. 4, pp. 251–254.)

3035. HIGH-FREQUENCY WIRED WIRELESS [Radio-Diffusion over Telephone Network: AEG Equipment].—Lörcher. (*AEG-Mitteilungen*, April 1938, No. 4, pp. 254–260.)

3036. DUPLEX RADIO-TELEPHONIC COMMUNICATION ON ULTRA-SHORT WAVES [Bordeaux Harbour Link on 1.00 and 0.80 Metre Waves, with Call Device].—Michel. (*Bull. de la S.F.R.*, No. 2, Vol. 12, 2nd Quarter 1938, pp. 47–53: in French and English concurrently.) Using the special magnetrons dealt with in 2767, above.

3037. A 300 & 200 Mc/s BROADCAST PACK TRANSMITTER & RECEIVER [for Relay Work: with Some Results].—Sigmon. (*Communications*, April 1938, Vol. 18, No. 4, pp. 21–22 and 41.)

3038. NEW YORK CITY'S FIRE BOAT COMMUNICATION SYSTEM [on Medium and Ultra-Short Waves].—Borsody. (*Electronics*, April 1938, Vol. 11, No. 4, pp. 10–13 and 62.)

GENERAL PHYSICAL ARTICLES

3039. CURRENT CONDUCTION BY CONVECTION & DIFFUSION IN CYLINDRICAL ARRANGEMENTS [*i.e.* between Concentric Cylinders with Radial Electric Field: Simplified Solution applicable in Most Practical Cases is given in addition to the General Solution].—F. Borgnis. (*Ann. der Physik*, 3rd April 1938, Vol. 31, No. 8, pp. 745–754.)

3040. THE MOST PROBABLE VALUES FOR THE ELECTRON AND ASSOCIATED CONSTANTS FOR 1938 [Charge on Electron = $4.796 \pm 0.005 \times 10^{-10}$ e.s.u.].—Millikan. (*Ann. der Physik*, May 1938, Vol. 32, No. 1/2, pp. 34–43.)

3041. THE RELATIONS BETWEEN STEFAN'S RADIATION LAW, NERNST'S HEAT THEOREM, AND MAXWELL'S FORMULA FOR THE RADIATION PRESSURE.—Guth & Haas. (*Proc. Nat. Acad. Sci.*, May 1938, Vol. 24, No. 5, pp. 224–227.)

3042. REDUCTION TO ABSOLUTE FORM OF THE LAW OF WIEDEMANN & FRANZ FOR THE THERMAL AND ELECTRICAL CONDUCTIVITIES OF METALS.—Labocceta. (*La Ricerca Scient.*, 15th/31st March 1938, Series 2, 9th Year, Vol. 1, No. 5/6, pp. 262–263.)

3043. THE PHOTON EMISSION OF THE SUN [Simple Theory suggests that Number of Photons emitted in 20 000 Years equals Total Number of Photons in the Sun].—Haas. (*Phys. Review*, 15th April 1938, Vol. 53, No. 8, p. 681: abstract only.)

3044. A METHOD OF CHECKING THE LIÉNARD-LORENTZ POTENTIALS AND FOR THE EVENTUAL MEASUREMENT OF ALL SPATIAL ANISOTROPY [H.F. Induction Method of disproving "Ether Wind": Results show Secondary Phenomenon related to Direction of Earth's Magnetic Field].—Hély & Malsallez. (*Rev. Gén. de l'Elec.*, 23rd April 1938, Vol. 43, No. 17, pp. 527–528.)

3045. THE SECOND UNION CONFERENCE ON THE ATOMIC NUCLEUS.—Walther. (*Physik. Zeitschr. der Sowjetunion*, No. 5, Vol. 12, 1937, pp. 610–622: in English.)

3046. "KINETIC THEORY OF GASES" [Book Review].—Kennard. (*Electronics*, May 1938, Vol. 11, No. 5, p. 30.)

3047. EXPERIMENTS ON ELECTRIFICATION BY FRICTION [leading to Hypothesis that Frictional Electricity is Result of Chemical Action].—Lahousse. (*Rev. Gén. de l'Élec.*, 30th April 1938, Vol. 43, No. 18, p. 555.)

MISCELLANEOUS

3048. A MECHANICAL LAG-SCREEN OSCILLOGRAPH [for Study of Low-Frequency or Non-Cyclic Wave Forms (*e.g.* Instantaneous Visualisation of Electrocardiograms): Short-Period Suspended-Magnet Mirror Galvanometer reflecting on to Moving-Belt Phosphorescent Screen].—Hoecker & Asher. (*Review Scient. Instr.*, May 1938, Vol. 9, No. 5, pp. 148–150.)

3049. DISCUSSION ON "THE EXAMINATION AND RECORDING OF THE HUMAN ELECTROCARDIOGRAM BY MEANS OF THE CATHODE-RAY OSCILLOGRAPH."—Robertson. (*Journ. I.E.E.*, May 1938, Vol. 82, No. 497, pp. 559–560.) *See* 2815 of 1937 and 739 of February.

3050. ON THE PROPERTIES OF GEOLOGICAL CONDUCTORS AND THEIR DETERMINATION [with Special Reference to Geological Exploration by Radio Methods].—Fritsch. (*Hochf:tech. u. Elek:akus.*, April 1938, Vol. 51, No. 4, pp. 138–146.)

3051. MAY SPOT AIRPLANES WITH TELEVISION RECEIVERS [Method based on "Ghost" Images produced by Reflection of Waves from Metal Aeroplanes].—(*Sci. News Letter*, 23rd April 1938, Vol. 33, p. 269.)

3052. RENTSCHLERISATION [Sterilisation of Air over Operating Table, of Food, etc., by 2537 A.U. Rays].—Rentschler: Hart. (*Science*, 11th March 1938, Vol. 87, Supp. pp. 8–9.)

3053. TIMING LONDON'S BUSES [Impulses transferred by Induction to Stationary Frames at Certain Points on Route].—(*Wireless World*, 7th April 1938, Vol. 42, p. 311.)

3054. APPLICATION OF QUARTZ CRYSTALS TO THE MODULATION OF LIGHT [*X* and 49° Cut: Frequencies up to 4 Mc/s: for Time Base for High-Speed Films: in conjunction with Tuned Photocell, for Velocity of Light Measurements: etc.].—McKinley. (*Canadian Journ. of Res.*, April 1938, Vol. 16, No. 4, Sec. A, pp. 77–81.)

3055. SOME UNUSUAL DEMONSTRATIONS WITH PIEZOELECTRIC RESONATORS [*e.g.* Friction between Vibrating Quartz Surface and a Stationary Surface is Almost Zero].—van Dyke. (*Phys. Review*, 15th April 1938 Vol. 53, No. 8, p. 686: abstract only.)

3056. ON A PIEZOELECTRIC METHOD FOR THE INVESTIGATION OF THE CONTRACTION OF MUSCLES.—Takenaka. (*Jap. Journ. of Phys.*, Transactions & Abstracts, No. 2, Vol. 12, 1938, Abstracts pp. 81–82.)

3057. THE MEASUREMENT OF ALTERNATING PRESSURE BY THE PIEZOELECTRIC METHOD.—Rasumikhin. (*Journ. of Tech. Phys* [in Russian], No. 5, Vol. 8, 1938, pp. 447–452.)

3058. PHOTOCHEMICAL COMBINATION USED AS A SWITCH CONTROL [at Physical Society's Exhibition, London].—Jupe. (*Electronics*, April 1938, Vol. 11, No. 4, p. 36.) *Cf.* 2838 of 1937.

3059. PHOTOELECTRIC SACCHARIMETER—A NEW PHYSICAL INSTRUMENT FOR THE POLARIMETRIC ESTIMATION OF CANE-SUGAR.—Singh & Rao. (*Current Science*, Bangalore, April 1938, Vol. 6, No. 10, pp. 506–507.)

3060. A PHOTOELECTRIC TACHOMETER [for Small, Low-Powered Machines].—Mäder. (*Zeitschr. V.D.I.*, 30th April 1938, Vol. 82, No. 18, p. 531: summary only.)

3061. A SUBMARINE PHOTOMETER FOR STUDYING THE DISTRIBUTION OF DAYLIGHT IN THE SEA.—Utterback & Higgs. (*Journ. Opt. Soc. Am.*, April 1938, Vol. 28, No. 4, pp. 100–102.)

3062. THERMOSTAT WITH SENSITIVE OPTICAL [Photocell] THERMAL CONTROL FOR MEASURING THE TEMPERATURES OF LIVING ORGANISMS WITH A THERMOCOUPLE.—Skublevskij. (*Journ. of Tech. Phys.* [in Russian], No. 23, Vol. 7, 1937, pp. 2255–2263.)

3063. A PHOTOELECTRIC COMPARATOR [with Application to measuring Wire Diameter in process in Manufacture, checking Thread in Screw-Cutting, etc.], *and* THE ROUY PHOTOELECTRIC EXTENSOMETER [on Similar Principle].—Roure & others: Rouy. (*Recherches et Inventions*, April 1938, No. 275, pp. 97–100: p. 100.)

3064. A MAGNETIC-COMPARATOR METAL-THICKNESS TESTER [having Quadrupled Effective Range owing to Use of Non-Pulsating Flux].—Stevenson. (*Journ. Scient. Instr.*, May 1938, Vol. 15, No. 5, pp. 156–158.)

3065. MAGNETIC METHOD FOR MEASURING THE THICKNESS OF NONMAGNETIC COATINGS ON IRON AND STEEL.—Brenner. (*Journ. of Res. of Nat. Bur. of Stds.*, March 1938, Vol. 20, No. 3, pp. 257–368.)

3066. CERTAIN CALCULATIONS IN MAGNETIC DEFECTOSCOPY.—Janus [Jaanus]. (*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 8, 1938, pp. 307–315.) For a Conference on this subject *see* 779 of February.

3067. TEST FOR SURFACE ACCURACY [*e.g.* of Anti-Friction Bearings] magnifies 50 000 Times ["Profilometer"].—(*Sci. News Letter*, 30th April 1938, Vol. 33, p. 285.)

3068. A STABILISED A.C.-OPERATED ULTRA-MICROMETER [Direct-Reading Galvanometer shows 1 mm Deflection for 4×10^{-10} cm Shift of Condenser Plates: Bridge with 2 Arms Pure Resistance and 2 Arms consisting of Triode Oscillators, both on 3 Mc/s].—Arenberg & Roope. (*Phys. Review*, 15th April 1938, Vol. 53, No. 8, p. 687: abstract only.)

3069. "FLOATING" SUSPENSION BY ELECTRO-MAGNETIC FORCE: A POSSIBILITY FOR A FUNDAMENTALLY NEW FORM OF TRANSPORT.—Kemper. (*E.T.Z.*, 14th April 1938, Vol. 59, No. 15, pp. 391–395.)

Modern technique of current control by amplifiers and rectifiers, combined with the capacity-change principle for the conversion of change of position into electrical change, enables a practically "floating" condition to be maintained between electromagnet and armature. Preliminary experiments give hopeful results for high-speed wheel-less railways.

3070. A Practical Metal Detector [originally for detecting Metallic Bits in Cigars during Manufacture: Reasons for discarding the Beat-Frequency Method: a Tuned Inductance Bridge Equipment].—Broekhuysen. (*Electronics*, April 1938, Vol. 11, No. 4, pp. 17–19.)

3071. Electrical Recording of Forces by Changes in Inductance.—Wieselsberger. (*Yearbook of German Aeronautical Research*, 1937, pp. 592–594: *Report of Aerodynamic Inst., Tech. College, Aachen*, No. 15, 1937.)

3072. Dynamic Extension Measurements on a Locomotive Connecting Rod at Full Speed [by Electro-Magnetic Device].—Lehr. (*Zeitschr. V.D.I.*, 7th May 1938, Vol. 82, No. 19, pp. 541–545.)

3073. Apparatus for the Continuous Measurement and Recording of the Concentration of Any Gas in a Gaseous Mixture.—Malsallez & Foldès. (*Rev. Gén. de l'Élec.*, 14th May 1938, Vol. 43, No. 20, pp. 616–618.) Further development of the method referred to in 2639 of June.

3074. Electrical Measuring Processes applied to the Diesel Engine.—Sulzer Company. (*Génie Civil*, 21st May 1938, Vol. 112, No. 21, p. 440.)

3075. Booklets, Catalogues, and Pamphlets Received.—(*Proc. Inst. Rad. Eng.*, April 1938, Vol. 26, No. 4, pp. 488–490.)

3076. Technical Manuscripts in Foreign Languages: *Electronics* in future will only accept Contributions in English.—(*Electronics*, April 1938, Vol. 11, No. 4, p. 9.) "Thus shifting to the author the translation difficulty": the previous procedure has often resulted in the incorrect handling of shades of meaning, to the author's own dissatisfaction. The author will be paid the full rate instead of (as before) the difference between that rate and the cost of translation.

3077. Ways to Improve the U.S. Patent System.—(*Electronics*, May 1938, Vol. 11, No. 5, pp. 9–11 and 34, 36.)

3078. Abstracts of Recent Marconi Company Patents.—(*Marconi Review*, April/June 1938, No. 69, pp. 42–51.) *See* 1675 of April.

3079. Journals for Electrical Engineers [Abridged Report on Evaluation of English-Language and Foreign Journals].—Dalziel. (*Elec. Engineering*, March 1938, Vol. 57, No. 3, pp. 110–113.) For somewhat similar analyses, including one dealing separately with Wireless journals, *see* 839 of 1936.

3080. "Text Book of Thermodynamics" [including Thermodynamics of Electron Clouds and of Magnetic Behaviour: Book Review].—Epstein. (*Science*, 18th March 1938, Vol. 87, pp. 258–259.)

3081. "Radioélectricité Générale" [Vol. 2—The Functioning of Valves. Transmission and Reception: Book Review].—Mesny. (*Rev. Gén. de l'Élec.*, 12th Feb. 1938, Vol. 43, No. 7, p. 194.)

3082. "Alternating Current Electrical Engineering: 5th Edition" [Book Review].—Kemp. (*Wireless Engineer*, March 1938, Vol. 15, No. 174, p. 149.)

3083. "Electrical Resistivity Surveying."—Le Grand, Sutcliff & Gell, Ltd. (At Patent Office Library, London: Cat. No. 78 421: 12 pp.)

3084. "Measurement of Radiant Energy" [Heat and Light: Book Review].—Forsythe (Edited by). (*Phil. Mag.*, April 1938, Vol. 25, No. 169, p. 703.)

3085. "Definitions and Formulae for Students: Electrical: Telegraphy and Telephony" [Book Reviews].—Kemp: Mallett. (*P.O. Elec. Eng. Journ.*, April 1938, Vol. 31, Part 1, p. 81.)

3086. "Technisches Wörterbuch, Polnisch-Deutsch" [Book Review].—Stadtmüller. (*Zeitschr. V.D.I.*, 19th March 1938, Vol. 82, No. 12, p. 364.)

3087. The "Grands Prix" for Telefunken, Telefunken Gramophone Record Company, and Klangfilm, at the Paris World Exposition, 1937.—(*Telefunken*, March 1938, Vol. 19, No. 78, pp. 69–75.)

3088. The 14th Great German Radio Exhibition [New Valves, Pentodes, Tuning Indicators: Receivers, Automatic Sharp Tuning Device: Loudspeakers: Television Reception, Transmission].—Fuchs. (*Hochf:tech. u. Elek:akus.*, Jan. 1938, Vol. 51, No. 1, pp. 3–10.)

3089. The Exhibition of Detached Pieces [Component Parts], Paris, February 1938.—(*L'Onde Élec.*, April 1938, Vol. 17, No. 196, pp. 211–216.)

3090. Novelties in Radio Construction [based on Paris Exhibition-Demonstration 1st–4th February].—Adam. (*Génie Civil*, 5th March 1938, Vol. 112, No. 10, pp. 206–209.)

3091. The 28th Annual Exhibition of the Physical Society.—(*Television*, Feb. 1938, Vol. 11, No. 120, pp. 87–90.)

3092. Electric Interference between Urban Power Distribution and Communication Circuits.—Noda & Nisiyama. (*Memoirs of the Ryojun Coll. of Eng.*, Manchuria, March 1938, Vol. 11, No. 2, pp. 55–78.)

3093. Twenty Years of Soviet Physics, and Other Papers on Russian Research.—Joffe & others. (*Tech. Phys. of USSR*, No. 11/12, Vol. 4, 1937, pp. 891–943: *Physik. Zeitschr. der Sowjetunion*, No. 5, Vol. 12, 1937, pp. 493–549: all in English.)

3094. Fundamental Research and Its Human Value.—Langmuir. (*Scient. Monthly*, April 1938, pp. 358–365.)

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.

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

480 209.—Automatic biasing arrangement for the LF stage, particularly of a battery-driven set, designed to cut down the normal consumption of H.T.

Magyar Wolframlampa Co. Convention date (Hungary) 24th December, 1935.

482 284.—Reproducing musical sounds, particularly chords, by electro-static means.

A. H. Midgley and A. M. Midgley. Application dates 23rd and 28th September, 1936.

AERIALS AND AERIAL SYSTEMS

480 577.—Spaced aerial system for transmitting and receiving ultra-short-wave signals over distances greater than the normal "optical" range.

Marconi's W.T. Co. (assignees of V. K. Zworykin). Convention date (U.S.A.) 18th July, 1936.

481 903.—Short-wave directional aerial consisting of a number of horizontal half-wave antennae fed from a vertical transmission line which comprises a number of crossed-over half-wave sections.

Marconi's W.T. Co. (assignees of G. H. Brown). Convention date (U.S.A.) 20th September, 1935.

DIRECTIONAL WIRELESS

480 572.—Direction-finder of the "impulse" or "flicker" type in which the ground-wave alone is allowed to reach the indicator, the reflected space wave being automatically rejected.

Telefunken Co. Convention date (Germany) 20th June, 1936.

481 961.—Direction-finding receiver in which the usual figure-of-eight curve of a frame aerial is elongated or flattened-out, so as to increase its directional sensitivity.

L. L. Kaess. Application date 22nd June, 1936.

482 101.—Direction-finding installation in which "quadrantal error" is automatically corrected by means of a specially-shaped "mask" interposed between a source of light and a photo-sensitive cell.

Telefunken Co. Convention date (Germany) 24th July, 1936.

483 437.—Radio-navigational scheme in which the outline of a befogged landing-ground is projected on to the fluorescent screen of a cathode-ray receiver.

The British Thomson-Houston Co. Convention date (U.S.A.) 6th July, 1936.

RECEIVING CIRCUITS AND APPARATUS

(See also under Television)

479 991.—Method of automatic selectivity control in which the width of signal frequencies accepted by a wireless receiver is varied directly with the amplitude of the incoming signal and inversely with the amount of interference present.

Hazeltine Corporation (assignees of J. F. Farrington). Convention date (U.S.A.) 12th June, 1936.

480 017.—Method of automatic frequency control in which use is made of the mutual conductance between the signal-input electrode and the local-oscillator anode of a single-valve frequency changer of the heptode type.

R. I. Kinross. Application date 15th August, 1936.

480 019.—Grid-leak detector with a feed-back circuit designed to suppress the passage of high-frequency components through the valve.

G. W. Johnson (communicated by Philco Radio and Television Corpn.). Application date 19th August, 1936.

480 074.—Construction and arrangement of a "unitary" push-pull amplifier for very short waves.

Standard Telephones and Cables (assignees of R. J. Kircher). Convention date (U.S.A.) 30th June, 1936.

480 378.—Circuit arrangement designed to maintain the internal impedance of a valve constant over a wide range of operating frequencies.

The General Electric Co. and L. I. Farren. Application date 26th October, 1936.

480 417.—Circuit arrangement for stabilizing the operation of a high-gain tuned amplifier, particularly of a pentode used in a band-pass filter.

Philco Radio and Television Corpn. Convention date (U.S.A.) 3rd July, 1936.

480 680.—High-frequency transformer coupling, the primary and secondary circuits being given different tuned characteristics in order to give uniform gain over a wide band of frequencies and a constant degree of selectivity over that range.

B. J. Banfield. Application date 25th July, 1936.

480 755.—Band-pass filter for a wireless set in which the effective selectivity is varied by a knob which moves the iron-cores of associated inductances.

The General Electric Co. and W. H. Peters. Application date 28th August, 1936.

480 839.—Wireless receiver in which selectivity-control is linked with tone-control in such a way that the two adjustments are effected in sequence.

Standard Telephones and Cables (assignees of Standard Villamossagi Reszveny Tarsasag). Convention date (Hungary) 9th July, 1936.

480 970.—Short-wave adaptor unit designed to be conveniently mounted on the spindle of the tuning condenser of a wireless set.

T. A. Biddington and R. Pearl. Application date 29th September, 1936.

480 992.—Telegraph receiver for ultra-short waves comprising one or more relaxation oscillation-generators acting as frequency-changers, and also one or more heterodyning stages.

The General Electric Co. and E. C. S. Megaw. Application date 1st February, 1937.

480 994.—Circuit-arrangement for deriving automatic grid bias for a push-pull amplifier of the quiescent type.

The General Electric Co. and K. A. Macfadyen. Application date 12th February, 1937.

481 001.—Screened transformer-coupling from AC mains to a wireless set, designed to eliminate high-frequency disturbances.

E. Huber. Convention date (Switzerland) 23rd March, 1936.

481 020.—Superhet set in which the local-oscillator is switched from the Hartley circuit to another according to which gives the best frequency stability on the different wave-bands.

Marconi's W.T. Co. Convention date (U.S.A.) 31st August, 1935.

481 064.—Push-pull detector for receiving phase-modulated signals.

Marconi's W.T. Co. (assignees of C. W. Hansell). Convention date (U.S.A.) 5th May, 1936.

481 086.—Method of mounting and connecting the valves of a push-pull cross-neutralised amplifier for very high-frequency working.

Marconi's W.T. Co. (assignees of N. E. Lindenblad). Convention date (U.S.A.) 19th September, 1936.

481 310.—Controlling the selectivity of a wireless set, without introducing distortion or lowering efficiency, by switching-in an auxiliary coupling circuit.

E. K. Cole; T. W. Martin; and H. Hunt. Application date 30th November, 1936.

481 750.—Secondary-emission amplifier in which the "gain" is made to depend upon the applied frequency, so that some degree of selectivity is secured.

The General Electric Co. and N. R. Bligh. Application date 21st September, 1936.

481 790.—Visual tuning indicator consisting of a miniature cathode-ray tube with a bowl-shaped anode coated with fluorescent material.

Marconi's W.T. Co. (assignees of H. M. Wagner). Convention date (U.S.A.) 27th June, 1935.

481 791.—Visual tuning indicator of the small cathode-ray type in which the fluorescent screen is differently illuminated according to the wave range.

Marconi's W.T. Co. (assignees of H. C. Thompson). Convention date (U.S.A.) 27th June, 1935.

481 888.—Circuit for receiving frequency-modulated signals, but not signals above or below a predetermined frequency.

Standard Telephones and Cables (assignees of R. A. Heising). Convention date (U.S.A.) 23rd January, 1936.

482 074.—Cutting-out "static" and similar interference by paralysing one of the amplifying stages during the duration of the disturbing impulse.

L. Gabrilovitch. Convention date (France) 28th April, 1936.

482 152.—Means for automatically setting all the wireless receivers connected to the same supply network to a given wavelength so that they will simultaneously receive an emergency call, such as the warning of an imminent air-raid.

U. G. Petracchini. Application date 3rd November, 1936.

482 162.—Local oscillator for an all-wave superhet set in which different feed-back circuits are used for different wave-bands in order to ensure stability of operation.

Hazeltine Corpn. (assignees of N. P. Case). Convention date (U.S.A.) 15th February, 1936.

482 182.—Wireless set in which the control shaft is fitted with epicyclic gearing to allow fine-tuning adjustments without back-lash.

Fabrica Italiana Magneti Marelli. Convention date (Italy) 25th June, 1936.

482 591.—Multi-grid detector-amplifier in which a space-charge formed between an anode and a positive grid serves to rectify the signals.

J. H. O. Harries and E. G. Autie. Application date 2nd October, 1936.

482 740.—Push-pull amplifier in which negative feed-back is used to produce a substantially balanced output from an unbalanced input.

A. D. Blumlein. Application date 4th July, 1936.

482 785.—Valve amplifying circuit in which negative feed-back is applied to control efficiency and to prevent distortion.

Standard Telephones and Cables (assignees of E. Peterson). Convention date (U.S.A.) 1st April, 1936.

482 992.—High-frequency amplifier valve of the screen-grid type in which an auxiliary grid is arranged to prevent screen-grid currents and "rustling" noises.

The Philips' Lamp Co. Convention date (Holland) 22nd June, 1936.

483 320.—Superhet receiver in which a high or first intermediate-frequency is followed by a lower or second intermediate frequency.

G. von Schaub. Convention date (Germany) 17th October, 1935.

TELEVISION CIRCUITS AND APPARATUS

(For Transmission and Reception)

480 017.—Automatic tuning control regulated by the mutual conductance of the grid and oscillator anode of the frequency-changing valve in a superhet set.

R. I. Kinross. Application date 15th August, 1936.

480 073.—Cathode-ray tube provided with an electromagnetic focusing coil mounted inside the glass vessel to ensure a more concentrated beam of electrons.

Farnsworth Television Inc. Convention date (U.S.A.) 1st June, 1936.

480 275.—Cathode-ray tube in which the electron stream is modulated by potentials of small magnitude and is then intensified by secondary emission.

Baird Television; D. M. Johnstone; and C. Szegho. Application date 20th August, 1936.

480 279.—Television system in which one set of signals is transmitted for domestic reception, and another set of signals is simultaneously transmitted for theatrical reproduction on a large viewing screen and with equal clarity.

Radio-Akt D. S. Loewe. Convention date (Germany) 22nd August, 1935.

480 355.—Circuit for supplying the operating voltages to a cathode-ray tube, with means for preventing variations due to changes in the load current taken by the first and second anodes.

A. D. Blumlein and R. E. Spencer. Application date 18th July, 1936.

480 521.—Means for automatically adjusting the size of the image point in a cathode-ray tube in accordance with the number of scanning lines used in the particular television programme that is being received.

Radio-Akt D. S. Loewe. Convention date (Germany) 22nd May, 1935.

480 646.—Television system in which an auxiliary photo-electric cell is used to produce a control current representing low-frequency changes in the average illumination of the scene being transmitted.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 17th September, 1936.

480 672.—Arrangement of the focusing lenses and electrodes used for controlling the concentration of the electron stream in a cathode-ray tube.

Radio-Akt D. S. Loewe. Convention date (Germany) 25th June, 1935.

480 673.—Television scanning system based on the use of a mirror vibrated simultaneously in two directions by the electro-magnetic control of two torsion rods.

W. H. Priess. Convention date (New Zealand) 13th July, 1935.

480 691.—Cathode-ray television receiver in which the modulated electron stream releases secondary electrons from one or more grids interposed between the "gun" and a comparatively small fluorescent screen, the image on which is magnified optically.

Baird Television and V. Jones. Application date 25th August, 1936.

480 711.—Multiple-anode and electron-lens system for a "soft" cathode-ray television receiver designed to be operated by comparatively low supply voltages.

Marconi's W.T. Co. and N. Levin. Application date 27th August, 1936.

480 779.—Electron-optical focusing arrangement for a cathode-ray tube.

Radio-Akt D. S. Loewe. Convention date (Germany) 27th June, 1935.

480 857.—Electrode arrangement forming a focusing lens for the electron stream in a cathode-ray tube.

W. D. Wright and O. Klemperer. Application dates 30th July, 1937 and 7th May, 1937.

480 859.—Scanning system for television based upon the production of an electric field which diverges symmetrically from a central axis which forms the scanning line.

Soc. Anon. Franco-Belge d'Electricite and J. Loeb. Application date 28th May, 1936.

480 944.—System of television in natural colours depending upon the use of a prismatic spectrum produced from a single source of white light.

W. H. Priess. Convention date (New Zealand) 13th July, 1935.

480 946.—Method of preparing the photo-electric mosaic-cell screens used in cathode ray television transmitters.

L. Klatzkow. Application date 25th June, 1936.

480 996.—Television system in which an image of the picture is projected upon one face of a photo-sensitive screen so as to vary the transverse resistance of each elementary area, the opposite side of the screen then being scanned by an electron stream.

Electrical Research Products Inc. Convention date (U.S.A.) 4th March, 1936.

480 997.—Method of forming the fine apertures in a rotating-disc scanner having several spiral turns.

The General Electric Co.; D. C. Espley; H. W. B. Gardner; and W. O. Russell. Application date 23rd February, 1937.

480 948.—Means for safeguarding the fluorescent or mosaic-cell screen of a cathode-ray tube from being damaged by ionic bombardment from the cathode.

F. H. Nicoll. Application date 25th July, 1936.

481 094.—Cathode-ray tube arranged to produce on a fluorescent screen a trace or picture, which persists after the originating signals and until it is deliberately wiped out.

The British Thomson Houston Co. and D. Gabor. Application date 4th June, 1936.

481 132.—Projecting an incoming television picture upon a luminescent screen which is constantly subjected to the action of ultra-violet light.

Telefunken Co. Convention date (Germany) 7th September, 1935.

481 264.—Television scanning system in which an elongated scanning spot is deliberately used in order to improve the "lifelike" appearance of the picture.

E. Michaelis. Convention date (Germany) 28th August, 1936.

481 343.—Short-wave television transmitter with a push-pull master-oscillator controlled by a concentric "line resonater" coupled to the two grids.

Marconi's W.T. Co. (assignees of O. E. Dow and N. E. Lindenblad). Convention date (U.S.A.) 6th May, 1936.

481 430.—Electron-optical arrangement for focusing the stream in a cathode-ray tube and for giving it as small a cross-section as possible in the region of the deflecting plates.

Radio-Akt D. S. Loewe. Convention date (Germany) 6th July, 1935.

481 444.—Relaxation-oscillator for producing scanning voltages for television, in which the return path of the spot of light is thrown outside the field of the image.

Radio-Akt D. S. Loewe. Convention date (Germany) 11th September, 1935.

481 516.—Magnetic deflecting-system for the electron stream of a cathode ray tube.

Baird Television and A. H. Gilbert. Application date 11th September, 1936.

481 549.—Electrode arrangement for controlling the electron stream of a cathode-ray tube and for preventing the production of field-effects likely to distort it.

Standard Telephones and Cables. Convention date (U.S.A.) 20th August, 1936.

481 563.—Cathode-ray television transmitter, or receiver, based upon the use of a variable secondary-emission effect.

H. G. Lubszynski. Application date 10th September, 1936.

481 592.—Cathode-ray television receiver in which a grid-like assembly of electrodes is used to modulate a ray of light from an external source by electrostatic action.

P. N. G. Toulon. Convention date (France) 15th May, 1936.

481 621.—Housing for a rotating-disc scanner with an associated mask having a radial slot.

J. G. S. Arathoon. Application date 3rd November, 1936.

481 659.—Cathode-ray tube with a repulsion electrode for modulating the electron stream without affecting the size of the spot produced on the screen.

V. Zeitline; A. Zeitline; and V. Kliatchko. Convention date (France) 13th June, 1935.

481 660.—Cathode-ray tube in which three grids, placed between the cathode and an apertured diaphragm, are used to focus the electron stream.

V. Zeitline; A. Zeitline; and V. Kliatchko. Convention date (France) 13th June, 1935.

481 792.—Compensating for the effect of irregularities in the apertures used to produce the synchronising signals in a rotating-disc type of television scanner.

The General Electric Co. and D. C. Espley. Application date 11th August 1936.

481 944.—Compensating for leakage fields likely to affect the electron stream of a cathode-ray television receiver.

E. Michaelis (communicated by E. Kinne). Application date 18th September, 1936.

482 007.—Scanning and synchronising circuit for a cathode-ray tube in which the return or "flyback" stroke is substantially extinguished.

Farnsworth Television Inc. Convention date (U.S.A.) 10th February, 1936.

482 208.—Light-sensitive device, suitable for television purposes, in which the known "actino-dielectric" effect of phosphorus is used, the phosphorus forming the dielectric of a condenser inserted in one of the arms of a balanced Wheatstone bridge.

Telefunken Co. Convention date (Germany) 24th September, 1935.

482 370.—Saw-toothed oscillation-generator, suitable for television scanning, and designed to ensure a minimum consumption of power.

E. L. C. White and A. D. Blumlein. Application date 27th August, 1936.

482 513.—Deflecting coil for a cathode-ray tube in which the windings are arranged to produce a substantially-homogeneous field over the whole interior of the coil.

Fernsch Akt. Convention date (Germany) 30th September, 1935.

482 704.—Construction of screen for a cathode-ray television receiver in which the pictures are reproduced by incandescence instead of fluorescence.

N. V. Philips Lamp Co. Convention date (Germany) 23rd October, 1936.

482 724.—Relaxation oscillation-generator for producing saw-toothed scanning voltages for a cathode-ray tube.

Cie pour la Fabrication des Compteurs, etc. Convention dates (France) 4th October, 1935, and 29th July, 1936.

482 835.—Television outfit adapted for the scanning of pictures under water, *e.g.* for the close examination of deeply-submerged objects.

G. Sylven. Convention date (Sweden) 28th July, 1936.

483 012.—Cathode-ray tube in which one or more auxiliary discharge-paths are provided, independent of the main stream, and preferably at right-angles to it, for amplifying, rectifying or modulating currents subsequently used for controlling the main stream.

Radio Akt D. S. Loewe. Convention date (Germany) 14th October, 1935.

483 332.—Television system in which three or more lenses are used in succession for scanning.

E. Traub and M. J. Goddard. Application date 20th October, 1936.

483 348.—Television receiver in which a biased diode is used to separate synchronising-impulses from the picture signals.

The General Electric Co. and G. W. Edwards. Application date 1st March, 1937.

483 372.—Television transmission system in which one channel is used for the higher frequencies, and another for the lower frequencies and the D.C. component.

Marconi's W.T. Co. (assignees of G. Guanella). Convention date (Germany) 26th March, 1936.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

480 667.—Method of stabilising the operation of high-frequency electron-multipliers, or oscillation-generators, of the double-resonance type, utilising secondary emission.

Marconi's W.T. Co. (assignees of C. H. Brown and W. van B. Roberts). Convention date (U.S.A.) 28th October, 1935.

481 527.—Multiplex system based on the use of frequency-modulated signals, and provided with means for eliminating interference due to cross-talk.

E. H. Armstrong. Convention date (U.S.A.) 14th September, 1935.

481 841.—Common-wave broadcasting system in which the modulated carrier-wave is first stepped-down in frequency for transmission from the central station to the various relay stations, where it is again stepped-up to the original frequency.

Standard Telephones and Cables (assignees of H. A. Affel). Convention date (U.S.A.) 10th July, 1936.

481 855.—Transmission system in which the unmodulated carrier is radiated from one aerial and the upper and lower side bands from two other aerials.

Marconi's W.T. Co. (assignees of G. H. Brown). Convention date (U.S.A.) 16th July, 1936.

481 251.—Electrode arrangement in a magnetron tube of the split-anode type as used for generating or receiving ultra-short waves.

Telefunken Co. Convention date (Germany) 16th July, 1936.

482 241.—Modulating or demodulating system in which a two-electrode rectifier is used in series with a high resistance to secure an improved characteristic curve.

Siemens and Halske Akt. Convention date (Germany) 30th June, 1936.

482 420.—Means for attenuating or absorbing signals, so as to prevent reflection, on a transmission line of the so-called dielectric-guide type for propagating centimetre waves.

Standard Telephones and Cables (assignees of S. A. Schelkunoff). Convention date (U.S.A.) 31st October, 1936.

483 540.—Capacitive and inductive "loading" elements for high-frequency transmission lines of the so-called "dielectric-guide" type.

Standard Telephones and Cables (assignees of S. A. Schelkunoff). Convention date (U.S.A.) 4th December, 1936.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

479 978.—Construction and preparation of the primary cathode of an electron multiplier, so that it shall be photo-sensitive to light of wavelength up to 7000 Å.

The M-O. Valve Co. and W. H. Aldous. Application date 21st January, 1937.

480 066.—Construction of high-frequency discharge tube with provision for ensuring a symmetric disposition of the electrodes.

C. Lorenz Akt. Convention date (Germany) 9th May, 1936.

480 313.—Loud speaker with a separate adjustable reflecting member for improving the quality of the reproduced sounds.

G. Lakhovsky. Convention date (France) 11th July, 1936.

480 786.—Electrode arrangement for an electron multiplier in which the stream is subjected to electrostatic and magnetic control fields.

British Thomson Houston Co. and D. Gabor. Application date 27th May, 1936.

480 867.—Electron discharge tube of high mutual conductance, in which the cathode discharge flows in one or more fan-like streams and is subjected to secondary emission.

Ferranti and M. K. Taylor. Application date 2nd September, 1936.

481 012.—Electron multiplier in which the initial discharge stream is subjected to variable secondary-emission, under the control of a deflecting electrode, in order to produce different characteristic responses. (Divided from No. 480 786.)

British Thomson-Houston Co. and D. Gabor. Application date 27th May, 1936.

481 170.—Target electrode for an electron multiplier with a sensitised coating of aluminium oxide, giving a high ratio of emission under bombardment.

Marconi's W.T. Co. (assignees of V. K. Zworykin). Convention dates (U.S.A.) 6th September, 1935, *and 30th April,* 1936.

481 282.—Construction and assembly of a multi-grid valve with a metal casing.

Egyesult Izzolampa es Villamossagi Reszvenytarsag. Convention date (Hungary) 8th July, 1935.

482 026.—Electron multiplier in which the "target" electrodes are alternately plane and cylindrical surfaces arranged in cascade.

Farnsworth Television Inc. Convention date (U.S.A.) 1st June, 1936.

482 909.—Method of mounting the cathode of a "dual purpose" valve, such as a double-diode-triode.

E. K. Cole and F. W. O. Kennedy. Application date 26th October, 1936.

SUBSIDIARY APPARATUS AND MATERIALS

479 979.—Preparing and mounting piezo-electric crystals capable of giving a single-frequency response up to four million cycles a second.

Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.) 21st February, 1936.

479 987.—Cutting and preparing piezo-electric crystals having a zero or other predetermined temperature coefficient of frequency.

Standard Telephones and Cables (assignees of W. P. Mason). Convention date (U.S.A.) 12th June, 1936.

480 710.—Microphone fitting for an oxygen face-mask as used by aviators when flying at very high altitudes.

Marconi's W.T. Co. and J. Stewart. Application date 27th August, 1936.

480 744.—Construction and method of assembling the constituent parts of a cylindrical screening case for valves, tuning-coils, and the like.

A. F. Bulgin & Co. and A. F. Bulgin. Application date 23rd September, 1937.

480 752.—Method and apparatus for testing the mutual conductance of a valve, as a criterion of its "goodness" or standard of merit.

S. R. Wilkins and The Automatic Coil Winder and Electrical Equipment Co. Application date 26th August, 1936.

481 081.—Measuring high-frequency currents by a thermo-converter arranged to indicate values on differently-marked scales, at will.

Siemens and Halske Akt. Convention date (Germany) 6th August, 1936.

481 287.—Telegraphone type of apparatus for measuring small intervals of time, and the form of transient electrical disturbances in an electric circuit.

W. M. Burden and G. O. C. Probert. Application date 8th August, 1936.

481 319.—Means for reducing the "skin" effect in high-frequency conductors and coils.

E. Friedlaender. Convention date (Germany) 8th January, 1936.

481 543.—Piezo-electric crystal mounted in a fluid or semi-fluid setting so as to prevent changes of frequency due to atmospheric conditions.

H. Ando. Convention date (Japan) 27th February, 1936.

481 551.—Microphone of the ribbon type fitted with a sectioned "loading" tube which is free from air-leakage.

Marconi's W.T. Co. (assignees of L. J. Anderson). Convention date (U.S.A.) 30th June, 1936.