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Editorial

Short-Wave Transmitters with Spherical Circuits

A BEAUTIFULLY symmetrical oscillatory circuit for ultra-short wavelengths can be made by mounting two metal hemispheres on a metal rod or tube, the two rims being fitted with flanges which form the air-condenser of the circuit. The current will have its maximum value at the mid-point of the rod. Owing to the large surfaces and short paths the damping of such a circuit is very small and, owing to the simple and rigid mechanical construction, the stability of frequency is very high, and the effect of temperature variation accurately calculable. Based on the pioneer work of Kolster*, many interesting applications of such circuits have been recently described by Hollmann†. The spherical shape is only one of a large range of ratios of axial length to diameter of rim, and there is no special virtue in the exact spherical shape. Fig. 1 shows how such a circuit can be connected to the valve in an ultra-short-wave transmitter. Choking coils are inserted in the anode and grid supply leads and the latter also include a high resistance R. To isolate the two supplies a blocking condenser is inserted in the middle of the central tube by fitting it with flanges which are screwed together with a sheet of mica between them. The capacitance is not confined to the space between the flanges; there will be a certain distributed capacitance between the two hemispheres and even between the ends of the central rod. To this must also be added the capacitance between the anode and the grid of the valve. The magnetic field will be confined almost entirely within the sphere. In experiments made to determine the wavelength with various spacings between the flanges, it was found that on plotting λ^2 against $1/a$ (where a = distance between the flanges) a straight line was obtained, as one would expect from the formula for the capacitance of a plate condenser, but that the line did not go through the origin, but through a point indicating a constant valve and stray capacitance of 7.25 cm; of this the calculated valve

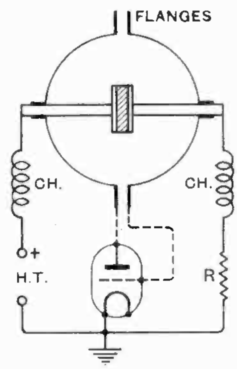


Fig. 1.

* *QST*, Vol. 18, p. 69, 1934; *Proc. Inst. Rad. Eng.*, Vol. 22, p. 1335, 1934.
† *Hochf. tech. u. Elek:akus.*, Vol. 50, p. 109, 1937.

capacitance contributed 1.75 cm. The simple plate condenser formula is only applicable so long as the distance between the flanges is relatively small. If spherical circuits are constructed of various sizes, but of exactly the same geometrical proportions, the wavelengths will, of course, be proportional to the linear dimensions—apart from the disturbing effect of valve capacitance—since both the inductance and the capacitance will be strictly proportional to the linear dimensions.*

An ingenious way of avoiding the difficulties that arise due to the length of the leads connecting the valve to the circuit is to place the valve inside the sphere. Although to make this possible the valves must be small, several valves can be accommodated and operated in parallel, but even then the available power is very limited. Fig. 2a and b shows a transmitter with three acorn valves mounted within the sphere. The vertical extension acts as the aerial. In this example the sphere has a diameter of 10 cm. and the wavelength is about 2 metres.

* Hollmann does not appear to realise this fact, and his treatment of this part of the subject is very unsatisfactory. His formula $\lambda^2 = 4\pi^2\sqrt{L(C_f + C')}$ should not contain the root sign.

Fig. 3 shows how the leads are taken in to the cathode; the blocking condenser at

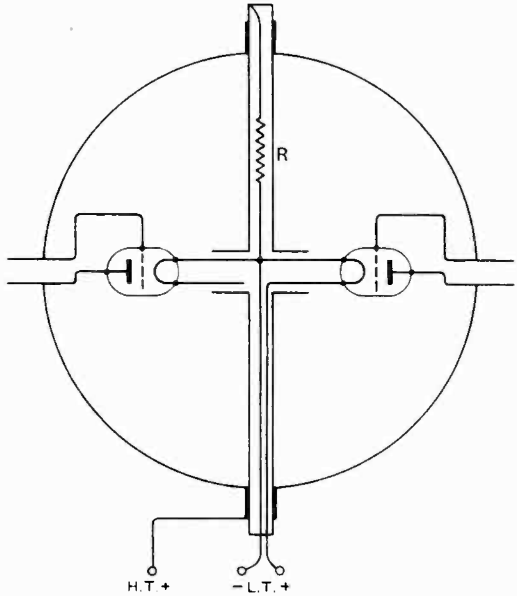
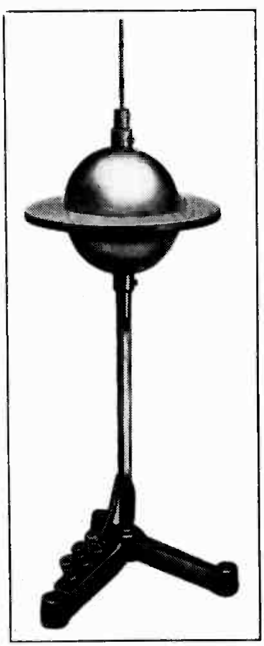


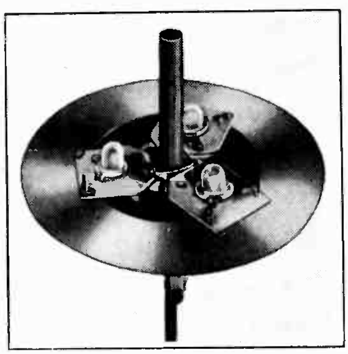
Fig. 3.

the middle of the central tube is made up of four insulated metal plates, of which the two inner ones serve as cathode terminals.

To obtain a large amount of power at a short wavelength the valves must neces-



(b)



(a)

Fig. 2 (a) and (b). — *Spherical circuit with three acorn valves inside the sphere.*

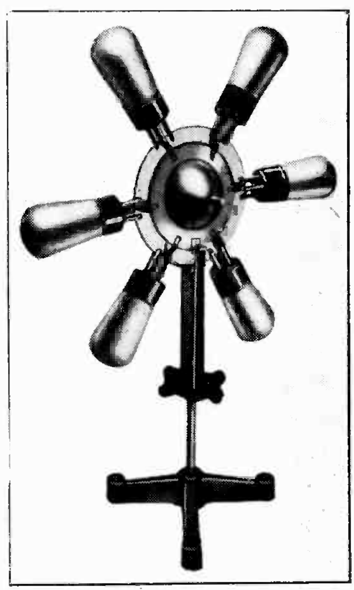


Fig. 4 (*Right*).— *Spherical circuit with six valves in parallel.*

sarily be large and the sphere necessarily small, so that it is not possible to place the valves inside the sphere. They can, however, be mounted around the flanges as shown in Fig. 4, and it is then possible to operate a large number of valves in parallel. Here again the central blocking condenser may consist of four plates, but with the inner pair made so large that they project between the flanges of the sphere and serve as the filament terminals as shown in Fig. 5. The unbalance caused by the difference between the grid and anode capacitances may be counterbalanced by adjusting the air-gaps between the flanges and these central plates.

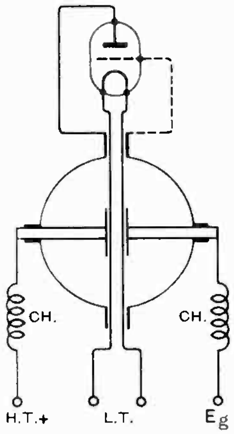


Fig. 5.

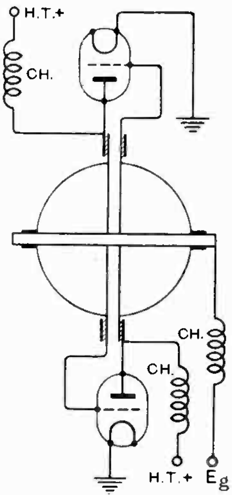


Fig. 6.

Fig. 6 shows how the whole system can be balanced by adopting a push-pull arrangement, half the valves being connected up like the upper one, and the other half like the lower one. The central tube, which is no longer divided, and the two hemispheres, are all a part of the grid connection. The two metal rings, which are insulated from the flanges, are connected to the H.T. supply through separate chokes, and the anodes are connected alternately to the one or the other. Similarly the grids are connected alternately to the opposite hemispheres. It will be seen that when the system is oscillating, those valves which have their anodes connected to the hemisphere (strictly speaking, coupled to the hemisphere via the capacitance between the ring and the flange) that has a positive maximum potential at the given moment will have their grids connected to the other hemisphere, the potential of which will be at its negative maximum, and vice-versa. The whole system is so balanced that the cathodes of the valves can be earthed. Such an oscillator can be used to energise a Lecher wire system by terminating the wires with metal shells which can be placed over the hemispheres without actually touching them, or with metal rings of the same size as the flanges to which they can be approached, thus giving a condenser coupling with the oscillatory circuit.

Hollmann proposes to deal with the application of such spherical circuits to ultra-short-wave receivers in a subsequent communication. G. W. O. H.

Interference Specification

A BRITISH Standard Specification* has recently been issued which aims at defining permissible limits for interference-producing voltages generated by electrical appliances and machines. The Specification has been prepared by a Committee representing a number of official bodies and associations of interested manufacturers.

As we see it, the importance of this document lies in the fact that it represents agreement amongst manufacturers which is so important in paving the way for legislation on the subject of suppressing interference generally to go through smoothly, so avoiding the troubles arising from organised opposition which might have resulted if any attempt had been made to push forward a Bill without first ensuring that it had the approval of the industry affected by its terms.

The new Specification requires that measurements of interference shall be made in the manner described in British Standards Specification No. 727 already issued, and details of devices suitable for suppressing interference with various electrical appliances were given in B.S.S. 613. Separate specifications relating to trolley-buses, tramways, electric lifts and signs, ignition systems and electro-medical appliances, are in course of preparation.

* B.S.S. No. 800: pp. 12; price 2/-. The British Standard Institution, 28, Victoria Street, London, S.W.1.

Background Noise Produced by Valves and Circuits*

By W. S. Percival, B.Sc., and W. L. Horwood, B.Sc.

SUMMARY.—A brief review is given of the well-established theories relating to Johnson Noise and Valve Noise. The noise of a diode is considered as that of its impedance at a certain temperature. A new method of considering the noise of triodes is given according to which an equivalent temperature can be obtained analogous to that obtained for diodes. A formula is also obtained giving an upper limit to the noise due to current sharing in screen grid valves. The theory is compared with experimental results at radio frequency on commercial valves using an improved method of measuring noise.

Introduction

THE "noise output" produced by any high gain amplifier when no signal is applied can be traced to small fluctuations of current or potential difference which are produced in all electrical conductors. Since this noise output provides a limit to the practicable amplification it is desirable to be able to predetermine the value of the fluctuations which produce the noise. In the case of solid conductors it is possible to calculate the value of the fluctuations by the application of simple formulae, but when conductors constituted by the electron streams of amplifying valves are considered, the position is very different. A study of the literature relating to the fluctuations which occur in such electron streams shows that the existing theory is inadequate for the purpose of predicting the noise to be expected from a valve of given constants. Furthermore, very few measurements have been made on commercial valves at frequencies high enough for "flicker" effect to be neglected.

As the amplification of modern radio and television receivers is frequently limited mainly by the noise of the first stage, it has been found necessary to make an examination of the noise of various types of commercial valves in order to select suitable valves for receivers. At the same time, certain hypotheses as to the cause of noise in different types of valves have enabled the results to be correlated. The method of Williams[7, 8] has been applied to diodes and triodes in that the noise of the valve is compared with that of a solid conductor of equivalent resistance, the difference of noise being allowed for by assigning a suitable "effective temperature" to the electron stream. Also, a simple expression is obtained relating to the noise of screen grid valves in which secondary emission is suppressed. In this way certain regularities have appeared, so that it now appears possible to hazard at least a rough guess as to the probable noise of many types of valves without actual measurement. In particular it is generally possible to assign a minimum below which the noise of a valve of given constants would not be expected to fall.

The first part of the article contains some quite well known theory which is included to enable the rest of the article to be understood without constant reference to previous work.

Source of Noise in Amplifiers

The noise output of any amplifier arises from two main sources.

(1) The "circuit noise" of the grid circuit of the first stage of the amplifier.

(2) The "valve noise" of the first valve. Although the first grid circuit and the first valve are stated to be the main sources, it is possible for noise to arise from subsequent stages when the stage gain is very low—usually, however, the noise from subsequent stages is negligible.

The general theoretical considerations relating to the two sources of noise will now be briefly considered.

Circuit Noise.

The electrons within any conductor to which no external source of e.m.f. is applied are in constant motion in a manner which,

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

for the conductor as a whole, can be considered as random. At any instant, however, the resultant effect is that of a small electronic drift either towards one end or the other of the conductor, and therefore is equivalent to the development of a small e.m.f. between the ends of the conductor. It is the e.m.f. arising in this manner in the grid circuit of the first valve of an amplifier which produces a portion of the noise output.

This e.m.f. is due to "thermal agitation" of the electrons and its mean square value is directly proportional to the absolute temperature of the conductor. Also, since the e.m.f. arises from an entirely random effect, the energy associated with it is distributed equally over the ordinary radio frequencies, and therefore for a constant resistance the measured mean square e.m.f. of thermal agitation is directly proportional to the band width over which the measurement is effective.

Johnson investigated this effect[2, 3] and gave an equation for the value of the e.m.f. The equation is now usually stated as follows :—

$$(\Delta E)^2 = 4kT \int_{f_1}^{f_2} R df \quad \ldots \quad \ldots \quad (1)$$

where (ΔE) is the R.M.S. e.m.f. in volts produced across a conductor between the frequency limits f_1 and f_2, R is the resistance of the conductor in ohms at any frequency f cycles per second, k is Boltzmann's gas constant expressed in joules per centigrade degree and T is the absolute temperature of the conductor.

If the resistance is constant and equal to R over a frequency range Δf, then the equation becomes

$$(\Delta E)^2 = 4kT R\Delta f \quad \ldots \quad \ldots \quad (2)$$

If the equation is applied to a conductor constituting a complete circuit, then the fluctuating e.m.f. will produce a fluctuating current such that

$$(\Delta I)^2 = \left(\frac{\Delta E}{R}\right)^2 = \frac{4kT}{R} \Delta f \ldots \quad \ldots \quad (3)$$

where (ΔI) is the fluctuating current in amperes.

By dividing equation (2) by R an expression having the dimensions of power is obtained, thus

$$\frac{(\Delta E)^2}{R} = 4kT \Delta f \quad \ldots \quad \ldots \quad (4)$$

Now $k = 1.37 \times 10^{-23}$ joule per centigrade degree, and taking the room temperature as $288°K$ as has been done throughout the article, equation (4) becomes

$$\frac{(\Delta E)^2}{R} = 1.6 \times 10^{-20} \Delta f \ldots \quad \ldots \quad (5)$$

Thus under these stated conditions $\frac{(\Delta E)^2}{R}$ is 1.6×10^{-20} watt for unity band width. This is a useful fact to remember when thermal agitation e.m.f.'s are to be estimated.

Valve Noise.

As in the case of a solid conductor the electrons in a thermionic discharge have a constant random motion and this is superimposed on the steady flow of current from cathode to anode. Thus the total current is not steady, but has a random component which may be amplified and caused to deflect a measuring instrument. This fluctuation current is uniformly distributed over the normal frequency spectrum as is the fluctuation current due to circuit noise. However, no general formula has so far been discovered by which valve noise can be calculated in the same simple manner as can the noise from a solid resistance.

Now there are three conditions which may exist in the space between the cathode and anode of a valve. In the first the anode potential is so high that all electrons emitted by the cathode are attracted to the anode. This is known as *temperature limited* emission since the current is limited only by the temperature of the cathode.

In the second the anode potential is negative so that those electrons which are emitted from the cathode with less than a certain velocity never reach the anode but fall back into the cathode. The number of available electrons is, however, insufficient to form a space charge. This will be called the *retardation condition*.

In the third the anode potential may be either positive or negative, but the number of electrons flowing to the anode is sufficient to form a space charge which limits the current. This is known as *space charge limited* emission.

The noise of a valve is fundamentally dependent upon which of these conditions exists. Amplifying valves, of course, always operate under the condition of space charge limited emission. The other cases are, however, easier to analyse theoretically and will therefore be considered first.

Valve Noise in the Absence of Space Charge

The equation relating to the shot effect in a diode on closed circuit, i.e., with no anode impedance and in the absence of space charge, is

$$(\Delta I)^2 = 2eI\,\Delta f \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

where (ΔI) is the R.M.S. fluctuating current in amperes measured with reference to a frequency range Δf cycles per second, when the "steady" current is I amperes and e is the charge of an electron (1.59×10^{-19} coulomb). This equation is a rearrangement of the original expression due to Schottky, and applies to both temperature limited emission and to the retardation condition.

Condition of Retardation.—The equation for the current in a diode on closed circuit under the condition of retardation is

$$I = I_s \epsilon^{\frac{-Ve}{kT_c}} \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

where I is the current in amperes for a cathode temperature T_c degrees absolute and an anode-cathode p.d. of V volts, I_s is the saturation current value attained when all electrons emitted reach the anode, k is Boltzmann's constant and $\epsilon = 2.7183$.

By differentiation of equation (7)

$$\frac{dI}{dV} = \frac{eI}{kT_c}$$

Thus the differential resistance r (ohms) at a current I is given by the relation

$$r = \frac{kT_c}{eI} \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

Now consider the electron stream as a conductor of resistance r at an effective temperature T_e degrees absolute producing noise due to thermal agitation. From equation (3), substituting from equation (8)

$$(\Delta I)^2 = 4kT_e\left(\frac{eI}{kT_c}\right)\Delta f$$

$$= 4eI\frac{T_e}{T_c}\Delta f \quad \ldots \quad \ldots \quad (9)$$

Note that the use of equation (3) implies that the circuit impedances external to the electron stream are negligible compared with the valve impedance.

But equation (6) applies to this condition also. Hence, by equating the two expressions for $(\Delta I)^2$

$$T_e = \frac{T_c}{2} \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

Thus if the electron stream is considered as a conductor producing an e.m.f. of thermal agitation, the effective temperature of this conductor must be half that of the cathode. The above derivation of equation (10) follows the method of F. C. Williams [7].

Valve Noise in the Presence of Space Charge.

A.—Diodes:—The effect of the space charge in a diode is primarily to reduce the current flowing by acting as a potential barrier. It can be shown that if this were the only effect then the effective temperature of the diode resistance would be the same as in the absence of space charge. However, the space charge is itself of a fluctuating character and therefore the equivalent potential barrier must also fluctuate in potential and in position. The effect of this is exceedingly complicated and has not been satisfactorily worked out. It is possible, however, to measure the effective temperature of the diode resistance and ascribe its deviation from half the cathode temperature to the effect of space charge fluctuations.

B. Triodes:—The usual method of expressing the noise of an amplifying valve is in terms of an equivalent solid resistance R_n at room temperature, which, if placed in the grid circuit of a noiseless but otherwise similar valve would produce an identical fluctuation of anode current. This is an extremely useful method for practical purposes as it enables a direct comparison to be made with the circuit noise actually produced by the resistive component R_c of the grid circuit impedance. Thus by adding the two resistances R_c and R_n the total effective voltage fluctuation at the grid of the valve due to the valve and circuit can be easily calculated with the aid of equation (2).

However, values of R_n differ widely from valve to valve. It is therefore desirable, if possible, to obtain a parameter which is relatively constant and from which the actual value of R_n can be calculated with the aid of the known constants of the valve.

A suitable parameter would appear, by analogy with the diode, to be the effective temperature of the valve resistance or rather the ratio of this to half the cathode temperature, i.e., $\frac{T_e}{T_c/2}$. However, it has been shown by Williams[8] that the effective temperature of the valve resistance may be thousands of degrees absolute. It is unlikely that the electrons leave the space charge region with this temperature and it would therefore appear that in some way an amplifying valve magnifies the effective temperature. What is required is clearly the effective temperature before this magnification takes place.

The device adopted is to connect the plate capacitively to the grid. The valve then ceases to amplify although the condition of the space charge region is unaltered. In fact the valve now acts to A.C. as a diode of resistance $\frac{1}{g\left(1+\frac{1}{\mu}\right)}$ in which g is the mutual conductance of the valve as an amplifier and μ is its amplification factor.

An effective temperature can now be measured as if the valve was a diode. This effective temperature might be expected to be equal to, or at least bear a close relation to, the temperature of the electrons in the space charge region. It is therefore necessary to find the relation between the noise produced on open circuit by the resistance $\frac{1}{g\left(1+\frac{1}{\mu}\right)}$ at an effective temperature T_e and that produced by a resistance R_n in the grid circuit at a temperature of T_o.

Let the anode circuit of the valve be short circuited (to A.C.). Then the current fluctuation (Δi) in the anode circuit due to noise will be independent of whether the grid is connected capacitively to cathode or to anode, since both are at the same potential. Thus (Δi) can be considered as due either to the resistance $\frac{1}{g\left(1+\frac{1}{\mu}\right)}$ at an effective temperature T_e, or to a resistance R_n at a temperature T_o in the grid lead of a similar but noiseless valve. Equating the two expressions for $(\Delta i)^2$

$$(\Delta i)^2 = 4kg\left(1+\frac{1}{\mu}\right)T_e\Delta f. = 4kR_n g^2 T_o \Delta f$$

$$\therefore R_n T_o = \frac{\left(1+\frac{1}{\mu}\right)T_e}{g} \quad \ldots \quad \ldots \quad (11)$$

Now write $\frac{1}{g\left(1+\frac{1}{\mu}\right)} = \rho_d$, the resistance of an amplifying valve connected as a diode for A.C. Then :—

$$R_n T_o = \left(1+\frac{1}{\mu}\right)^2 \rho_d T_e \quad \ldots \quad \ldots \quad (12)$$

For valves likely to be used for the first stage of amplifiers $\mu \gg 1$ and within the limits likely to be of interest for noise measurements, equation (12) becomes

$$R_n T_o = \rho_d T_e \quad \ldots \quad \ldots \quad \ldots \quad (13)$$

Hence a resistance ρ_d at a temperature T_e connected in the grid circuit of the valve would produce the same noise as the resistance R_n at a temperature T_o. The latter is more convenient for use in circuit calculations as indicated above. However, the former method of expression has the advantage that it measures the quantity T_e which may be described as the effective temperature of the electron stream. It would be expected that this would be a relatively constant quantity for valves of different types, that is, that it would be relatively independent of the mutual conductance and amplification factor of a valve. This has been found to be the case in practice. Thus if T_e is known for a particular class of valve with a certain cathode temperature, then the noise resistance R_n can be calculated for a particular specimen from equation (13). A knowledge of T_e should therefore be of practical value. Moreover, its particular value and any variations that exist may shed light on conditions existing in the electron stream and should therefore be of theoretical importance. The value of T_e, or rather the value of $\frac{T_e}{T_c/2}$ has therefore been calculated for all the triodes whose measured noise resistances are given later.

C. Screen Grid Valves :—A screen grid valve differs from a triode as far as noise is concerned since a portion of the current which would otherwise flow to the anode is diverted into the screen grid circuit. This gives rise to a source of noise in addition to the ordinary triode noise due to the random current sharing between screen and anode. If secondaries are emitted by the screen and are attracted to the anode, then the random nature of their emission introduces yet another source of noise.

For measurement purposes a screen grid valve may of course be treated in the same way as a triode valve by connecting its anode and control grid capacitively and then measuring its noise as if it were a diode. However, although a value T_e can be calculated as for a triode this is no longer of any physical significance owing to the additional sources of noise which are unrelated to the cathode temperature.

If the current sharing between screen grid and anode could be considered as entirely random and if the screen current were small compared with the anode current, then the fluctuation current would be given by :—

$$(\Delta i)^2 = 2eI_s\Delta f \quad \text{.. .. ..} \quad (14)$$

in which I_s is the screen current in amperes. This noise can be expressed in terms of an equivalent grid circuit resistance R'_n such that—

$$2eI_s\Delta f = 4kT_o R'_n g^2 \Delta f$$

$$\text{whence } R'_n = \frac{eI_s}{2kT_o g^2} \quad \text{.. .. ..} \quad (15)$$

Substituting values for e, k and T_o

$$R'_n = \frac{20I_s}{g^2} \text{ (approx.)} \quad \text{.. ..} \quad (16)$$

in which g is in amperes per volt.

This value of R'_n can be added to the noise resistance due to the triode noise to give the total noise of the valve.

If secondary emission exists (as in ordinary tetrodes) then I_s in equation (16) should include the secondary emission current leaving the screen. However it is difficult to estimate I_s in such cases as the actual current measured by a meter in the screen lead represents the difference of the primary and secondary currents instead of the sum.

It is possible that the screen current is not entirely random since owing to focusing effects the current from one part of the cathode may inevitably strike a screen wire, while from another part it may inevitably pass through and strike the anode.

Further, if the screen current is not small compared with the plate current, the total noise cannot be obtained by the simple addition of the noise due to the valve acting as a triode and that due to the noise associated with the screen. However, so long as the screen current is smaller than the anode current the calculation is sufficiently accurate for the purpose.

The triode noise of a screen grid valve can of course be measured by connecting the screen to the plate capacitively so that, for A.C., there is no current sharing between screen and anode.

Measurement of Valve Noise

The Method.

This was suggested by the analogy explained above between a diode and an amplifying valve in which the plate and grid are connected capacitively. The equivalent noise resistance of a diode can be measured in a perfectly straightforward manner by amplifying and measuring its noise voltage on open circuit and then substituting a resistance producing the same voltage. The equivalent noise resistance of an amplifying valve connected as a diode can be measured in the same way. Moreover, the resistance substituted is equal to the noise resistance R_n of the valve as can be seen from equation (13), the valve resistance ρ_d at its effective temperature T_e producing the same noise voltage as a resistance R_n at the room temperature T_o.

Choice of Frequency.

It has often been pointed out [4, 5] that if the frequency range selected is near the low frequency end of the spectrum, for example, below 5 kc/s, the measured noise of valves is very much greater than when the mean frequency is higher. The extra noise at the lower frequencies is termed " flicker effect " and is due to a variety of causes.

In the series of tests about to be described, a mean frequency of 2.5 Mc/s was chosen so that " flicker " could be considered negligible. On the other hand, this frequency is not so high as to lead to complications arising from transit time effects in the valves. Further, at 2.5 Mc/s there is not much chance of pick-up of broadcast signals by the amplifier.

A wide pass band of 200 kc/s (for a 6 db. loss) was chosen in order to reduce the gain required in the amplifier to provide a given noise output. Also as measurements at ultra high frequencies were contemplated using the noise amplifier to provide intermediate frequency amplification, too narrow a band width would have resulted in intolerably sharp tuning.

The Apparatus.

The apparatus consists of two parts, an effectively aperiodic test circuit comprising the valve under test and associated components, and an amplifier of limited band width which must amplify the noise up to a measurable level and rectify it so that it can operate a D.C. measuring instrument.

The Amplifier.

The circuit of the amplifier is shown in Fig. 1 and photographs of the actual apparatus are shown in Figs. 1(a) and 1(b). From the constructional point of view the lines of a tuned radio frequency vision receiver were followed, complete screening being provided by "cans" above and below the copper chassis. The noise e.m.f.'s of the

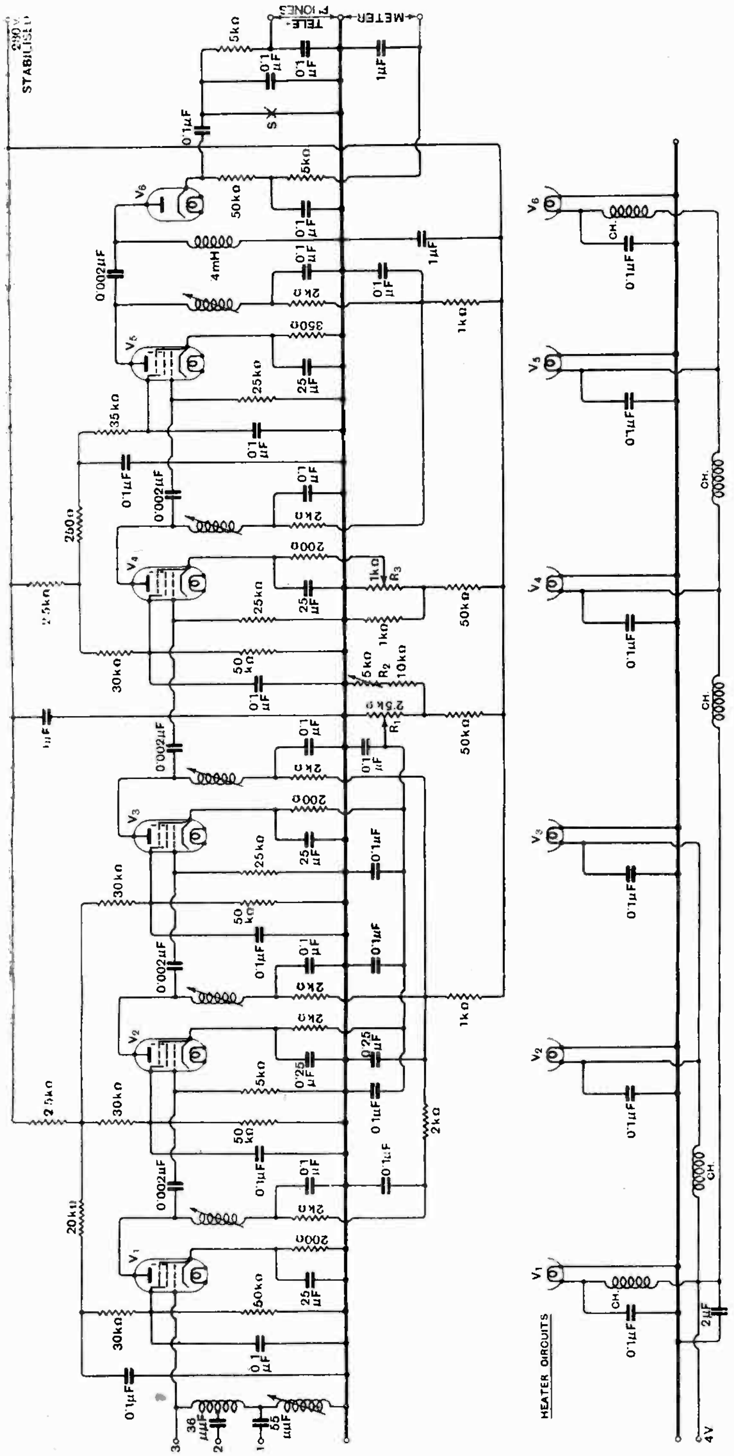


Fig. 1.—*Noise amplifier for 2.5 Mc/s. Valves V_1-V_5 are MSP4's and V_6 a D42.*

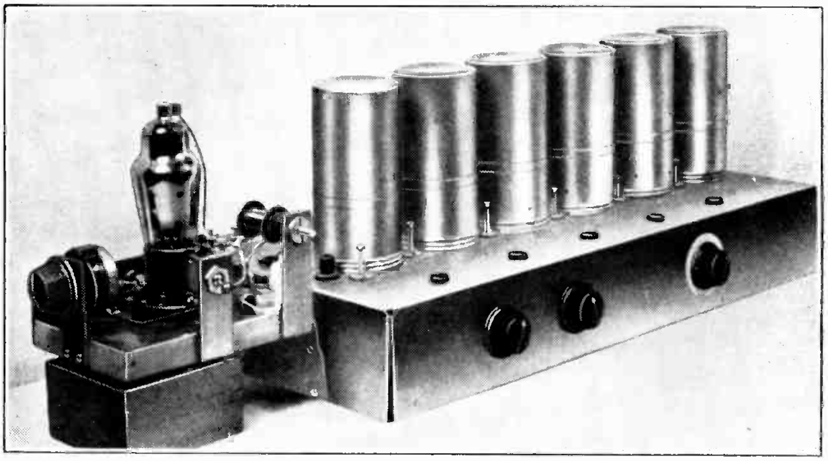


Fig. 1 (*a*).—*Top view of the apparatus.*

valve under test could be supplied to the amplifier via any of the sockets numbered 1, 2, 3. Condensers were connected between the coil tapping points and sockets 1 and 2 so that the effective leakage inductance of the input coil at these tapping points was tuned out at the working frequency of 2.5 Mc/s—the input impedance was therefore purely resistive in the three cases. The reason for the three input points will be explained later.

No additional capacities were used for tuning the circuits of the amplifier, since the tuning coils were solenoids, each provided with an internal adjustable copper "slug" the position of which determined the effective inductance. These tuning coils will be referred to as "plunger tuners." The resonant frequencies of the various circuits were staggered either side of 2.5 Mc/s to obtain a suitable response curve.

Three gain controls were provided. The potentiometer R_1 provided a coarse control for the bias of V_2 and V_3 whilst R_2 gave a fine control. The third control was provided by R_3 connected in the cathode circuit of V_4; this control was calibrated so that the gain could be altered by the factor $\sqrt{2}$—this was useful in certain tests, as will be shown later. The output current of the diode rectifier was normally indicated on a microammeter connected across the terminals marked "Meter"; the very thorough decoupling of the meter circuit will be observed. An alternative output to a telephone re-

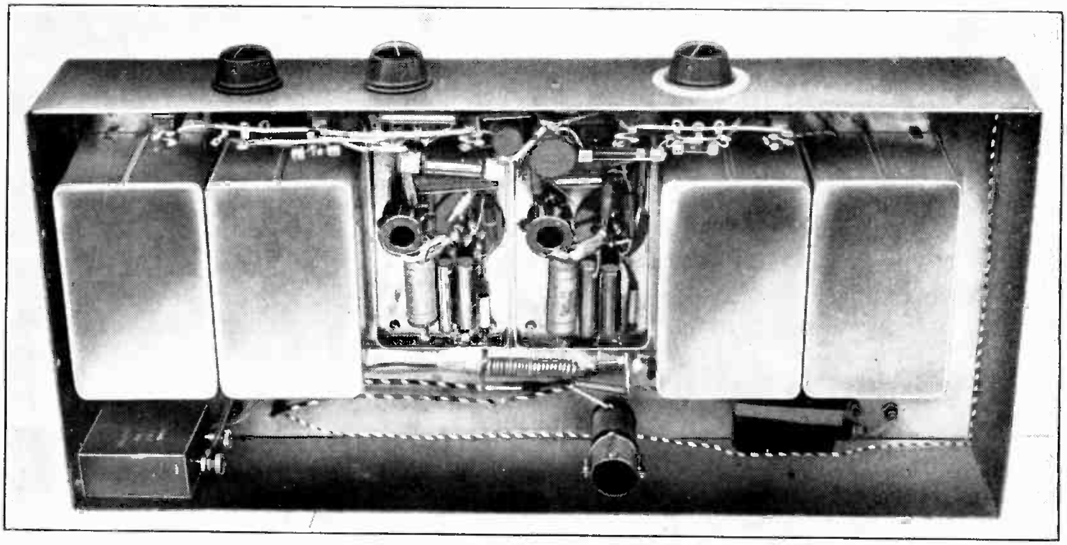


Fig. 1 (b).—*Underside view of the apparatus showing complete screening.*

ceiver was provided in order to make certain that no pick-up from external sources was taking place. The decoupling of this output was necessarily less than for the meter output and consequently the telephone circuit had to be short-circuited internally (by means of the switch *S*) when taking measurements, as otherwise some slight feed back occurred.

The general decoupling of the amplifier, and in particular that of the heater circuits was very thorough. This was tested by turning up the gain of the amplifier until a reading of noise on the output meter was obtained due chiefly to noise in the first circuit. Additional decoupling condensers were then held across various points, and if more than a very small percentage change in the output reading was observed additional decoupling was permanently inserted.

Since it was desired to employ an unscreened test circuit for convenience in changing valves and making other alterations, it was necessary to be quite sure that there was no appreciable feed back due to magnetic or electrostatic fields set up by the last stage of the amplifier. Accordingly a wire about two feet long was connected to input socket 3 of the amplifier and the input circuit retuned. If this connection caused any change in the output reading then the source of feed back was traced, and as far as possible eliminated. Finally no appreciable change took place so long as the wire was not allowed to approach the output end of the chassis.

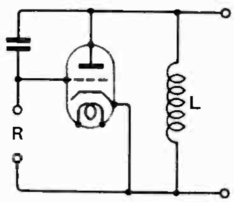


Fig. 2.

It was found best to support the chassis about one inch above a copper sheet and to earth the chassis to the sheet at one point only.

To ensure stable power supplies, accumulators were used for the heater supplies and Stabilovolt tubes were employed in the H.T. power packs.

The Test Circuit.

This is shown schematically in Fig. 2 and in full for the case of a triode in Fig. 3. The anode and grid were connected together by means of a large condenser so that with respect to A.C. the measurement was made with the valve acting as a diode. The value of the equivalent resistance R_n was obtained by substitution of a fixed non-inductive resistance for the valve.

The capacity to earth of the anode and

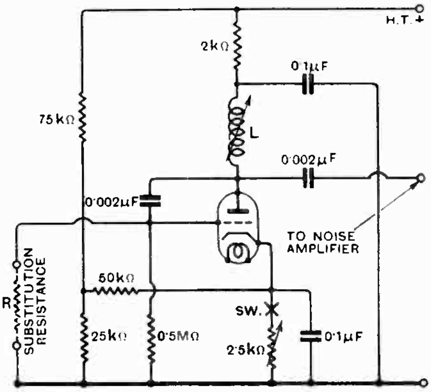


Fig. 3.

grid was tuned by the coil *L* so that the impedance of the anode circuit was high at the frequency of measurement.

The tuning coil *L* was a plunger tuner. A variable inductance was preferable to a variable capacity to avoid reducing the pass band of the input circuit. It is of course essential that this should always be wide compared with that of the amplifier so that it shall be substantially resistive over the pass band of the amplifier.

If a multi-grid valve was under test the extra grids were connected normally. The switch *SW* was provided so that the valve could be switched off when the substituted resistance was in circuit. When *SW* was opened a large positive voltage was applied to the cathode of the valve, thereby backing it off.

Since the valve operating conditions could be varied whilst the noise produced was indicated by the meter at the output of the amplifier, it was possible to observe small changes of noise which were not clearly indicated by a series of substitution measurements. In this way any rather flat maxima or minima in a series of results could be verified or a general indication of the effect of any variation in operating conditions could be obtained before proceeding to take a series of values by the substitution of resistances. Further, since the method is one of substitution, other sources of noise such as that due to the first amplifier valve do not cause error.

If the input resistance of the amplifier were infinite the substituted resistance would be equal to R_n, the equivalent grid resistance of the valve, to the close approximation existing in equation (13). Since the input resistance is finite, however, it is necessary to apply a correction factor to the value of the substituted resistance. The correction factor (C.F.) is given by the expression

$$\text{C.F.} = \frac{1 + \frac{2\rho_d}{R}}{1 + \frac{r_n}{R}} \quad \ldots \quad \ldots \quad (17)$$

In this expression R is the input resistance in ohms of the amplifier, r_n is the value, in ohms, of the substituted resistance and ρ_d is the differential resistance in ohms, of the value under test as a diode. Normally, in the experimental work, the correction factor did not differ very much from unity. A proof of equation (17) is given in the Appendix.

It is evident that the correction is smaller the greater the value of R, the input resistance of the amplifier. From this it might appear that the input tap to the amplifier which gives the highest resistance (tap 3) would always be selected. If this were done, however, the noise resistance of the first valve of the amplifier would be in series with the resultant noise resistance of the input circuit and the valve under test. Now the first valve of the amplifier is known to have a noise resistance of approximately 2,500Ω, whilst valves having noise resistances as low as 300Ω may need to be measured. It is clear that in the measurement of such valves using tap 3 the noise to be measured would be swamped by that of the amplifier, so that the sensitivity of the test would be reduced. If, however, the test circuit is connected to a lower tap, a step-up of the noise p.d. to be measured is obtained so that this is not swamped by the noise e.m.f. arising in the first valve of the amplifier.

Thus if σ is the voltage step-up from the tapping point on the input circuit to the grid of the first amplifying valve and R_n and R'_n are the noise resistances of the valve under test and of the first amplifying valve respectively, the effective noise resistance at the grid of the amplifying valve, neglecting losses in the input circuit, is $\sigma^2 R_n + R'_n$. By a suitable choice of tap it was always possible to obtain a satisfactory compromise. Since the method is that of substitution the effect of R'_n is not to produce an error, but merely to reduce the sensitivity of the measurements. The impedances at the taps 1, 2 and 3 were resistive and were respectively 17,000Ω, 26,000Ω and 75,000Ω.

A number of practical points in regard to the arrangement of the test circuit may be mentioned. To avoid stray pick-up the experiments were conducted in a screened room and this enabled an open baseboard to be used for the test circuit. The baseboard was metal-covered and this was securely earthed to the amplifier chassis. A short connection was taken from the test circuit to one of the input sockets 1, 2, 3, of the amplifier. Without a screened room a screened test circuit would have been essential, but this would not have lent itself so well to rapid tests of different types of valves.

To prevent spurious oscillations at very high frequencies, it was found necessary to place the coupling condenser directly between the anode and grid using as short a lead as possible.

It was necessary to use separate H.T. supplies for the amplifier and the valve under test since with a common supply the amplifier gain was found to vary slightly when a valve under test, which might require a heavy current, was switched off.

Test Procedure.

The valve to be tested was placed in the test circuit and the connection to the amplifier was made through a suitable socket. With the amplifier gain low so that there was no reading due to noise, a signal from a standard signal generator was fed via an impedance of a few thousand ohms to the anode-grid portion of the test circuit and the plunger tuner was adjusted until resonance was indicated (at the amplifier output) at a frequency of 2.5 Mc/s. It was better to switch off the valve by means of *SW* during this tuning to obviate the heavy damping which would otherwise exist.

To obtain the value of ρ_d the valve was switched on and a suitable output reading obtained. The valve was then switched off and a non-inductive resistance substituted at R (Fig. 3) such that with the same signal generator output and amplifier gain the amplifier output was as before. The resistance substituted was equal to the value ρ_a for the valve. Actually provision was made for placing two resistances in parallel at R to allow of adjustment to small limits.

The signal generator connection was then removed, the valve switched on once more and the amplifier gain increased until a suitable output reading was obtained due to noise from the valve being tested. Then without altering the amplifier gain a resistance was placed at R and the valve switched off. The new output was observed and the resistance substituted was altered until the output was equal to that obtained when the valve was operating. The resistance value so obtained, when corrected by means of equation (17), gave the value R_n for the valve.

Checks on the Method of Test Described.

A number of factors which would influence the accuracy of the tests were examined. These factors included :—

(1) Feed back in the amplifier. This was found to be negligible.

(2) Influence of the tuned test circuit on the effective band width. Calculations and tests showed that the shapes of the response curves with and without this circuit connected were sensibly the same.

The reliability of the complete test was also checked as follows :—

(1) The test results for a given valve (an MSP4) were checked with those obtained by the method in which a resistance is placed in the grid circuit of the valve under test such that with the valve acting as an amplifier, the R.M.S. noise voltage is $\sqrt{2}$ times that produced when the grid is connected to earth. In this method use was made of the $\sqrt{2}$: 1 gain calibration of the control R_3. The value of the substituted resistance, which should be equal to the equivalent grid resistance of the valve, was found to agree within 5 per cent. with that obtained by the method previously described.

(2) Two similar valves were tested separately and then in parallel. In the latter case the measured noise resistance was half that obtained for a single valve.

(3) The whole apparatus was rewired for a mean frequency of 450 kc/s with a band width (for 6 db. loss) of 50 kc/s. The noise resistances measured for a number of valves at this frequency differed by only a small percentage of the order of 5 per cent., from the values obtained at 2.5 Mc/s.

(To be concluded.)

A list of references will be given at the end of the concluding part, to be published next month.

Sound Engineering

On behalf of the eight leading American motion picture companies, the Research Council of the Academy of Motion Picture Arts and Sciences deals on a co-operative basis with the various technical and research problems of the industry. A series of technical courses on sound recording and reproduction have been conducted during the past few years, and the Council has now decided to publish the subject matter of the series in book form under the title of "Motion Picture Sound Engineering," price $4. A copy of the publishing announcement, containing a table of contents, is available from the Council ; its address is : Suite 1217, Taft Building, Hollywood, California, U.S.A.

The Industry

CHANGES of address : Radio Transmission Equipment Ltd., to 45, Nightingale Lane, Balham, London, S.W.12. The Cambridge Instrument Company (Head Office and Showrooms) from No. 45 to No. 13, Grosvenor Place, London, S.W.1.

To comply with increasingly exacting standards of capacity stability, the Dubilier Condenser Company has introduced a new series of moulded metallised condensers (Types S690W and S691W).

Quartz crystals for various wavebands are listed in the newly published catalogue (5th Edition) of The Quartz Crystal Company, 63, 71, Kingston Road, New Malden, Surrey.

A new leaflet describing the Marconi-Ekco Signal Generator, as shown at the Physical Society's recent Exhibition, has been issued by Marconi-Ekco Instruments, Ltd., Electra House, Victoria Embankment, London, W.C.2.

A Valve-Voltmeter with Retroactive Direct-Voltage Amplification*

By F. M. Colebrook, B.Sc., D.I.C., A.C.G.I.

(Radio Department, National Physical Laboratory)

1. Capabilities and Characteristics

THE following is a description of a sensitive form of valve-voltmeter having the following capabilities and characteristics.

(a) It can be used for the measurement, on a robust pointer instrument such as a fairly inexpensive milliammeter, of direct-voltage changes from about one volt down to a millivolt, across a high resistance of the order of a megohm, corresponding to direct-current changes of about one microampere down to a millimicroampere.

(b) In association with a diode rectifier, embodied in the same case, it can be used for the measurement of radio-frequency voltages of about 1 volt down to about 25 millivolts, at frequencies up to the limit set by the transit-time effect in the particular diode used.

(c) The assembly can be made self-protecting, as far as the output instrument is concerned. That is to say, if an over-load voltage is applied to the input terminals, the output current rises to a limited maximum value which can be arranged to be little in excess of the full-scale value for the output instrument.

(d) It involves a form of retroactive direct-voltage amplification in two stages, resulting in an over-all mutual conductance which can be raised to 500 milliamperes per volt or more. The instability of calibration which would normally be associated with this high sensitivity is, however, eliminated by using the combination of amplifier and output instrument only as a sensitive null-indication, the input direct-voltage change to be measured being balanced against a known small direct-voltage. The arrangement thus combines the high sensitivity obtainable from valve-circuits with the reliability and stability of ordinary direct-current components and instruments.

2. The Basic Retroactive Direct-Voltage Amplifying Circuit

Consider a triode valve having voltage factor μ, internal slope resistance R_a and a small resistance r common to the anode and grid circuits—as, for example, in the familiar arrangement for obtaining grid-bias by means of a resistance in the cathode lead. It is easily shown that, over the range of sensibly linear operation, the effect of the small resistance r is to decrease the mutual conductance of the valve from μ/R_a to $\mu/\{R_a + (\mu + 1)r\}$. Thus the resistance r common to anode and grid circuits is equivalent in its effect on the mutual conductance to a resistance $(\mu + 1)$ times as large inserted in the anode circuit only. (In the grid-bias scheme already mentioned this loss of mutual conductance is of course prevented by by-passing the resistance r with a condenser of negligible reactance at the frequency of operation.)

This degradation of mutual conductance by a resistance common to both electrodes makes impracticable or uneconomic any scheme of direct-voltage amplification with directly-coupled indirectly-heated valves supplied by a potential divider on a single source of high voltage, the cathodes of successive valves being at appropriate voltages above earth. Such an arrangement was actually tried, but the effect referred to reduced the over-all mutual conductance to a fraction of its full value.

A two-stage arrangement with the usual battery-coupling between valves was therefore adopted, but the above-mentioned common resistance effect was turned to useful account by utilising the reversal of phase of the anode current changes in the

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

second valve. That is to say, a resistance common to the grid circuit of the first valve and the anode circuit of the second was included in the arrangement. This, as will be shown below, causes, not a loss of over-all mutual conductance, but a very considerable increase over the normal value.

Essentially the arrangement is as shown in Fig. 1. Using the symbols indicated in the diagram, it can be shown that the over-all mutual conductance (i.e., i_{a2} in terms of v_{g1}) is negative in sign and of magnitude

$$\frac{\mu_1\mu_2(R + r) + \mu_1 r}{(R'_{a1} + R)R'_{a2} - (\mu_1 + 1)\{\mu_2(R + r) + r\}r}$$

where $R'_{a1} = R_{a1} + (\mu_1 + 1)r$

and $R'_{a2} = R_{a2} + (\mu_2 + 1)r$

The important feature of this result is, however, much more clear in an approximate solution in which certain small quantities have been neglected, i.e.

$$\frac{\mu_2 M}{R_{a2} - \mu_2 M r}$$

where $M = \frac{R}{R + R_{a1}}\mu_1$

If r is zero, this reduces to

$$M \cdot \frac{\mu_2}{R_{a2}}$$

i.e., the over-all mutual conductance is equal

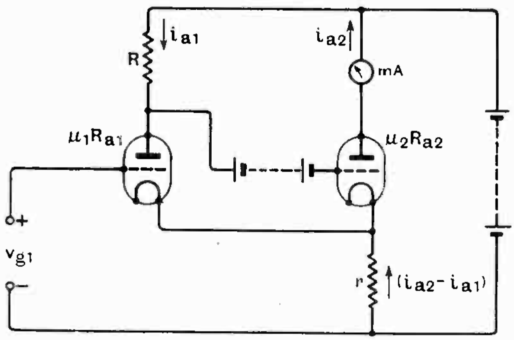


Fig. 1.

to the mutual conductance of the second valve multiplied by the voltage-magnification factor of the first stage, which is otherwise obvious. The over-all mutual conductance can clearly be increased considerably over this lower limiting value by choosing r to be just less than $R_{a2}/\mu_2 M$, i.e., just less than one over the product of the mutual conductance of the second valve and the gain of the first stage. This corresponds

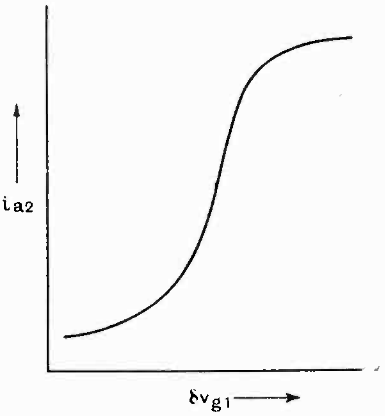


Fig. 2.

to a comparatively small value for r. For example, with a mutual conductance of 3 mA/v in the second valve and a first-stage gain of 20, the over-all mutual conductance becomes theoretically infinite when $r = 16.6$ ohms. The system is, of course, unstable under these conditions, but it is quite stable with a somewhat smaller value of r, and there is no difficulty in realising an over-all mutual conductance which is tenfold greater than the initial value, i.e., about 600 mA/v., compared with 60 mA/v when $r = 0$.

Under these conditions the actual shape of the over-all mutual conductance curve will be of the type shown in Fig. 2. The sharp cut-off at the top is due to the fact that the grid of the second valve becomes positive, the consequent flow of grid current then acting as a short-circuit on the high-resistance anode-circuit load of the first valve, which ceases to amplify. This feature can be turned to account by arranging that this maximum current corresponds to little more than the full-scale value for the output instrument, which is then safe against overloading.

The use of a resistance connected in the way described above to produce an effect of the nature of retroaction, is not new. British Patent 373309 (Evans), for example, describes a circuit essentially the same as that of Fig. 1, though primarily intended to function as a sensitive "trigger" relay. The original "kallirotron" circuit developed by L. B. Turner is also of this type and various other workers have exploited the same idea. There are, however, certain practical features in the present design, particularly the manner of use, which are thought to justify the publication of a description.

3. Calibration

The over-all mutual conductance curve shown in Fig. 2, though of a useful shape in respect of the self-protecting feature referred to, is not very suitable for direct calibration and has a restricted range of maximum sensitivity. Further, it will be dependent to an appreciable extent on the valves and other initial conditions. It was therefore decided not to attempt any over-all calibration in terms of output meter deflection, but rather to adjust the system to the region of maximum sensitivity and then to use it as a sensitive means of indicating a balance between an unknown input-voltage change and an auxiliary known voltage introduced in series with it, the basic arrangement being as shown in Fig. 3. The unknown voltage v is applied to the input terminals, and the known auxiliary voltage v_0 is then varied until the indication of the output instrument is restored to its original value when $v = -\delta v_0$. This mode of use has the disadvantage that the whole assembly is not direct-reading, but, on the other hand, it has the very great advantage that all variations arising from small changes in the valves or the supply voltages are eliminated, and the only calibration involved is that of the D.C. components controlling the auxiliary known voltage v_0.

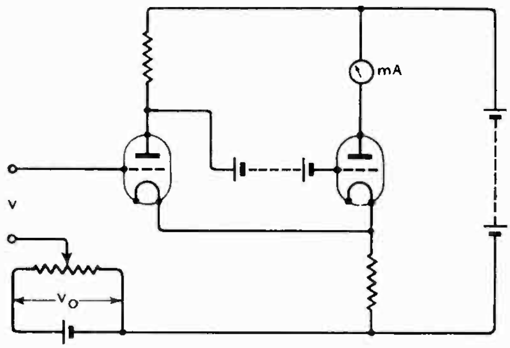


Fig. 3.

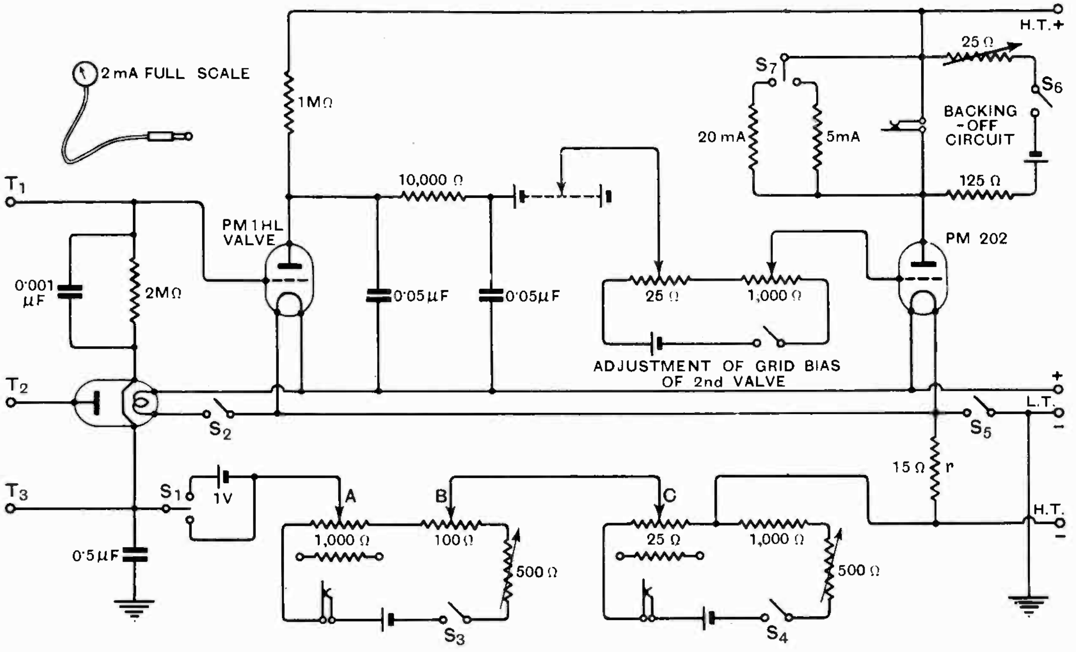
4. An Actual Assembly

The principles outlined above can of course be embodied in a variety of ways appropriate to any contemplated application. The particular assembly detailed below and illustrated in Fig. 4 was intended primarily for application to field-strength measurements, requiring the measurement of the rectified direct voltage produced across a high resistance in a diode circuit connected to a loop receiving aerial. To increase its potential usefulness, however, it is provided with an optional alternative input circuit consisting of a diode-valve rectifier. It can thus be used for the measurement of small direct or radio-frequency voltages as may be required. (Alternatively, the first triode could be used as a rectifier, though probably with some loss of gain as an amplifier.) With switch S_2 closed and S_1 on the upper stop, the diode is brought into action and, incidentally, a 1-volt dry cell is brought into circuit to balance the fall of potential due to the diode current in the rectifier load-resistance (2 megohms). The input terminals for radio-frequency measurements are T_1 and T_2. If the diode is not required, switches S_1 and S_2 are changed over and opened respectively and the input terminals T_1 and T_3 are used. (This leaves the 2 megohm load across these terminals, but it can be disconnected if desired.)

The auxiliary voltages for balancing the input unknown direct voltages are derived from potentiometers A, B and C, the first two having ten 100 ohm and 10 ohm steps respectively, and the third being a continuously variable 25 ohm rheostat. The current in each circuit is supplied by a single 1½ volt cell (the small round cells used in flash-lamps are suitable) and is adjusted to exactly 1 mA by the variable resistances shown. The output meter is plugged into the jacks for this adjustment, which need only be checked at the beginning of each run of measurements. (As a point of detail, the jacks are double-contact jacks and are arranged to close the circuit through a resistance equal to that of the milliammeter when the latter is withdrawn. The details of these connections are not shown in the sketch.)

It will be noted that with the arrangement shown the initial grid bias of the first valve is zero. In cases where it is desired that the input conductance should be a minimum, it would be preferable to have a small negative bias on the first grid, but with the valve shown (PM1 HF) it was found that the input conductance was sufficiently low with zero grid bias for the purposes contemplated, and the stage gain somewhat higher than with a small negative bias.

output valve includes a jack for the output meter which, in this case, is a 0-2 mA pointer instrument, mounted in the front panel and fitted with a cord and a plug. Alternative shunts for 20 and 5 mA ranges are paralleled with the output jack, and also a circuit for backing off the normal current to zero if desired. In general, the 0-20 range only is used in which case the normal anode current will be 7–10 mA and there is no need to back it off. A small mark can be made on the scale for the initial set position and the anode current adjusted to this setting



POTENTIOMETER CIRCUITS, CURRENTS ADJUSTED TO 1mA

Fig. 4.

The 10,000 ohm resistance and the two 0.05 μF condensers shown in the coupling from the first amplifying valve to the output valve are included to filter out radio-frequency voltages and prevent them from affecting the output valve. The grid bias of the output valve is adjusted by a tapping on the coupling battery (two 15-volt grid-bias batteries) and by the potential-dividers shown in the sketch, supplied by a 1½-volt dry cell of the same type as used in the A, B and C circuits. The anode circuit of the

by the grid bias controls provided. For the highest degree of sensitivity the 0–5 range can be used and in this case the backing off adjustment is necessary. The zero is naturally somewhat less stable under these conditions. On the 0–20 range it is quite satisfactorily stable.

The retroactive resistance is r in the diagram, in this case adjusted to about 15 ohms.

The operating voltages used in the present instance are 60 volts and 2 volts. On account of the portability involved in the particular application intended, a dry battery of adequate capacity was used, this and a 2-volt accumulator being housed in a separate battery box, with a 4-way cable and plug for connection to the set.

Fig. 5 is a photograph of the complete assembly. The arrangement admittedly involves rather a large number of small components and controls, but these are of a comparatively simple and inexpensive character, being for the most part standard commercial items in the mass - production class. The meter, in particular, can be of an inexpensive type, as the accuracy of indication depends on the preliminary adjustment of resistances to a known value rather than on that of the meter.

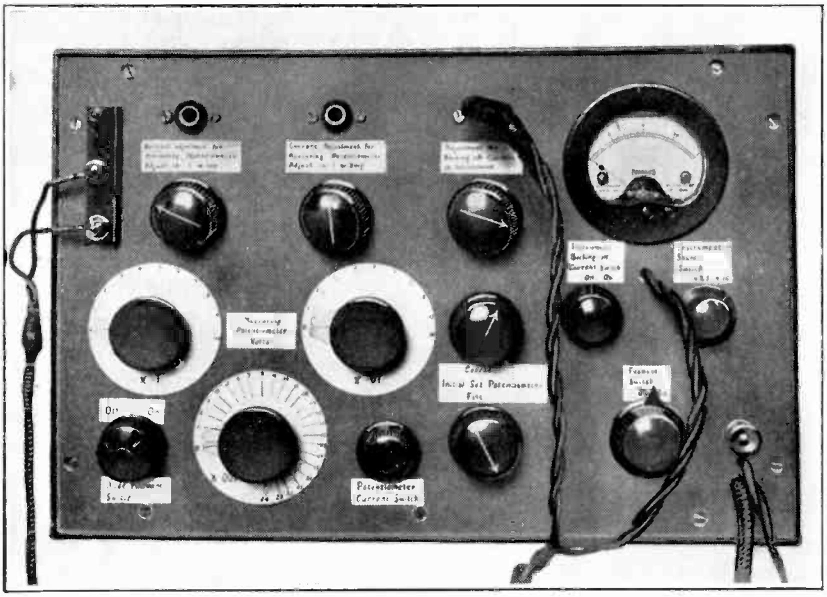


Fig. 5.

5. Method of Adjustment and Use

By means of the grid bias controls of the second valve, the output anode current is adjusted to a condition of maximum over-all mutual conductance (i.e. the steepest part of the curve in Fig. 2), with the potentiometers A, B, and C set to zero. This is the standard initial condition and for any given unknown input voltage, the potentiometers are adjusted to reproduce this condition, when the input voltage change can be read on the potentiometer dials in tenths, hundredths, and thousandths of a volt respectively. For the measurement of small R.F. voltages, the diode is switched into circuit before the initial adjustment is made, and the R.F. calibration made in any of the usual ways (e.g. with a standard signal generator) and recorded in terms of the potentiometer dial readings.

The set has proved useful and satisfactory in action, particularly in respect of reliability and robustness. Not even the rather rough handling involved in extensive field work, including an accidental fall in one case, has disturbed its calibration.

The writer is indebted to Mr. B. J. Byrne and Mr. C. W. Spencer, of the Radio Department, National Physical Laboratory, for carrying out the construction and associated experimental measurements. The work was carried out as part of the programme of the Radio Research Board and is published by permission of the Department of Scientific and Industrial Research.

G.R. Type 684A Modulated Oscillator

In the description of this instrument on page 86 of the last issue, the upper limit of the frequency range was given as 5 Mc/s. Claude Lyons, Ltd., ask us to point out that the range of this instrument is actually from 9.5 kc/s to 50 Mc/s.

Low Distortion Volume Expansion Using Negative Feed-back*

By B. J. Stevens, B.Sc.(Eng.)

(South African Broadcasting Corporation)

A GREAT deal of attention has lately become focused upon volume expansion. This seems to indicate that although the purist might object to expansion on the grounds that the expansion law is not the exact inverse of the compression law, there seems to be an increasing demand for it.

It must be admitted that under present conditions it is impossible to obtain a replica of the original music—music because expansion is not desirable on speech, on which compression is rarely used—because the compression or " control " has been manually effected without reference to any fixed law. Control of music in the broadcasting studio, although carried out to give an increased sensation of volume range, can, nevertheless, hardly simulate the original. Here, volume expansion at the receiver, although admittedly imperfect in exactly reproducing the original, nevertheless gives such an added impression of realism that its use is quite justified, and especially on recorded music.

Automatic volume compression at the transmitter is not easily obtained. In fact, the difficulties of successfully applying it are enormous. That does not mean to say, however, that they are insuperable.

The Wireless World has in the past published details of various types of expanders. Probably the earliest system of expansion to be practically applied is that which makes use of a pair of variable-mu screen-grid or pentode valves in push-pull. The signal voltage to be expanded is applied to the grids, which have an initial negative bias sufficient to reduce the effective amplification to a small value. In series with the bias supply is injected a D.C. voltage obtained by rectifying part of the input signal after suitable amplification, causing the bias of the valves and so their effective gain to be varied in sympathy. Although the expansion so obtained is sufficient for normal purposes, the distortion accompanying even moderate degrees of expansion is particularly distressing, for although second harmonics are cancelled out by virtue of the push-pull connections, higher order harmonics producing combination tones are not.

Another expander circuit originating in America makes use of a Pentagrid valve with a variable-mu base.[1] This system was tried but here also the distortion was very high.

The bridge-type expander recently described[2] is free from the defect of harmonic distortion, and although superior to the above systems has defects of its own.

A minor fault is that because the step-down and step-up transformers must needs be of high ratio, if they are not of expensive construction, the overall frequency response is likely to be poor. Another factor against it is that the time-constant cannot be varied, and this is of utmost importance if the expanded music is to sound natural. The most serious disadvantage, however, is that in common with all bridge-type expanders, the expansion curve resembles a logarithmic one. At and near the point of unbalance the expansion is a maximum, gradually decreasing as the bridge becomes more and more unbalanced, until a point is reached where not only does the bridge fail to expand but actually compresses.

Having been busy for some time past on the problem of devising some form of volume expander free from the defects of existing systems, it is felt that others might be interested in the results obtained. The expanders finally developed make use of the

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

[1] *Wireless World*, Dec. 18th, 1936.

[2] *Wireless World*, Jan. 15th, 1937.

now quite well-known principle of negative feed-back.

They may be divided into two classes :—

Type 1. Characterised by high output impedance.

Type 2. Characterised by ow output impedance.

Type 1

The skeleton circuit is illustrated in Fig. 1, and is probably known to readers, having been dealt with in *The Wireless World* of November 6th, 1936. For the sake of completeness it would be in order to describe briefly the operation.

As the resistance R_2 is common to the anode and grid circuits, the voltage developed across it—which is out of phase with the input voltage—is fed back to the grid in series with the input voltage. This reduces the actual grid voltage, and consequently the output. If the value of R_2 is altered, the feed-back voltage will alter, the overall effect being as if the gain of the valve has changed. In practice, the expansion is obtained by altering the value of R_2 in sympathy with the input signal voltage. This is accomplished by tapping off a portion of the input voltage, which, after suitable amplification, is rectified. The rectified voltage is applied, through a suitable time-delay resistance-capacity network giving a delay of from 0.2 to 0.3 seconds, to the paralleled control and suppressor grids of a variable-mu pentode. This pentode has an initial negative bias such that its impedance is high, the rectified signal voltage being so connected that it tends to reduce this negative bias. As the signal voltage fed to the rectifier increases, so the bias is reduced, the anode impedance likewise decreasing. If this pentode is used as the variable resistance R_2, then the variation in input signal will cause the impedance of the pentode either to rise or fall according to whether the signal falls or rises, so causing expansion.

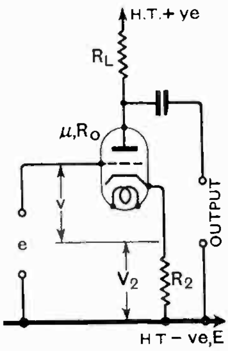


Fig. 1.

If we assume that the value of R_2 varies between a maximum of R_{2m} and a minimum of R_{20} and that R_L, R_0, μ are the anode load resistance, anode resistance and amplification factor respectively, we may write :—

Expansion voltage ratio

$$E = \frac{R_0 + R_L + (1 + \mu)R_{2m}}{R_0 + R_L + (1 + \mu)R_{20}}$$

See Appendix 1.

A practical circuit using Type 1 as given in Fig. 2.

To obtain a large degree of expansion, $(1 + \mu)R_{20}$ should be at least equal to or greater than $R_0 + R_L$, also the ratio of R_{2m} to R_{20} should be as high as possible, but too high a ratio should not be used in the interests of smooth expansion. Using the VP4B pentode, R_2 can be varied between about 4,000 and 100,000 ohms. If R_L is 20,000 ohms, R_0 8,000 ohms and μ 20 (as would be the case for a MHL4 valve) then the value of E for R_{20} and R_{2m} equal to 5,000 and 100,000 ohms respectively, will be 15.8, which corresponds to an expansion of 24 decibels.

By shunting the pentode with a fixed resistance of from 50,000 to 100,000 ohms, the expansion will be reduced, but the smoothness of action increased. It will be found that the adjustment of the initial fixed bias is fairly critical. If the bias is too high, the expander will come into action only when the input signal voltage reaches a certain value. The screen voltage is also fairly critical, because if it is too high the impedance ratio R_{2m}/R_{20} will be low, whereas if too low the effect will be the same as if the negative bias were too high.

When the pentode resistance is low, the triode load is equal to $R_L + R_{20}$; consequently R_L must be so chosen that $R_L + R_{20}$ is equal to the optimum load of the valve. Also, to ensure that the pentode will present a linearly varying resistance, its anode voltage should be kept high and as constant as possible. This is secured by using a triode which has a fairly low anode resistance, such as the MHL4, and a reasonably high H.T. supply voltage.

On account of the negative feed-back voltage applied to the grid of the triode, the distortion is always low. On high outputs not only has the triode still considerable feed-back, but it has its optimum load. The disadvantage of this system is that the output impedance of the expander is high. This is not always serious, however, because the larger but at the same time the bias rises. The operating point thus moves up the line *OA*.

By assuming a constant input voltage and

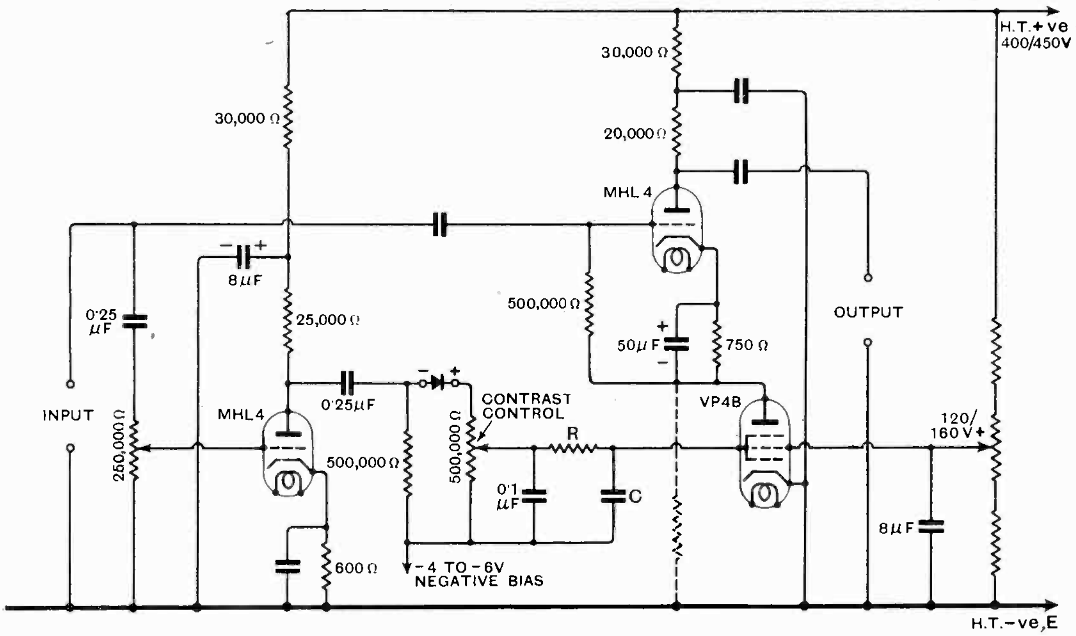


Fig. 2.

expansion takes place by decreasing the attenuation of the stage, in most cases the expander should be followed by a stage of amplification, in which a low gain valve could be used to minimise the danger to a high output impedance, namely the reflected shunt capacity of the following amplifying stage due to Miller effect.

Since the total resistance of the anode circuits in series varies with the loudness of the input signal, it is obvious that the bias of the triode is increasing on loud passages and decreasing on soft. The effect of this is shown in Fig. 3. *OA* represents the bias line corresponding with the value of the triode's bias resistance. As the output voltage is expanded the load resistance swings about the point *D* (the value of which corresponds to the supply voltage) from the line *BD* to the line *CD*. (*BD* and *CD* correspond to maximum and minimum values of load resistance respectively.) As the output voltage increases due to increase in input voltage, plate voltage variations become varying values of R_2, and calculating the ratios of output/input voltages from Eqn. 4 Appendix 1, the actual grid voltages for any required anode voltage excursions are known. This is done for various values of $R_L + R_2$, plotting the grid voltages obtained on the

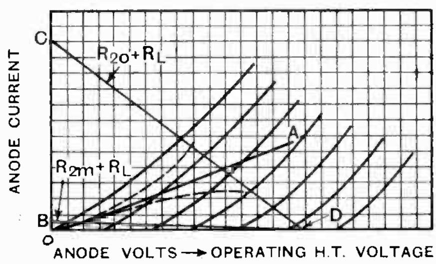


Fig. 3.

load curve to give the dotted curves, which therefore show the actual expanded output voltages for any values of *R*.

This expander can be used with high level inputs before overloading takes place.

From Eqn. 3 it can be seen that for values of R_0, R_L, R_2 and μ as above, the actual grid signal voltage is only $\frac{1}{4}$ of the input.

Under certain conditions the high output impedance (equal to $R_0 + (1 + \mu)R_2$ is a disadvantage. Because of this, expanders having a low output impedance were investigated, and which are here designated as Type 2.

Type 2

The basic circuit diagram is shown in Fig. 4. Negative feed-back is here also used to obtain the desired expansion.

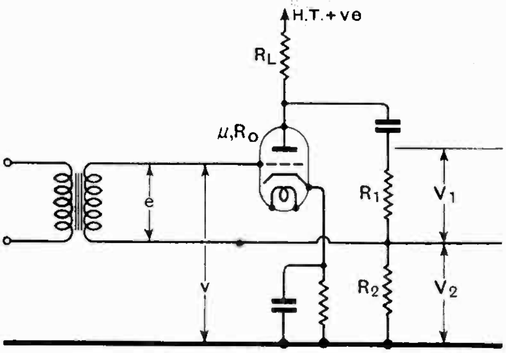


Fig. 4.

Briefly, the proportion $R_2/R_1 + R_2$ of the signal voltage developed across the anode load resistance R_L is fed back to the input in series with the secondary of the input transformer, and being out of phase, causes an effective reduction in the actual grid signal voltage, producing a reduction in output as if the stage gain had been lowered.

There are three sources of output voltage we could use; the voltage V_1 appearing across R_1, that across R_2, namely V_2, or $V_1 + V_2$ which appears across R_L.

Type 2(a)

Let R_1 be fixed while R_2 varies between a maximum of R_{2m} and a minimum of R_{20}. Then if the output voltage used is V_2, the expansion voltage ratio E is given by:

$$E = \frac{R_1 + (S + 1)R_{2m}}{R_1 + (S + 1)R_{20}} \cdot \frac{R_{20}}{R_{2m}}$$

(for S see Eqn. 9, Appendix 2).

It can be seen that the value of E can never be much larger than unity, unless R_1 is much greater than $(S + 1) R_{2m}$ when compression takes place.

When the voltage V_1 is used, however, the expansion is quite considerable, being given by

$$E = \frac{R_1 + (S + 1)R_{2m}}{R_1 + (S + 1)R_{20}} \quad .. \quad \text{Eqn. 12}$$

where $S = \mu R_L/R_0 + R_L$

To make E large, $(S + 1)R_{20}$ should be equal to or greater than R_1. This can be accomplished by reducing R_1 to a low value. But since the anode load R_L is shunted by R_1 and R_2 in series, at maximum output, the anode load resistance would become very low. This would not cause anything like the distortion that would be experienced with a valve working without feed-back, as the feed-back is greatest at maximum output in this case. However, to overcome this defect, the variable feed-back potentiometer R_1, R_2 is fed from a tapping on the load resistance R_L. A skeleton circuit of this is shown in Fig. 5.

Only the voltage developed across R_5 is used, and matters can now be so arranged that when the maximum output is reached, the sum of R_5 and the effective resistance R_a—obtained by shunting R_6 with R_1 and R_2 in series—is equal to the optimum load resistance of the valve. Distortion will now become negligible.

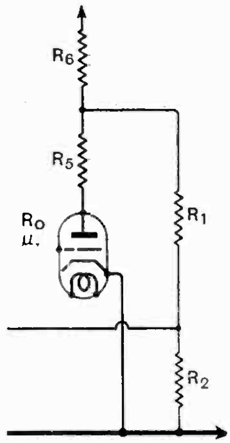


Fig. 5.

Now, as R_2 varies, the shunting effect on R_6 will also vary, with the result that the value of S (which was reduced by tapping up on R_L) will change from a maximum value S_m at low output levels, to a minimum of S_0 at high outputs, and this will modify the value of expansion voltage ratio E calculated from Eqn. 12.

The modified value is given by:

$$E_c = \frac{R_1 + (S_m + 1)R_{2m}}{R_1 + (S_0 + 1)R_{20}} \cdot \frac{S_0}{S_m} \quad .. \quad \text{Eqn. 1}$$

where $S_0 = \mu R_a / R_0 + R_5 + R_a$

$S_m = \mu R_b / R_0 + R_5 + R_b$

and $R_a = R_6 \,.\, (R_{20} + R_1)/R_6 + R_1 + R_{20}$

$R_b = R_6 \,.\, (R_{2m} + R_1)/R_6 + R_1 + R_{2m}$

resistance R_2) must be high, it must have an initial negative bias as used with type 1.

For the VP4B the bias should be approx. – 5 volts, while a suitable screen potential is about 140 volts, the actual values varying with individual specimens.

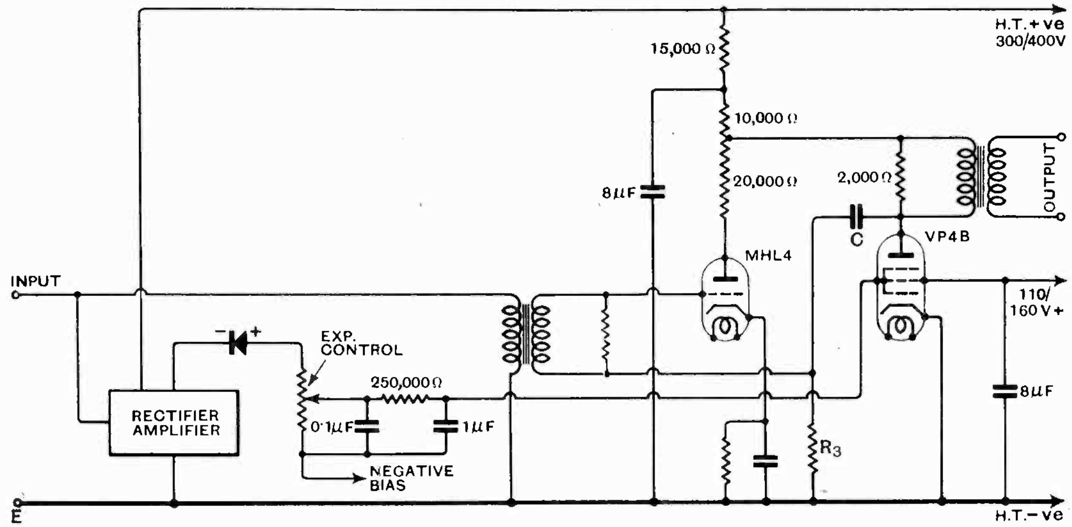


Fig. 6.

A practical circuit diagram illustrating the use of this type is given in Fig. 6.

Due to the fact that R_1 is at a D.C. potential above the earth line and that only the signal voltage across R_1 must be used, an output transformer is essential. For a good low-frequency response, the primary inductance must be high. In practice, the fact that it is shunted by the low resistance R_1 makes this condition easily attainable. If the primary inductance is too low, however, the effect of the attenuation at the lower frequencies will be increased. This is because the feed-back is increased as the effective value of R_1 is reduced by the increased shunting of the primary as the frequency falls.

The bass attenuation can be compensated for by so choosing the values of the feed-back capacity C and the grid earth-return resistance R_3 that the feed-back voltage decreases with frequency.

The overall frequency response curve can in this manner be made to rise at the lower end.

As the initial no-signal resistance of the pentode (which serves as the variable

Type 2(b)

The basic circuit is shown in Fig. 7.

When R_1 is varied between a maximum of R_{1m} and a minimum of R_{10}, and R_2 is fixed, V_1, while showing a large possible expansion, is so difficult to use that this method is not advocated.

When the voltage V_2 across the resistance R_2 is chosen, however, the expansion is considerable and can be used in a practical system.

The expansion is given by :

$$E = \frac{R_{1m} + (S + 1)R_2}{R_{10} + (S + 1)R_2}$$

For the same reasons which appear in the application of Type 2(a), the feed-back circuit must be fed from a tapping on R_L. Also, because R_2 should be low for a large value of E, in spite of tapping up on the anode load resistance R_L, the value of S changes with the output signal voltage. Here again the tapping point is so chosen that the valve works into its optimum load at maximum output.

Correcting for the variation in S, the expansion voltage ratio becomes:

$$E_c = \frac{R_{1m} + (S_m + 1)R_2}{R_{10} + (S_0 + 1)R_2} \cdot \frac{S_0}{S_m} \quad \text{.. Eqn. 1}$$

where S_0, S_m, R_a, R_b have values as defined in Type 2(a). Here, also, the feed-back is greatest on maximum output, which is highly desirable in keeping the distortion content at a minimum.

The bias conditions are the same as with Types 1 and 2(a).

Assuming component values as below:—

R_5 = 20,000 ohms
R_6 = 10,000 ohms
R_0 = 8,000 ohms
μ = 20

then for 2(a) if in addition

R_1 = 2,000 ohms
R_{2m} = 100,000 ohms
R_{20} = 5,000 ohms

The expansion voltage ratio E = 15.6 or 24 decibels.

For Type 2(b), if R_2 = 200 ohms
R_{1m} = 100,000 ohms
R_{10} = 5,000 ohms
E = 9.15 or 19.2 decibels.

Here the expansion can be considerably increased by reducing the value of S, when

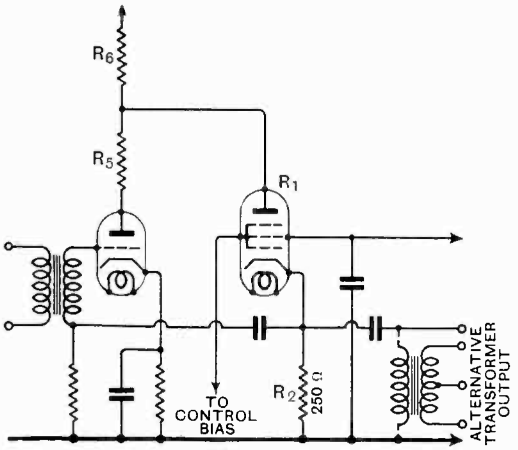


Fig. 7.

the ratio S_0/S_m will more closely approach unity.

In conclusion, it should be pointed out that by inverting the method of expansion, volume compression free from distortion can be obtained.

The uses of compressors are many. By arranging for a delay voltage to be applied to the rectifier—a diode would prove best for this purpose—which controls the pentode resistance, the compression can be made to come into action only when the input signal level exceeds a certain predetermined amount. This has an important application in the prevention of over-modulation in sound-recording, as well as in automatic relay stations. Another important use exists in the prevention of acoustic feed-back or "howl-back" with public address systems, when the delay voltage can be so adjusted as to limit the sound output to a point just below the verge of howl-back, making for maximum working efficiency and range.

APPENDIX 1

In Fig. 1,

Let e = Input voltage
v = Actual grid voltage
V_2 = Feed-back voltage across R_2
R_2 = Common anode-cathode resistance (variable)
R_L = Triode anode load resistance
R_0 = Triode anode-cathode resistance assumed constant
μ = Amplification factor of triode
R_{2m} = Maximum value of R_2
R_{20} = Minimum value of R_2
V_3 = Output expanded voltage

Then:

$$V_2 = \frac{\mu R_2}{R_2 + R_0 + R_L} v \quad \text{.. .. (1)}$$

As V and e are in series,

$$V_2 + v = e \quad \text{.. .. .. .. (2)}$$

and from (1) and (2)

$$v = e \cdot \frac{1}{1 + \mu R_2/(R_0 + R_L + R_2)} \quad \text{.. .. (3)}$$

Also $$-V_3 = \frac{\mu R_L}{R_0 + R_2 + R_L} \cdot v \quad \text{.. .. (4)}$$

Solving for v in (4) we get:

$$-\frac{V_3}{e} = \frac{\mu R_L}{R_0 + R_L + (1 + \mu)R_2}$$

Hence

$$\frac{\left(\frac{V}{e}\right)_{R_{20}}}{\left(\frac{V}{e}\right)_{R_{2m}}} = E = \frac{R_0 + R_L + (1 + \mu)R_{2m}}{R_0 + R_L + (1 + \mu)R_{20}} \quad \text{.. (5}$$

As R_0 ; R_L ; R_{2m} ; R_{20} are known, the expansion voltage ratio E can be calculated. Expressed in decibels, db expansion $= 20 \text{Log}_{10} E$.

APPENDIX 2

From Fig. 4,

$$V_2 = \frac{R_2}{R_1 + R_2} \cdot \frac{\mu R_L}{R_0 + R_L} \cdot v \quad \ldots \quad (6)$$

and $\quad v = e + V_2 \quad \ldots \quad (7)$

From (6) and (7)

$$v = \frac{e}{1 + \dfrac{R_2}{R_1 + R_2} \cdot \dfrac{\mu R_L}{R_0 + R_L}} \quad \ldots \quad (8)$$

Hence $V_2 = \dfrac{S}{S + \dfrac{R_1 + R_2}{R_2}} \cdot e \quad \ldots \quad (9)$

Where $\quad S = \mu R_L / R_0 + R_L \quad \ldots \quad (10)$

Now $\quad V_1 = \dfrac{R_1}{R_1 + R_2} \cdot Sv$

so therefore $V_1 = \dfrac{R_1 \cdot S \cdot e}{R_1 + (S + 1) R_2} \quad \ldots \quad (11)$

For Type 2(a) where R_1 is fixed, and R_2 varies between a maximum of R_{2m} and a minimum of R_{20}, and where V_1 is used,

$$\frac{\left(\dfrac{V_1}{e}\right)_{R_{20}}}{\left(\dfrac{V_1}{e}\right)_{R_{2m}}} \equiv E = \frac{R_1 + (S + 1) R_{2m}}{R_1 + (S + 1) R_{20}} \quad \ldots \quad (12)$$

For Type 2(b), R_2 is fixed and R_1 varies between R_{1m} and R_{10}, also V_2 is used as the output.

$$\frac{\left(\dfrac{V_2}{e}\right)_{R_{10}}}{\left(\dfrac{V_2}{e}\right)_{R_{1m}}} \equiv E = \frac{R_{1m} + (S + 1) R_2}{R_{10} + (S + 1) R_2} \quad \ldots \quad (13)$$

If the combined output $V_1 + V_2$ is used, the expansion becomes :

$$E = \frac{R_0 + R_L(1 + \mu R_{2m}/R_{2m} + R_1)}{R_0 + R_L(1 + \mu R_{20}/R_{20} + R_1)} \text{ if } R_2 \text{ is varied.}$$

The expansion is here much lower than that obtainable from either (a) or (b).

Due to the loading of R_6 by $R_1 + R_2$, the effective load on the valve is

$$R_5 + R_6 + (R_1 + R_2)/R_1 + R_2 + R_6$$

or $\quad R_5 + R_a$ or $R_5 + R_b$.

Alternating Current Electrical Engineering

By Philip Kemp. 611 + x pp., with 421 Figs. 5th Edition, 1937. Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2. Price, 15s.

At first glance one might suppose that there has been little change in the text of this edition from that of the fourth edition (which was reviewed in the August 1931 issue of this journal), since the increase in the number of pages is only 16. But a careful comparison of the two shows that this supposition is far from the truth, there are many additions and amendments, the bulk of the volume has only been kept down by "careful pruning," as mentioned in the preface. Both author and publishers are to be congratulated in that considerations of the cost of altering the make-up of pages and of resetting type have not been allowed to stand in the way of this policy of thorough revision and excision wherever desirable ; a policy which is seen, by comparison with the first edition of 1918, to have been followed throughout the history of the book. *O si sic Omnes !*

The application of the method of symmetrical components to the problem of unbalanced polyphase circuits (pp. 124 *et seq.*) is a particularly welcome addition, since this powerful method is deserving of more widespread use.

All demonstrations involving the notation of the calculus are relegated to footnotes ; while this will be appreciated by some readers, any writer who labours under the self-imposed handicap of developing proofs from first principles without the aid of the calculus has a difficult course to steer between the Scylla of circumlocution and the Charybdis of mere plausibility. The author has, for the most part, avoided these two great dangers with unusual skill, but adverse criticism of his treatment of Mutual Inductance cannot be suppressed.

If unit current in circuit 1 produces M_{12} flux-turns linked with circuit 2, and conversely for M_{21}, then Moullin (*Principles of Electromagnetism*, p. 44) states :—" The proposition that $M_{12} = M_{21}$ is of great importance and must never be overlooked : it is a proposition which is far from obvious . . ." Now the author develops his proof of this proposition from the statement (p. 23) that :—" If the two coils have the same number of turns, it is clear that the same current in either coil will set up the same number of linkages with the other coil." But is this " clear " ? Do we not rather feel with Moullin that it is " a proposition which is far from obvious " ? Consider for example, the old " standard field " used for calibrating ballistic galvanometers ; to fix ideas suppose it to consist of a solenoid 1 metre long, 10 cm. diameter, having 1,000 turns (coil 1), having at its centre a short coaxial multilayer circular coil of mean diameter 3 cm., and also of 1,000 turns (coil 2). The coils have the same number of turns, but that the linkages with 1 due to unit current in 2 should be equal to the linkages with 2 due to unit current in 1, so far from being " clear," seems at first sight highly improbable. A demonstration founded on this assumption is barely even plausible, and certainly far from convincing. Would it not be better to write : " It can be proved that $M_{12} = M_{21}$ " and leave it at that (providing, if desired, a valid mathematical proof in a footnote or appendix) ?

It may be suggested that this criticism is merely pedantic ; but many years of teaching suggest that it is just the intelligent beginner who finds such vague demonstrations a stumbling-block, since he feels that his ideas must be all wrong, or his intellect deficient, if an author's " manifestly," " obviously," or " clearly," does not appear to him to be convincing ; whereas one more skilled in the art may, from his familiarity with the truth of the proposition, scarcely notice any obscurity in its demonstration. C. R. C.

The Application of Secondary Emission in Amplifying Valves*

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SUMMARY.—The principle of amplifying electron currents by means of secondary emission has been applied in practice in conjunction with photo-electric cells. It has been suggested to apply the same principle to a thermionic source of electrons, but serious difficulties arise when this is put into effect. It has been found that, if the volatilised materials emanating from an incandescent cathode can reach the surface of the secondary cathode, the coefficient of secondary emission will vary during operation.

The following article describes a construction and gives characteristics of an amplifying valve with an indirectly heated cathode, in which amplification is effected by secondary emission and in which the electrons are subjected to electrostatic deflection before reaching the auxiliary cathode, so that the latter may be screened from volatilised materials.

Limitations and Possibilities of the Application of Secondary Emission in Amplifying Valves

THE outstanding feature in the development of radio valves during the last decade is the increasingly high slope of their characteristics. It is therefore surprising that the use of secondary emission for this purpose has not been made practicable before now, especially in view of the various constructions to this end which have been announced in patent literature,[1] all of which have, however, presented certain drawbacks.

By making use of secondary emission, the anode current (and hence the slope) may be increased by a certain factor. In practice the anode current of amplifying valves is subject to certain maximum limits, such as anode dissipation or maximum load on the supply unit. It is therefore important to know the relation between slope and secondary emission factor "δ" (the ratio of electrons emanating from the auxiliary cathode to those impinging on it) for constant anode current. This can be calculated by taking as basis a construction comprising cathode, control grid and anode, with and without an aux. cathode, and ascertaining the anode current of this construction with and without secondary emission.

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

[1] U.S.A. Patents 1735294, 1732050, 1920863, D.R.P. 617353, Fr. Pat. 582428.

The cathode current I_c is, according to Langmuir, given by:

$$I_c = A(V_g + b)^K,$$

where V_g is the control-grid voltage, the values of A, b and K being determined by the construction and by the anode voltage. If

$$I_a = \delta I_c$$

the slope as inferred from the above equation will be:

$$\frac{dI_a}{dV_g} = K \,.\, \delta^{\frac{1}{K}} \,.\, A^{\frac{1}{K}} \,.\, I_a^{\frac{K-1}{K}}$$

Hence, with a constant anode current, the slope will be proportional to $\delta^{\frac{1}{K}}$. As long as the cathode current is so high that the region of minimum potential between the control grid and the cathode is situated close to the cathode, K will have a constant value of about 1.6, so that under these circumstances the slope may be expected to increase in proportion to $\delta^{0.6}$. In the case of tenfold multiplication we may therefore expect, at the same anode current, about 4 times as great a slope as compared with a valve having no secondary emission ($\delta = 1$).

If we apply secondary emission a large number of times, while keeping the anode current constant, the cathode current will steadily diminish. The region of minimum potential will be moved towards the control grid. It has been found that, within wide limits, the cathode current for small values can be represented by:

$$I_c = e^{M(V_g + c)}$$

thus giving a slope of

$$\delta \frac{dI_a}{dV_g} = \delta \frac{dI_c}{dV_g} = \delta M I_c = M I_a$$

M is governed by the Maxwellian distribution of velocities of electrons emanating from the cathode, so that when, for instance, $I_c < 50\ \mu A$, the value of M will be limited to a maximum of $\frac{11600}{T}$, or about 10.

For a triode with an anode current of 5 mA, the slope may amount to 3 mA/volt. By the application of 200-fold secondary emission multiplication, this slope may be increased to about 50 mA/volt, at the same anode current and with a cathode current of 25 μA.

Another limit is set by the maximum available D.C. anode voltage and its maximum permissible modulation.

As seen from Fig. 1, the value of δ for a secondary cathode depends largely on the voltage applied, its value in the present case (with a voltage between 50 and 250 V.) being $\delta = 0.037\ V_{ac}$. If, therefore, we wish to give δ a high value, we shall need a high total voltage. Moreover, a difference of

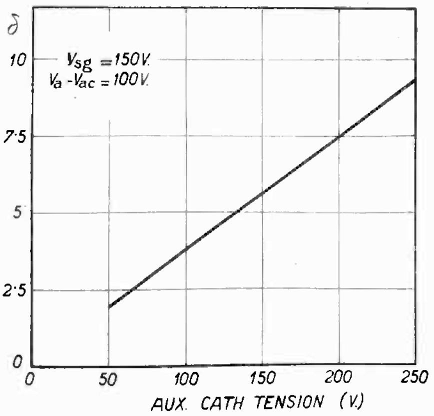


Fig. 1.

potential between the anode and the last secondary cathode is necessary in order to attract the secondary electrons and to ensure undisturbed operation when V_a is modulated.

The limit thus set by the maximum available voltage will be particularly marked in the case of radio apparatus and amplifiers equipped with secondary emission valves.

Measurements have been carried out on a

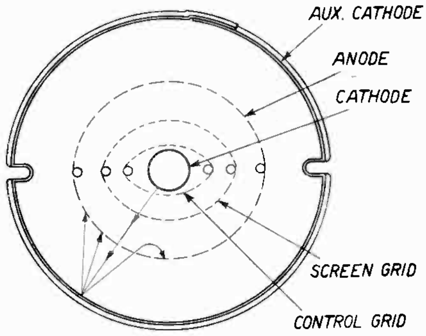


Fig. 2.

simple structure consisting of an indirectly heated cathode, three concentric grids and a plate-shaped external electrode (Fig. 2) internally coated with M_gO (secondary emitter).

For these measurements a positive voltage of 250V. was applied to the third grid and 150V. to the plate; both with respect to the cathode.

The electrons emanating from the cathode traverse all grids and impinge on the plate, where a certain number of electrons are liberated (δ = about 5), which are attracted by the penultimate electrode. In this way it has been found possible to double the slope for the same anode current. However, life tests showed that δ fluctuated considerably during operation. This trouble persisted when other coatings of widely divergent nature[2] were tried on the aux. cathode.

Estimating the surface area of the cathode to be 5 per cent. of that of the aux. cathode, and assuming a cathode temperature T = 1100 deg. K, we may conclude, from the equation[3] for the speed of volatilisation m of BaO in vacuo:

$$\log (m\sqrt{T}) = -1.97 \frac{10^4}{T} + 8.73$$

that in 40 hours the entire anode could be coated internally with a single-molecular

[2] E.g., Br. Pat. 302307.

[3] A. Claassen and C. F. Veenemans. *Zeitschr. F. Physik*, 80–342–1933. See also Günther Hermann, *Z.f. Phys. Chemie* 35–298–1937.

layer of BaO ($\delta = 4.75$ at 400 volts). The cathode emission will also cause volatilisation of a considerable amount of metallic Ba,[4] and since the value of δ is much lower for the metal ($\delta = 0.83$ at 400 volts) than for BaO,[5] δ will soon undergo a considerable reduction. To obviate these drawbacks we must therefore prevent Ba or BaO from reaching the aux. cathode. As the volatilisation of these substances in vacuo takes place along practically straight lines, the defect can be remedied by using a construction in which the aux. cathode is screened from volatilised material emanating from the cathode, whilst on the other hand the electrons emitted from the cathode will reach the aux. cathode as a result of deflection.

Construction of a Valve with a Single Stage of Secondary Emission

In constructing an amplifying valve it had to be borne in mind that the D.C. anode voltage normally employed in radio receivers should not exceed 250–300 volts, in view of safety regulations and the increase in cost of the supply unit and by-pass condensers when working with higher voltages. This meant limiting the number of stages of secondary emission amplification in the valve to one or two. If two stages of secondary emission are employed, the amplification per stage is less, owing to the smaller difference of potential of the secondary cathodes. As a result, the slope with two stages of secondary emission is only slightly greater than with one stage if the anode voltage does not exceed 250V. The slight increase of slope does not warrant the more complicated construction and a more expensive supply unit. In view of this we will only discuss the construction of a valve with one stage of secondary emission.

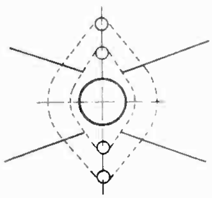


Fig. 3.

[4] Becker. *Phys. Review*, 34–1323–1929.

[5] H. Bruining and J. H. de Boer. *Physica*, 4–473–1937.

The same principle may also be applied when working with more than one stage of secondary emission and a higher anode voltage. As slopes are increased, smaller cathodes may be used, resulting in decreased damping of the control grid at high frequencies and decreased capacitances. In the case of broad-band amplification (as in television) it is possible to use higher impedances, thus increasing the amplification for the same slope.

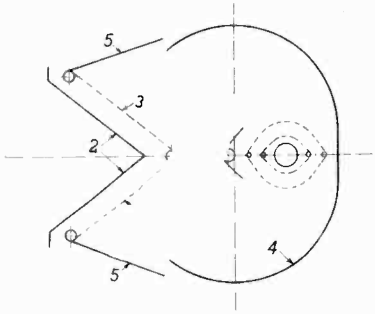


Fig. 4.

In order to obtain a good life, the electrons should be conducted along curved lines to an aux. cathode which cannot be "seen" from the main cathode. This has been achieved by the method of electrostatic deflection—in preference to magnetic deflection, as the latter necessitates the use of permanent magnets or electro-magnets around or inside the valve.

Electrostatic focusing of the electrons on to the aux. cathode may be effected by the use of a cylindrical field as described by Hughes and McMillen[6] or by means of con-

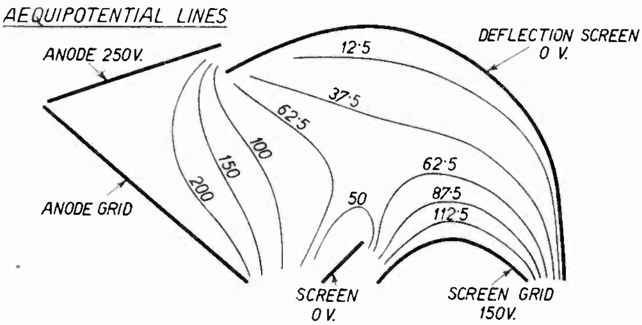


Fig. 5.

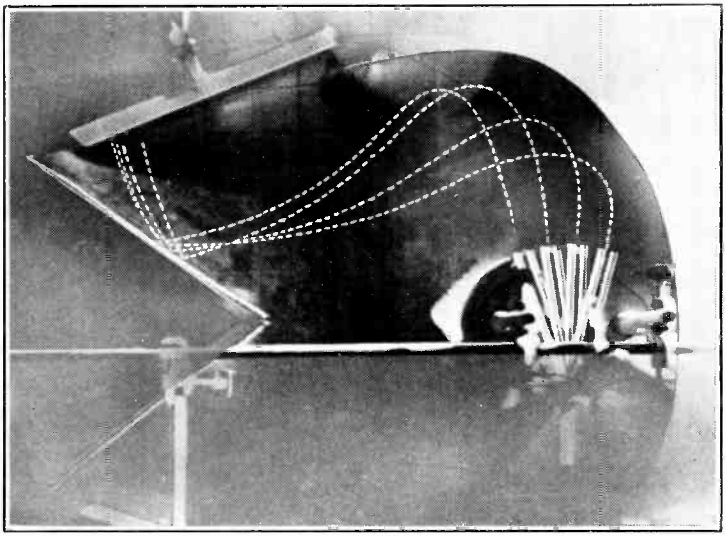
[6] A. L. Hughes and J. H. McMillen, *Phys. Rev.* 34–291–1929.

centrating lenses. This latter method has been used in the construction we are describing.

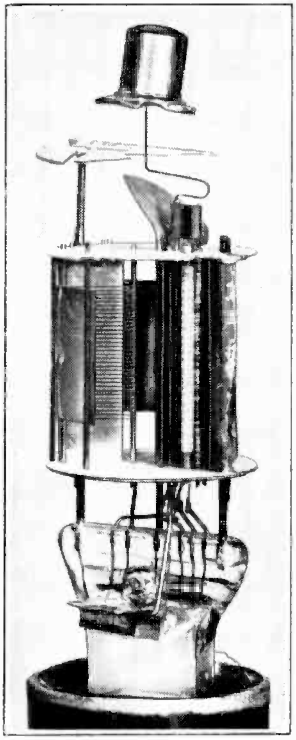
In order to obtain sufficient slope, the effective voltage in the plane of the control grid should be raised. This can be done by placing a high-potential auxiliary grid at a short distance from the control grid. This aux. grid also improves the screening between the control and the anode and increases the internal resistance. A system comprising a cylindrical cathode, an oval control grid and an oval aux. grid with a cross-section as shown in Fig. 3, can emit two diverging beams with an angle of divergence of about 60 deg. With a construction developed in Philips' laboratories and having a cross-section as shown in Fig. 4, it has been found possible to deflect these diverging electron beams and to concentrate them on an aux. cathode. The screening plates 4 and 1 are at cathode potential ; 2 is the aux. cathode, screened from the main cathode by plate 1, so that no cathode material can volatilise upon 2 ; 5 is the anode. The diverging beam emerging from the aux. grid is reflected and converged, so that it impinges on the aux. cathode, where the secondary electrons are liberated and "drawn" towards the gauze anode 3, situated about 1.5 mm. away from the surface of the aux. cathode. It was found necessary to pick up the electrons passing through this gauze anode, on a solid anode, to prevent the electrons near the anode from oscillating and thus from disturbing the potential-field on account of space charge, and causing anode damping on short waves.

If the gauze anode is omitted, a great potential difference between the anode and aux. grid will be required to make the gradient at the surface of the aux. cathode sufficiently high to draw all the secondary electrons to the anode.

The potential-field of a valve constructed on these lines is given in Fig. 5, which has been plotted from an enlarged model in an electrolytic trough. This figure shows that the electrons between the aux. grid and aux. cathode traverse two concentrating fields. Between these fields they undergo a kind of reflection (or deflection) from the low-potential region produced by the curved screen. In this region, as shown by the characteristics, a disturbing space charge is liable to be created during the passage of



(*Above*) Fig. 6.



(*Right*) Fig. 7.

heavy currents. This gives rise to variations in the potential field which may seriously affect the paths of the electrons.

The paths of the electrons (in the absence of space charge) between the aux. grid and the anode is clearly illustrated by Fig. 6, which represents a model of the valve, made with a sheet of rubber according to the method indicated by Kleynen.[7]

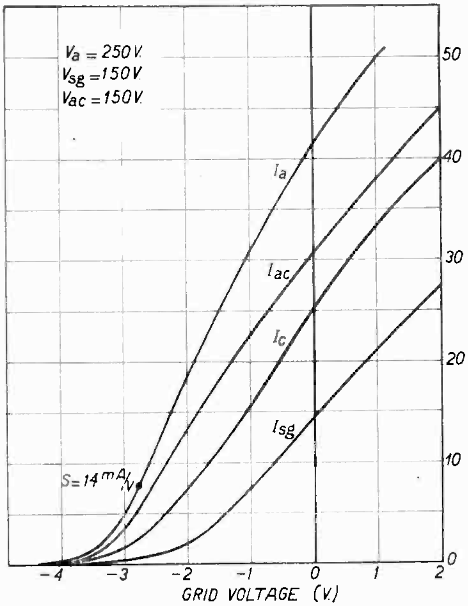


Fig. 8.

Fig. 7 shows a photograph of the construction. The screen has been cut away to show the interior. On the right is the cathode with the surrounding grids; on the left the aux. cathode, gauze anode and anode plate.

Characteristics of the Valve

The currents flowing to the anode, aux. cathode and aux. grid are indicated in Fig. 8 as a function of the control-grid voltage. It will be seen that, for a small cathode current (not exceeding a few milliamperes), the distribution of current is practically constant. If the cathode current is greater than about 6 mA, a space charge of such magnitude is produced in the space between the aux. grid and the anode that the field is disturbed and a portion of the electrons returns to the aux. grid.

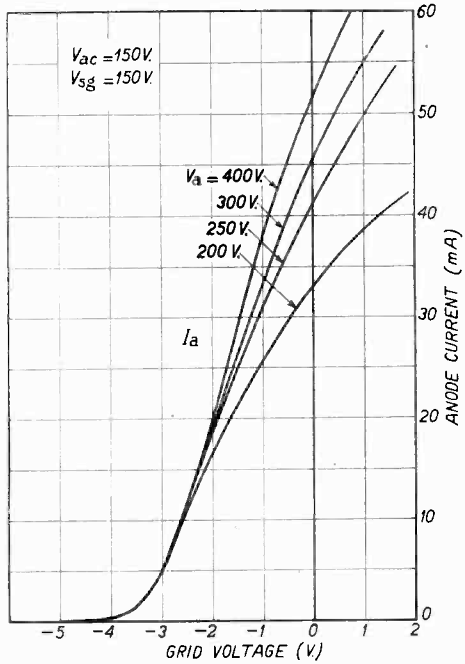


Fig. 9.

This is manifested in the characteristic as a disproportionate increase of aux. grid current at the expense of anode current. As a result the anode current characteristic

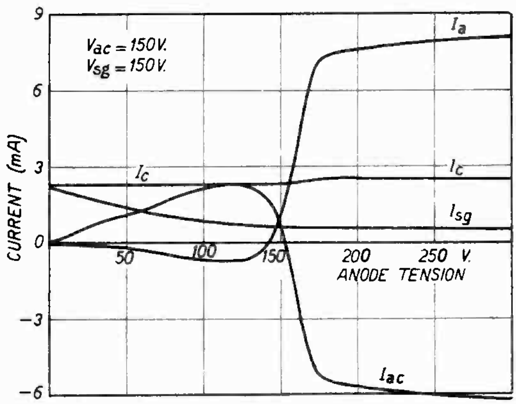


Fig. 10.

may have a point of inflexion, indicating a decrease of slope at high anode currents.

[7] *Philips Tech. Review*, November, 1937.

This effect depends on the anode voltage and aux. grid voltage (see Fig. 9). A portion of the electrons, on their way back to the aux. grid, re-enter the space between the cathode and control grid and influence the cathode current, causing a point of inflexion also in the cathode current characteristic.

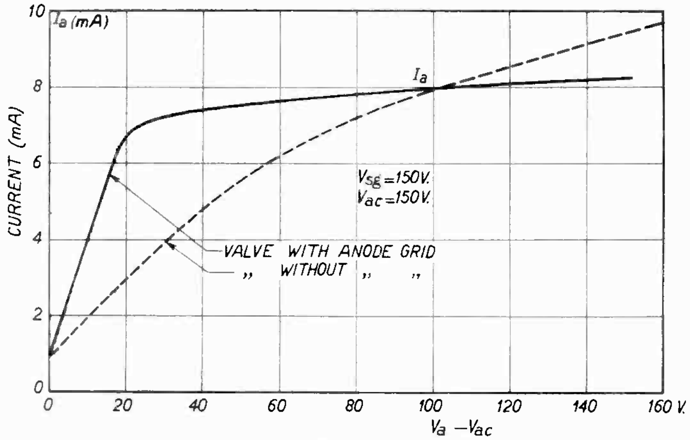


Fig. 11.

Fig. 10 gives the distribution of current over the various electrodes, as a function of the anode voltage. When using the valve as an amplifier, the section of the anode current characteristic commencing at high anode voltage should continue in a horizontal direction to a voltage as little as possible above the aux. cathode voltage. With the aid of this curve we can select the highest possible value for the aux. cathode voltage and hence for the slope, for a given anode voltage. It was found essential to make the distance between the aux. cathode and the gauze anode very small, because, when this distance exceeds a few millimetres, some tens of volts are required to prevent a portion of the secondary electrons from returning to the aux. cathode, even at a current density as low as 5 mA/cm². Fig. 11 illustrates the difference between the anode current characteristic obtained with a gauze anode mounted close in front of the aux. cathode, and with a plate-shaped anode situated some distance away.

The horizontal part of the curve $I_a = f(V_a)$ should have as small a slope as possible in order to obtain a high internal resistance. This slope is chiefly influenced by the variation in space charge of the primary electrons between the aux. grid and aux. cathode. The influence of the anode voltage on the primary current is particularly marked in the case of large currents (see Fig. 9). However, in spite of this influence, the internal resistance can be made high by the following method. When primary electrons are picked up by the anode, the anode current decreases because, if these primary electrons went to the aux. cathode they would yield a higher anode current. It has been found possible to direct the primary electrons in such a manner that, on increasing the anode voltage, an increasing portion of the primary electrons will be picked up by the anode, so that the internal resistance increases or may even become negative. Fig. 12 gives the internal resistance as a function of the anode voltage, for a valve to which this principle has been applied.

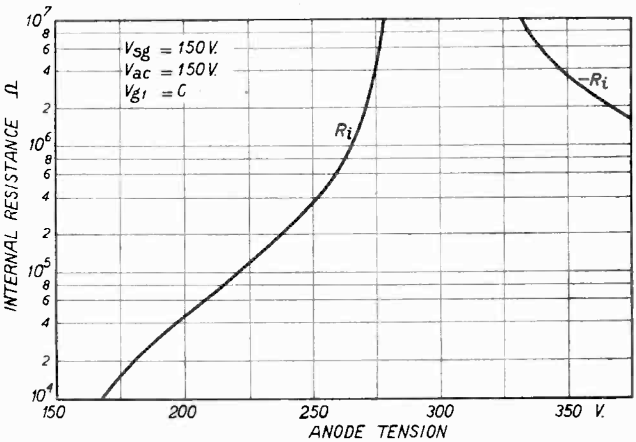


Fig. 12.

Power Supply to the Valve

When using the valve in amplifiers, consideration must be given to the greater tendency to oscillate and the greater influence of different settings of the neg. grid bias as a result of the high slope.

In order to maintain a constant anode current it is therefore desirable that the

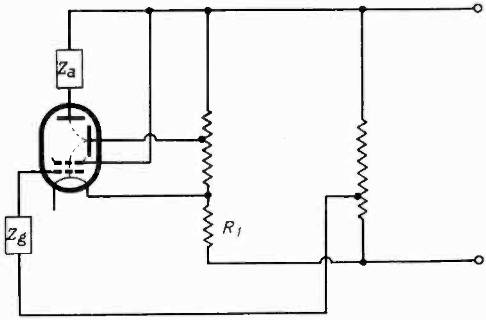


Fig. 13.

negative grid bias be automatically adjusted, because, during the life of the valve, the required neg. grid bias will vary as a result of alterations in contact potential of the control grid.

Fig. 13 shows an example of a suitable

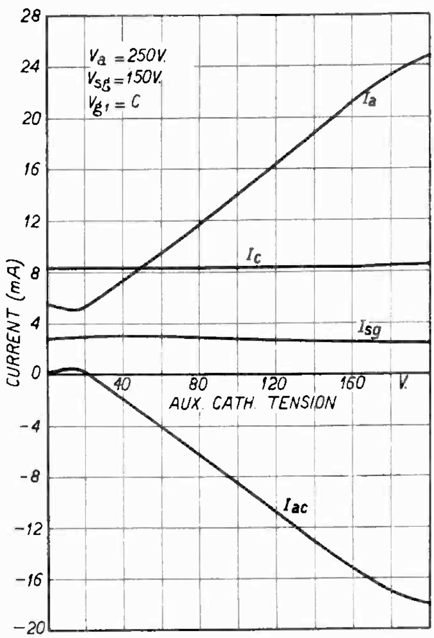


Fig. 14.

circuit. The anode current is kept constant by a cathode resistance R_1 carrying the cathode current and aux. cathode current. Neg. grid bias is taken from a potentiometer giving the control grid a positive potential of 10 volts with respect to the negative side of the supply unit. In this way R_1 can be given a high value and the anode current is thus kept constant. At the moment of switching on, the potentiometer feeding the aux. cathode only takes just enough current to supply the aux. cathode with a voltage sufficient for $\delta > 1$. After switching on, the neg. aux. cathode current causes this voltage to rise until it attains the operating value.

Lastly, Fig. 14 shows the distribution of current as a function of the aux. cathode voltage. This characteristic is important when using the valve as a dynatron.

The British Industries Fair

Items of Wireless Interest

AMONG exhibits of wireless interest at the British Industries Fair, which opened on February 21st, is a comprehensive range of television receivers and equipment shown by Baird in the Olympia section. The new Model T14 makes its first public appearance, and demonstrations of television reception are given. The new Baird Multiplier photo-electric cells are also on show, as is equipment for "communal" television installations in blocks of flats, etc.

Demonstrations of interference suppression are given by Belling and Lee on Stand No. Cb702 in the Electrical Section at Birmingham. In addition to anti-interference filters, chokes, set-lead suppressors and the "Eliminoise" screened aerial there are specialised suppressor units for connection to various appliances. Apparatus for the measurement of "noise" voltages and interference field strengths is also shown, and, in view of the fact that permissible limits of interference have now been defined, is of especial interest.

Catalin, a new synthetic resin plastic material which is cast rather than moulded in the familiar manner, is shown in the Plastics Section. This material seems to have many applications in the radio industry as well as in other fields.

Another "plastic" exhibit of special interest is that of Combined Optical Industries, Ltd., who have evolved a material for making lenses by a moulding process. It has been suggested that this substance may find a place in mechanical television systems, but perhaps of more immediate interest is the fact that it is being shown in the form of illuminated dials, etc., for radio receivers.

Appliances for home recording on discs are shown on Stand A742 at Olympia by Makers' Agents, Ltd. The exhibit comprises complete portable units, as well as cutting heads and tracking gear, etc., for use with existing amplifiers.

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

803. Transmission Theory of Plane Electromagnetic Waves [in Free Space and in Cylindrical Tubes of Arbitrary Cross Section: Definitions of "Transverse Electric," "Magnetic," and "Electromagnetic" Waves: Generation of Each Type: Plane Waves in Cylindrical Tubes: Graphic Representation of Guided Waves: etc.].—S. A. Schelkunoff. (*Proc. Inst. Rad. Eng.*, Nov. 1937, Vol. 25, No. 11, pp. 1457–1492.)

804. Electromagnetic Waves in Conducting Tubes [Points in Optical Analogy].—S. A. Schelkunoff. (*Phys. Review*, 15th Nov. 1937, Series 2, Vol. 52, No. 10, p. 1078.) For papers on the subject *see* 42 of January and back references.

805. On the Dielectric Constant of Air.—D. Nasilov. (*Journ. of Tech. Phys.* [in Russian], No. 16, Vol. 7, 1937, pp. 1672–1674.)

In modern theories of the propagation of radio waves, little attention is paid to the rôle played by the lower strata of the atmosphere. This is due, in the opinion of the author, to incorrect assumptions regarding the dielectric constant of air, ϵ. In the present paper, which is a preliminary communication on an investigation carried out by the author, attention is drawn to the presence of electrical charges on the particles of water in humid air, and to the ionisation processes taking place in the lower strata of the atmosphere. A brief account is also given of experiments which show that there is insufficient justification for asserting that ϵ is practically independent of the degree of humidity.

806. The Reflection Coefficients of Ionospheric Regions [Ionisation Bursts at Heights 80–160 km act as Reflecting Centres].—E. V. Appleton & J. H. Piddington. (*Proc. Roy. Soc.*, Series A, 7th Dec. 1937, Vol. 163, No. 914, p. S 60: abstract only.)

"Experiments on the radio sounding of the ionosphere are described which give no support to the supposed existence of permanent highly reflecting regions at heights of 10 km. It is considered possible that the echoes of short delay noted by previous workers are due to scattering from patches of ionisation of very low effective reflection coefficient. It is found that, after the normally recognised regions of the ionosphere, the radio reflecting centres in the atmosphere next in order of importance as regards wireless echo production are transitory bursts of ionisation which occur at equivalent heights of from 80 to 160 km. Such bursts of ionisation are due to some cosmic agency which is usually effective throughout the whole of the day and night."

807. Dissociation, Recombination, and Attachment Processes in the Upper Atmosphere: I [Probabilities of Various Collision Reactions: Dynamical Equilibrium between Negative Ions and Electrons: Number of Negative Ions in E Region should considerably exceed the Number of Electrons required by Magnetic Variations: Atmospheric Gases in F Region probably Inert towards Electron Attachment].—H. S. W. Massey. (*Proc. Roy. Soc.*, Series A, 19th Nov. 1937, Vol. 163, No. 913, p. S 9: abstract only.)

808. The Propagation of Electromagnetic Waves in an Ionised Atmosphere [Theory considering Essential Gaseous Character of Ionic Cloud].—L. G. H. Huxley. (*Phil. Mag.*, Jan. 1938, Series 7, Vol. 25, No. 166, pp. 148–159.)

Theoretical results obtained previously by the writer (1669 of 1937) for the conductivity of an ionised gas under the influence of an alternating electric force are here applied to the development of a theory of ionospheric propagation which considers the essentially gaseous character of the ionic cloud. Equations are found which "contain all the information necessary to determine the polarisation and absorption of the waves and the refractive index of the medium"; these are applied to the cases of propagation along, perpendicular to, and in any direction to the lines of magnetic force. The individual appearance of the transverse and longitudinal components of the permanent magnetic field, displayed by the Appleton-Hartree formula, does not occur here; "the total field strength H_0 alone appears in the expressions for the conductivity, and, moreover, not linearly," and the conclusions concerning the propagation of waves in any direction to the magnetic field are found to be "essentially different" from those derived from the Appleton-Hartree formula, though in certain special cases there may be agreement.

809. THE RESULTS OF IONOSPHERIC MEASUREMENTS OVER THE ENTIRE WORLD [Authors' Measurements show that Conditions of Ionisation differ greatly between One Latitude and Another: F_2-Region Theory (Appleton, Hulburt, Martyn) requires Revision: Deductions from General Survey: Need for Large Scale Research].—K. Maeda & T. Tukada. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 445–446.)

810. MEASURING THE REFLECTING REGIONS IN THE TROPOSPHERE [with 4-Microsecond Pulses (about 1.6–3.5 Mc/s) and Oscillograph Sweep Velocity 9000 Inches/Second: Very Strong Reflections from Heights 1–12 km (C Region), Occasional Echoes from 15–65 km (D Region): C Region apparently "Somewhat Diffuse": Connection with Certain Types of Rapid Broadcast Fading: C-Region Changes and Their Relation to Average Signal Strength, Barometric Changes, Magnetic & Solar Disturbances: Measured Velocities 50–85% of Velocity in Vacuum: etc.].—A. W. Friend & R. C. Colwell. (*Proc. Inst. Rad. Eng.*, Dec. 1937, Vol. 25, No. 12, pp. 1531–1541.) *See* also 401 of February.

811. ON THE IONISATION OF THE F_2 REGION [Peru, Australia, and U.S.A. Data analysed to separate Variations in Solar Ionising Force from Suggested "Seasonal" Effects and "Annual" Effects: Indications that Both Effects occur, the Latter possibly due to Meteorological Conditions].—W. M. Goodall. (*Proc. Inst. Rad. Eng.*, Nov. 1937, Vol. 25, No. 11, pp. 1414–1418.)

812. ANNUAL VARIATION OF THE ABSORPTION OF WIRELESS WAVES IN THE IONOSPHERE [Curve for 1935: Two Absorption Zones].—F. W. G. White & L. W. Brown. (*Nature*, 27th Nov. 1937, Vol. 140, p. 931.) For method *see* 2072 of 1936.

813. WORK ON CONDITIONS IN THE IONOSPHERE BY THE AUSTRALIAN RADIO RESEARCH BOARD [Pulse Emission Method combined with Partial Employment of Frequency-Change Technique: Polarisation, Angles of Incidence, and Lateral Deviation Investigations (Defocusing Method): Fade-Outs: etc.].—(*Journ. of Council for Sci. & Indust. Res. of Australia*, Nov. 1937, Vol. 10, No. 4, pp. 334–335.)

814. NEW RESULTS OF IONOSPHERIC RESEARCH AND THEIR IMPORTANCE FOR GEOPHYSICS [Summary of Recent Work].—R. Penndorf. (*Naturwiss.*, 26th Nov. 1937, Vol. 25, No. 48, pp. 774–779.)

815. CHARACTERISTICS OF THE IONOSPHERE AT WASHINGTON, D.C., SEPTEMBER, 1937: OCTOBER, 1937.—Gilliland & others. (*Proc. Inst. Rad. Eng.*, Nov. 1937, Vol. 25, No. 11, pp. 1493–1496: Dec. 1937, No. 12, pp. 1648–1651.)

816. CHARACTERISTICS OF THE IONOSPHERE AT WASHINGTON, D.C. [Notes on Bureau of Standards Activities].—Nat. Bureau of Standards. (*Journ. Franklin Inst.*, Dec. 1937, Vol. 224, No. 6, pp. 779–781.)

817. PULSE TRANSMITTER FOR DECIMETRE WAVES.—E. C. Metschl. (*Funktech. Monatshefte*, Nov. 1937, No. 11, pp. 337–338.)

818. SHORT-WAVE PROPAGATION AND THE 11-YEAR SOLAR ACTIVITY PERIOD [Short Survey, including Waldmeier's Method of Analysing Sunspot Curves, leading to Forecast of Sunspot Maximum (124) in Mid-September, 1937].—O. Morgenroth: Waldmeier. (*Funktech. Monatshefte*, Nov. 1937, No. 11, pp. 340–341.)

819. FORECASTING SUNSPOTS AND RADIO TRANSMISSION CONDITIONS [Author's Method of Analysing Sunspot Data gives Possibility of Short-Range Forecasts].—A. L. Durkee. (*Bell Lab. Record*, Dec. 1937, Vol. 16, No. 4, pp. 127–129.)

820. SUDDEN FADE-OUTS OF RADIO WAVES: THEIR RELATIONS TO MAGNETIC AND SOLAR PHENOMENA [Results for 1936/37: Fade-Outs and Simultaneous Small Local Magnetic Disturbances may be due to Chromospheric Eruptions].—R. Jouaust, R. Bureau, & L. Éblé. (*Comptes Rendus*, 27th Dec. 1937, Vol. 205, No. 26, pp. 1427–1428.) Continuation of work dealt with in 846 of 1937.

821. THE RECENT STATE OF AN ABNORMAL PHENOMENON IN SHORT-WAVE TRANSMISSION [Dellinger Effect: Examination of Past Records in Japan show Occurrence when Relative Sunspot Numbers are Increasing, Weather is Bad or Very Cloudy, and Ionisation Density is greatly Increased (Good for U.S.W. Communication): etc.].—D. Arakawa, H. Maeda, & others. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 448–452.) For previous work *see* 2448 of 1937.

822. THE EFFECT OF THUNDERSTORMS ON THE IONOSPHERE [67% of Thunderstorm Days in Japan in 1935 accompanied by Sudden Increase of Critical Penetration Frequency, followed (1–2 Hours) by Disappearance of Reflected Wave (1–1.5 Hours), Normal Conditions returning gradually: Lightning Effects probably include Change of Distribution of Electron Density with Height].—T. Minohara, Y. Ito, & others. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 453–454.)

823. Broadcast Reception and Meteors [Short Survey, including Observations of Skellet, Bhar, Pickard: French, German (Lehwald) & New Zealand (Raplay) Observers].—O. Morgenroth. (*Funktech. Monatshefte*, Dec. 1937, No. 12, pp. 387–388.) The French, German and New Zealand observations have not been dealt with in past Abstracts.

824. A Survey of the Facts and the Theories of the Aurora.—E. W. Hewson. (*Reviews of Modern Physics*, Oct. 1937, Vol. 9, No. 4, pp. 403–431.)

825. Study of the Lunar Effect on the North/South Earth Currents recorded at the Observatory of Parc Saint-Maur [Semi-Diurnal Lunar Component].—P. Rougerie. (*Comptes Rendus*, 13th Dec. 1937, Vol. 205, No. 24, pp. 1252–1253.)

826. Light of the Night Sky [Selective Production of Tail Bands of Cyanogen].—J. Kaplan. (*Phys. Review*, 15th Dec. 1937, Series 2, Vol. 52, No. 12, p. 1252.)

827. Spectrum of Nitrogen and Atmospheric Pressure at High Altitudes [Energy of Electrons and not Pressure is Factor affecting Relative Intensity of Emitted Radiation].—R. Bernard. (*Nature*, 27th Nov. 1937, Vol. 140, p. 930.) *See* also 2069 of 1937, and Kaplan, 3242 of 1937.

828. Results of the Fluorometric Estimation of the Atmospheric Ozone [First Direct Measurement at 10 km: Curve of Distribution up to 10 km].—Konstantinova-Schlesinger. (*Bull. de l'Acad. des Sci. de l'URSS, Série Physique*, No. 2, 1937, pp. 213–222: Russian, with French summary.)

829. Atmospheric Absorption and the Absorption Coefficients of Ozone in the Visible Spectrum [Value for Reduced Thickness of Atmospheric Ozone].—G. Déjardin, A. Arnulf, & R. Falgon. (*Comptes Rendus*, 29th Nov. 1937, Vol. 205, No. 22, pp. 1086–1088.)

830. On Some Properties of Ozone, and Their Geophysical Consequences [Variation of Absorption Spectrum with Temperature: Deduction of − 30° C as Mean Temperature of Atmospheric Ozone, and Rapid Rise of Temperature of Atmosphere above 30 km: Deductions as to Origin of Ozone].—E. Vassy. (*Ann. de Physique*, Dec. 1937, Series 11, Vol. 8, pp. 679–777.) For a preliminary paper *see* 2462 of 1937.

831. Remark on a Possible Interpretation of the Ozone Bands [Relations between Electronic Levels].—L. Herman & Herman-Montagne. (*Comptes Rendus*, 29th Nov. 1937, Vol. 205, No. 22, pp. 1056–1057.)

832. Ultra-Violet Solar Radiation Intensities in the Stratosphere [Wireless Signals from Balloon give Altitude and Ultra-Violet Intensity].—Nat. Bureau of Standards. (*Journ. Franklin Inst.*, Dec. 1937, Vol. 224, No. 6, pp. 781–782.)

833. Electromagnetic Wave Fields near the Earth's Surface [Observations on Broadcast Transmissions: Effects of Sky-Wave Horizontal and Vertical Magnetic Components separated from Ground-Wave Effects by keeping within "Sky-Wave Furrow" of Directional Pattern of Loop Receiver: Variations of Tilt Angle with Time: with Space Changes (Buried Conductors: Vertical Lamp-Posts: Deep Gorges: etc.): Possible Origins of Multiple Sky Waves: etc.].—C. R. Mingins. (*Proc. Inst. Rad. Eng.*, Nov. 1937, Vol. 25, No. 11, pp. 1419–1456.)

In his final section the writer remarks that "it seems quite possible that some of the intermediate layers postulated by Colwell & Friend and by Watson Watt *et al.* may prove to be the result of multiples from the lower layers when account can be taken of the ionisation gradients."

834. Corrections to "The Physical Reality of Space and Surface Waves in the Radiation Field of Radio Antennas" and "The Propagation of Radio Waves over the Surface of the Earth and in the Upper Atmosphere: Part II."—Norton. (*Proc. Inst. Rad. Eng.*, Nov. 1937, Vol. 25, No. 11, p. 1366.) *See* 32 & 33 of January.

835. The Measurement of the Reflection Coefficient of the Earth at High Radio Frequencies [6–15 Mc/s].—K. Maeda & M. Nakagami. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 446–447.)

836. On a Method of Measuring the Velocity of Electromagnetic Waves, *and* The Velocity of Medium Radio Waves near the Earth's Surface.—Mandelstam & Papalexi: Viller & Schegolev. (*Tech. Phys. of USSR*, No. 10, Vol. 4, 1937, pp. 767–786: pp. 787–826: both in English.) Papers in Russian covering the same ground were dealt with in 3981/3983 of 1937. For associated papers *see* 837, below.

837. The Measurement of Phase Difference between Harmonic Oscillations of Different Frequencies, *and* On a Method of Measuring the Phase Displacement introduced by H.F. Amplifiers.—Schegolev: Viller. (*See* 1124.)

838. Propagation of Waves along Electric Lines: Graphical Method.—L. Bergeron. (*Bull. de la Soc. franç. des Élec.*, Oct. 1937, Vol. 7, No. 82, pp. 979–1004.)

839. The Electric Spectrum of Liquid Water from Five to Twenty Centimetres [Free-Wave and Wire-Wave Methods of determining Refractive and Absorption Indices: No Clear Evidence of Dispersion: Comparison between Present Data and Previous Results of Other Investigators].—H. W. Knerr. (*Phys. Review*, 15th Nov. 1937, Series 2, Vol. 52, No. 10, pp. 1054–1067.)

840. THE REFRACTIVITY INTERCEPT AND THE SPECIFIC REFRACTION EQUATION OF NEWTON: II—THE ELECTRONIC INTERPRETATION OF THE REFRACTIVITY INTERCEPT AND OF THE SPECIFIC REFRACTION EQUATIONS OF NEWTON, EYKMAN, AND LORENTZ-LORENZ [Sellmeier/Drude Refraction Equation preferable to Lorentz/Lorenz Form for Dielectrics, in particular Hydrocarbons].—S. S. Kurtz & A. L. Ward. (*Journ. Franklin Inst.*, Nov. & Dec. 1937, Vol. 224, Nos. 5 & 6, pp. 583–601 & 697–728.)

841. REFLECTIVITY OF CORRUGATED SURFACES [assuming Surface composed of Small Planes fortuitously Oriented].—Ornstein & van der Burg. (*Physica*, Dec. 1937, Vol. 4, No. 11, pp. 1181–1189: in English.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

842. ON ERRORS IN ANALYSING RESULTS OF RADIO MEASUREMENTS [on Atmospherics].—D. Nasilov. (*Journ. of Tech. Phys.* [in Russian], No. 16, Vol. 7, 1937, pp. 1669–1670.)

During recent years it has been shown that interference by atmospherics is caused entirely by processes taking place in the lower strata of the atmosphere, and that it is therefore dependent on a great number of variable factors. In view of this the author disputes the validity of average values of interference, for different times of the day and of the year, derived by a simple statistical method from experimental observations. It is pointed out that even if the meteorological conditions prevailing during these observations are taken into account, no reliable information on interference can be obtained unless the "dynamics" of all the meteorological processes in their entirety is considered.

843. WORK ON ATMOSPHERICS BY THE AUSTRALIAN RADIO RESEARCH BOARD [Lightning & Cold Fronts: Wave Form; Evidence of Reflection from E Layer: Distances of Sources: Mean Energy and Power: etc.].—(*Journ. of Council for Sci. & Indust. Res. of Australia*, Nov. 1937, Vol. 10, No. 4, pp. 335–336.)

844. SOME NOTES ON RAIN STATIC IN JAPAN [Account of Rarely Observed Disturbance of Land Reception, and Examination of Its Theoretical Possibility].—T. Nakai. (*Proc. Inst. Rad. Eng.*, Nov. 1937, Vol. 25, No. 11, pp. 1375–1380.) In the much commoner case of interference with aircraft reception, the small aircraft aerial moves with such a high velocity that as regards rain-drop incidence it is equivalent to a very large one. The very strong disturbance of reception at a fixed station, here discussed, was observed in 1929.

845. THE IMPORTANCE OF OBSERVATIONS FROM THE UPPER ATMOSPHERE IN LONG RANGE WEATHER FORECASTING.—H. C. Willett. (*Journ. of Applied Physics*, Dec. 1937, Vol. 8, No. 12, pp. 807–814.)

846. INVESTIGATION OF THE UPPER AIR [with Notes on Wireless Transmitter for Use on Balloons, replacing Measures of Meteorological Elements by Time Intervals].—(*Nature*, 20th Nov. 1937, Vol. 140, pp. 876–877: notes on British Association discussion.)

847. THE EFFECT OF THUNDERSTORMS ON THE IONOSPHERE.—Minohara, Ito, & others. (*See* 822.)

848. POINT-DISCHARGE CURRENTS DURING THUNDERSTORMS [Data showing Nett Loss of Positive Electricity].—M. N. S. Immelman. (*Phil. Mag.*, Jan. 1938, Series 7, Vol. 25, No. 166, pp. 159–163.)

849. SOME DATA ON LIGHTNING.—Rawlinson. (*See* 949.)

850. LIGHTNING PROTECTION.—E. T. Norris. (*Electrician*, 17th Dec. 1937, Vol. 119, p. 730: summary of lecture.)

PROPERTIES OF CIRCUITS

851. SUDDEN CHANGES IN MODES OF ELECTRICAL OSCILLATION (BEHAVIOUR) ALONG THE "RING CIRCUIT" [80 cm Oscillator exciting, through Feeders, a Circular Ring of λ, 1.5λ, or 2λ Circumference: Standing-Wave Voltage Distribution: Phenomena similar to Those of Telephone Diaphragm].—H. Iwakata. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 349–352.)

852. ON THE OPTIMUM LENGTH FOR TRANSMISSION LINES USED AS CIRCUIT ELEMENTS.—Salzberg. (*See* 907.)

853. TRANSMISSION LINE STRUCTURES AS HIGH-FREQUENCY NETWORKS [Coaxial Structures containing Side Branches or Lumped Capacitances, as Band-Pass Filters or as Transformers].—W. P. Mason. (*Bell Lab. Record*, Dec. 1937, Vol. 16, No. 4, pp. 118–121.)

854. ON THE EXPERIMENTAL DETERMINATION OF PARAMETERS OF COMPLEX SYSTEMS.—A. A. Kharkevich. (*Journ. of Tech. Phys.* [in Russian], No. 18/19, Vol. 7, 1937, pp. 1880–1887.)

The difficulties encountered in practice in measuring total square deviation are discussed, and it is suggested that use should be made of analogical systems, *i.e.* systems differently constructed but represented by similar equations. As an example, a mechanical system with one degree of freedom is considered and a table (2) is given in which 8 possible analogical electrical circuits are shown, together with currents and voltages in each component, expressed as functions of either the input current or the input voltage. The discussion is further illustrated by two examples in which parameters of the following two circuits were determined experimentally with a view to obtaining a minimum total square deviation: (a) h.f. correcting circuit for wide-frequency-range amplifier, and (b) equivalent circuit of a moving-coil microphone.

855. THE HIGH-FREQUENCY RESISTANCE ATTENUATOR [and Its Errors due to Unavoidable Capacities: Analysis of Equivalent Circuit].—M. Monji. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 399–400.)

856. ON THE STAR DELTA TYPE WAVE FILTER [rivalling Zobel Composite and Cauer Lattice Filters].—K. Nagai & R. Kamiya. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 335–338.)

857. A NEW ELECTRIC WAVE SEPARATOR [Special Bridge-Type Network].—S. Chiba. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 339–340.)

858. THE DETERMINATION OF THE DIPOLE FUNCTIONS $Z_{1,2}$ AND $Y_{1,2}$ FOR THE CALCULATION OF BRIDGE-TYPE FILTERS [Simplifying Tables for Cauer's "Siebschaltungen"].—K. Steffenhagen: Cauer. (*Funktech. Monatshefte*, Dec. 1937, No. 12, pp. 373–386.) For previous work on the use of Cauer's methods *see* 2135 of 1937.

859. ON THE RELATION BETWEEN THE REAL AND IMAGINARY PARTS OF A COMPLEX TRANSFER FACTOR [with Application to a Low-Pass Filter].—R. Leroy: Bayard. (*Rev. Gén. de l'Élec.*, 18th Dec. 1937, Vol. 42, No. 25, pp. 778–783.) Leading from the work of Bayard (2587 of 1935).

860. REMARKS ON THE SUBJECT OF THE CALCULATION OF TRANSIENT RÉGIMES IN FILTERS [and the Possible Simplification of the Full Calculations].—R. Leroy: Poincelot. (*Ann. des Postes, T. et T.*, Dec. 1937, Vol. 26, No. 12, pp. 1048–1059.) Prompted by Poincelot's article (452 of February) giving the exact formula for the transient régime at the output of a low-pass filter.

861. A SIMPLIFIED THEORY OF FILTER SELECTIVITY.—H. Dudley. (*Communications*, Oct. 1937, Vol. 17, No. 10, pp. 12–13 and 42, 44.)

862. LIMITATIONS IN HIGH-FREQUENCY BAND FILTER DESIGN [and Their Removal].—C. E. Lane. (*Bell Lab. Record*, Oct. 1937, Vol. 16, No. 2, pp. 56–61.)

863. THE GRAPHICAL DETERMINATION OF FREQUENCY AND CONSTANTS OF ELECTRICAL OSCILLATORY CIRCUITS AND SIMPLE FILTERS [using Properties of Right-Angled Triangle].—J. Herz. (*Funktech. Monatshefte*, Nov. 1937, No. 11, pp. 349–350.)

864. ON A QUARTZ CRYSTAL FILTER [Crystal Cut giving Single Resonance Point, and Small Temperature Coefficient, between 50 kc/s and 250 kc/s].—S. Matumae & S. Yonezawa. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 333–335.)

865. NOVEL METHOD OF COUPLING.—Kinross: Beard. (*See* 930.)

866. COMPARISON OF PARALLEL AND SERIES COUPLING CIRCUITS FOR TRANSMITTERS.—(*See* 918.)

867. RESONANCE EFFECTS IN A NON-LINEAR SYSTEM WITH TWO DEGREES OF FREEDOM.—V. V. Migulin. (*Tech. Phys. of USSR*, No. 10, Vol. 4, 1937, pp. 850–865.) English version of the paper dealt with in 4027 of 1937.

868. SOLUTION OF VARIABLE CIRCUITS BY MATRICES [General Method for Systems expressed by Ordinary Homogeneous Linear Equation with Variable Coefficients: Free Oscillations of Circuits whose Parameters are Periodic Functions of Time].—L. A. Pipes. (*Journ. Franklin Inst.*, Dec. 1937, Vol. 224, No. 6, pp. 767–777.)

869. GENERALISED CHARACTERISTICS OF NON-LINEAR TRIODE AMPLIFIERS.—Baudoux. (*L'Onde Élec.*, Dec. 1937, Vol. 16 [wrongly labelled 17 on cover], No. 192, pp. 666–680.) Concluded from 439 of February.

870. HIGH-FREQUENCY POWER AMPLIFIERS: CALCULATION OF "B" AND "C" TYPES [Method to replace Usual "Cut-and-Try" Planning due to Excessive Complication or Inadequate Accuracy of Previous Methods].—F. M. Kósa. (*Wireless Engineer*, Dec. 1937, Vol. 14, No. 171, pp. 647–656.)

871. LAMINATED IRON-CORE COILS, WITH AIR GAP AT HIGH FREQUENCIES [and the Approximate Calculation of the "Upper Critical Frequency," due to Eddy Currents].—R. K. Hellmann. (*Communications*, Dec. 1937, Vol. 17, No. 12, pp. 18 and 28, 29.)

872. CIRCLE DIAGRAM FOR THE DETERMINATION OF THE DATA OF A PARALLEL RESONANCE CIRCUIT.—F. Benz. (*Funktech. Monatshefte*, Dec. 1937, No. 12, pp. 361–362.)

873. THE TURNER "KALLIROTRON" CIRCUIT AS A LOW-DISTORTION A.F. OSCILLATOR.—Reich: Turner. (*See* 1030.)

874. OPTIMUM STRIKING VOLTAGE OF A GLOW-DISCHARGE TUBE FOR THE PRODUCTION OF RELAXATION OSCILLATIONS.—J. Bethenod. (*Rev. Gén. de l'Élec.*, 25th Dec. 1937, Vol. 42, No. 26, p. 816.)

If θ is the time taken for the voltage to rise to the striking point, it is found that the maximum mean power is developed when $\theta/RC = 1.256$: this occurs when the striking voltage is 0.714 times the d.c. supply voltage.

875. DAMPING DUE TO A PERFECT DIODE RECTIFIER [and the Distinction between Series and Parallel Circuits: Formulation of a "Somewhat Unusual" Fourier Series].—L. Jofeh. (*Wireless Engineer*, Nov. 1937, Vol. 14, No. 170, p. 607.) From the Cossor laboratories.

876. NOTE ON LARGE-SIGNAL DIODE DETECTION [and Its Distortion].—Bennon. (*See* 940.)

877. THE GENERAL EQUIVALENT CIRCUIT OF A VACUUM-TUBE AMPLIFIER [with Grid/Plate Coupling by Electrode Capacitances: by Thévenin's Theorem].—T. Okabe. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 324–325.)

878. An Analysis of Admittance Neutralisation by means of Negative Transconductance Tubes.—Herold. (*See* 1099.)

879. The Clarification of "Average" Negative Resistance, with Extensions of Its Use [Necessity for Clarification: Failure of "Secant" Method of predicting Oscillation Amplitude, and New "R_n–V Curve" and "Constant R_n Curve" Methods: Simple Explanation of Appleton–van der Pol "Oscillation Hysteresis": Automatic Amplitude Control and Measurement of Resistance: etc.].—C. Brunetti. (*Proc. Inst. Rad. Eng.*, Dec. 1937, Vol. 25, No. 12, pp. 1595–1616.) The term R_n represents an "average effective resistance," based on a simple energy consideration.

880. Plate-Resistance Control in Vacuum Tubes as Audio Gain Control Means [Two General Methods (Control Valve as Amplifier and as Controlled Resistance) and Their Characteristics].—A. W. Barber. (*Communications*, Oct. 1937, Vol. 17, No. 10, pp. 23–25.)

881. Regeneration in Linear Amplifiers [Incorrect Results from Usual Method of calculating Gain: New Analysis free from This Defect: Determination of Stability Conditions: Series and Parallel Regeneration Systems, and Their Combination to give Special Characteristics: Neutralisation of Miller Effect: etc.]—G. S. Brayshaw. (*Wireless Engineer*, Nov. 1937, Vol. 14, No. 170, pp. 597–605.)

882. The Necessary Conditions for Instability (or Self-Oscillation) of Electrical Circuits: an Alternative Proof of Nyquist's Theorem on Regenerative Systems.—D. G. Reid. (*Wireless Engineer*, Nov. 1937, Vol. 14, No. 170, pp. 588–596.)

883. Parametrical Excitation of Combination Oscillations (Preliminary Communication).—V. Lazarev. (*Tech. Phys. of USSR*, No. 10, Vol. 4, 1937, pp. 885–888: in English.) The Russian version was dealt with in 4028 of 1937.

884. Parametrical Regeneration, and the Possibility of Its Application to Frequency Transformation with Arbitrary Ratio.—V. Lazarev. (In paper referred to in 883, above.)

885. Rectified Differential Feedback Circuit and Its Applications.—K. Kobayashi. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 381–383.)

886. A New Method of Duplex Feedback, and Its Behaviour to Transients.—Y. Kikuti. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 346–347.) For Watanabe's work on duplex feedback *see*, for example, 1043 of 1936.

887. Tone Improvement by Negative Feedback [Approximate Quantitative Treatment, including "Voltage" and "Current" Feedback: Latter rarely employed, but Useful for Reinforcement of High Frequencies: Practical Circuits].—H. Zimmer. (*Funktech. Monatshefte*, Dec. 1937, No. 12, pp. 389–392.)

888. Some Properties of Negative Feedback Amplifiers [Analyses of Various Methods: Phase Shift & Instability: Proportioning the Stages: Method of "Subsidiary Feedback": Non-Linear Distortion].—L. I. Farren. (*Wireless Engineer*, Jan. 1938, Vol. 15, No. 172, pp. 23–25.) With 15 literature and patent references.

889. Frequency-Selective [Negative] Feedback applied to the Design of Band-Pass Amplifiers.—Brailsford. (*See* 931.)

890. Correspondence on "Distortion in Negative-Feedback Amplifiers." — Sloane: Frommer: Marinesco. (*Wireless Engineer*, Nov. 1937, Vol. 14, p. 607, and Jan. 1938, Vol. 15, pp. 20–22: p. 22.) Continued from 3262 of 1937. For Marinesco's work *see* 3434 of 1936.

891. Inverse-Feedback Amplifiers: Applications to Repeaters for H.F. Carrier-Current Telephony.—J. Saphores. (*Bull. de la Soc. franç. des Élec.*, Nov. 1937, Vol. 7, No. 83, pp. 1121–1134.)

892. Impedance of Copper-Oxide Modulator and Demodulator.—M. Ishida & K. Ishii. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, p. 341.)

893. "Transient Electric Currents" [Book Review].—H. H. Skilling. (*Electrician*, 17th Dec. 1937, Vol. 119, p. 734.)

894. "Théorie et Pratique des Circuits fondamentaux de la T.S.F." [and the Use of the Technique of Complex Numbers: Book Review].—J. Quinet. (*Rev. Gén. de l'Élec.*, 11th Dec. 1937, Vol. 42, No. 24, p. 738.)

895. Attempt at a Classification of Vectorial Diagrams and Typical Circuits of Alternating-Current Technique.—A. Blondel. (*Rev. Gén. de l'Élec.*, 4th Dec. 1937, Vol. 42, No. 23, pp. 707–716.)

TRANSMISSION

896. Amplification and Self-Excitation of Decimetre Waves in the Normal Grid-Controlled Circuits. — H. Mailandt. (*Hochf:tech. u. Elek:akus.*, Nov. 1937, Vol. 50, No. 5, pp. 158–166.)

This investigation is concerned with the results attainable with "acorn" valves and the causes of the limitation of their utility in the decimetre wave-range. Methods of measurement in this range are referred to in § II; they include impedance measurements (§ IIa) with a Lecher-wire system, voltage measurements (§ IIb; absolute voltmeter Fig. 1, relative voltmeter Fig. 2), and amplification measurement (§ IIc, Fig. 3). Self-excitation of decimetre waves is discussed in § III;

Fig. 4 shows an emitter with an acorn valve in a normal circuit, which gave wavelengths down to 40 cm. For continuous wavelength variation, continuous variation of the inductance is required (emitter Fig. 5). § IIIb describes measurements with these emitters (h.f. voltage-measurement circuit Fig. 6). The results (§ IIIc) are shown in Fig. 7 (oscillating-circuit and anode impedances), Fig. 8 (efficiency). Fig. 9 (current output and voltage efficiency). § IV describes the amplification of decimetre waves (amplifier circuit Fig. 10; neutralised push-pull amplifier Fig. 11, with compensation of the grid/anode impedance). The results of measurements with these amplifiers are shown in Figs. 12–15 for five-electrode valves; Fig. 12 gives the attenuation impedance of the circuits, Fig. 13 the grid input impedance (which is due to the electron transit time), Fig. 14 the degree of amplification of simple and push-pull amplifiers, Fig. 15 a comparison of steepness and amplification. For the push-pull amplifier with three-electrode valves (equivalent circuit Fig. 16), Fig. 17 shows the effective impedances, and Fig. 18 the comparison of steepness and amplification. These push-pull amplifiers amplify below 60 cm, give double amplification at 100 cm and eight-fold at 300 cm. They are much more efficient than the simple amplifiers. The amplification may be increased by retroaction (§ V, comparison between emitters and amplifiers), but the relations are rather complicated.

897. A Few Considerations for the Conductor-Core-Coil, *also* Frequency Characteristics of Conductor-Core-Coil Oscillator, *and* On the Ultra-High-Frequency Receiver using Conductor-Core Coil.—S. Otaka [Ohtaka]: Otaka & Mano: Otaka & Hasegawa. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 484–485: pp. 485–486: pp. 486–487.) *See* also 2179 of 1937, and 81 of January.

898. A New Electron Oscillator ["Osaka Tube" with Magnetic Field].—Okabe, Hisida, & Owaki. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 461–467.) *See* 480 & 925 of 1937.

899. The Three-Split-Anode Magnetron and Three-Phase Oscillations [Analysis of Equivalent Circuit of Three Tetrodes].—Y. & T. Ito & S. Katsurai. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 467–477.) *See* also 459 of February.

900. Obliquely Split Magnetron [Summarised Experimental Results with Models with Different Degrees of Twist].—K. Morita. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 477–478.)

901. Recent Experiments on the Generation of Extremely Short Wavelengths with Magnetic-Field Valves (6 mm–5 cm).—H. Awender. (*Funktech. Monatshefte*, Nov. 1937, No. 11, pp. 347–349.) Based on papers by Rice (4006 of 1936) and Cleeton & Williams (1934 Abstracts, pp. 33 & 265, and 927 of 1937).

902. The Magnetron and the Generation of Ultra-Short Waves.—G.W.O.H. (*Wireless Engineer*, Jan. 1938, Vol. 15, No. 172, pp. 1–3.) Editorial on the work of Groos, Rice, and Helbig (460 of February, 4006 of 1936, and 131 of January). The possibility, not mentioned by Helbig, of completing the symmetry of his magnetron by a second spiral cathode at the other end of the cylinder, is pointed out: *cf.* Uda & others, 520 of February.

903. Generation of Micro-Waves by Spark Discharge [and the Failure of the Lecher-Wire Method of Wavelength Measurement: Two Better Methods (Interference, and Variation of Receiving Aerial Length): Two Doublet/Gap Combinations in Parallel give Max. Output 3.5 Times that of One, when 6 cm Apart—nearly a Half-Wavelength].—K. Awaya & T. Kurobe. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 482–483.)

904. Ultra-High-Frequency Design Considerations [Practical Hints on Components and Connections for Increased Efficiency: Importance of "Volume" Consideration (Mica Blocking Condensers at least as good as Air, etc.): Experiments show Ordinary Soldering Lug reduces Efficiency at ¾ Metres: etc.].—A. Binneweg, Jr. (*Communications*, Dec. 1937, Vol. 17, No. 12, p. 28.)

905. An Ultra-High-Frequency Oscillator [with "Lumped" Concentric-Element Tank Circuit (Q about 2500 at 100 Mc/s): Over-All Height 7 Inches].—A. Peterson. (*Communications*, Dec. 1937, Vol. 17, No. 12, pp. 26–27.)

906. Special Circuits with High "Supertension" [High Q Values] for Ultra-Short Waves: Their Use in the Construction of Stabilised Transmitters [and in Reception].—J. Loeb: Kolster. (*L'Onde Élec.*, Dec. 1937, Vol. 16, No. 192, pp. 645–654: Discussion pp. 655–665.)

Calculations and experiments on circuits using the Kolster "top hats" (1934 Abstracts, p. 378): comparison with "transmission-line" circuits: as good frequency stabilisation as that given by complicated master-oscillator arrangements, with advantages of cheapness and quickly changed wavelength: hope of commercial high-power transmitters on waves 15–20 m. In the Discussion, Podliasky deals at length with the great discrepancy between Loeb's calculated and measured values of Q, giving his reasons for considering that the high calculated values are the correct ones. In passing, he mentions the possibility ("certain to be exploited one day") of utilising supra-conductivity. Gantet gives Q values carefully measured both for "classic" and "special" (not "top hat") circuits on ultra-short waves: the maximum was 900 ("special") but one carefully constructed "classic" circuit gave as much as 500.

907. On the Optimum Length for Transmission Lines used as Circuit Elements [tuned by Low-Loss Capacitors: l/λ Ratio giving Max. Sending-End Impedance is 0.185 for Shorted and 0.472 for Open-Circuited Line, giving Impedances 14% and 3% Higher than Lines without Tuning Condensers: Short, Short-Circuited Line always Preferable to Half-Wave Line].—B. Salzberg. (*Proc. Inst. Rad. Eng.*, Dec. 1937, Vol. 25, No. 12, pp. 1561–1564.) Analysis strictly true only for completely closed coaxial line.

908. "Transmission Line" Modulation Method for Ultra-Short-Wave Transmitters.—Parker. (*See* 1098.)

909. The Multiple Modulation of Ultra-Short-Wave Transmissions.—von Ardenne. (*See* 1067.)

910. One Method of Modulation [to avoid Non-Linear Distortion of Ultra-Short-Wave Transmitters: Negative Feedback by taking Part of Modulated Radiated Output, Rectifying, and Feeding (through Suitable Network) back to Input Side of First Modulating Stage].—N. Tanaka. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 426–427.)

911. Modulation Methods in the Decimetre-Wave Region [Short Survey].—E. C. Metschl. (*Funktech. Monatshefte*, Nov. 1937, No. 11, pp. 335–337.)

912. Frequency Modulation of Ultra-Short Waves.—G. Froboess: Armstrong. (*Funktech. Monatshefte*, Nov. 1937, No. 11, pp. 344–346.) Based partly on a *Radio News* article on Armstrong's work (for which *see* also 2550 of 1936).

913. One Method of Phase Modulation and Frequency Modulation [using a Fundamental Circuit in which Outputs of Variable-Frequency and Fixed-Frequency Oscillators are Mixed and then Detected, Detector Output being used to control Frequency of Variable-Frequency Oscillator].—T. Kayano & K. Nakamura. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 424–426.)

914. On the Accelerating-Grid Series Modulation [Modulating Triode connected to Accelerating or Screen Grid Circuit of Pentode or Tetrode: Comparison with Suppressor-Grid Modulation].—H. Nukiyama & K. Yamauti. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 347–348.)

915. Modulation by Interruption and by Inversion, and Modulation in Non-Linear Networks.—M. Parmentier. (*Ann. des Postes, T. et T.*, Dec. 1937, Vol. 26, No. 12, pp. 1029–1047.) Continuation of the work referred to in 465 of February.

916. Limiting Amplifiers [for Automatic Volume-Range Compression for Broadcasting Transmitters: Description of Several Commercial Types].—J. P. Taylor. (*Communications*, Dec. 1937, Vol. 17, No. 12, pp. 7–10 and 39, 40.) "Why the practical application to broadcasting was so long delayed is something of a mystery." Now, "in a period of a few months, more than half the stations in the country have placed orders for these units."

917. Over-Modulation Control and Volume Compression with Varable-Mu Speech Amplifier, *and* Negative-Peak Control with 6L7 Speech Amplifier and All-A.C. Operation.—W. B. Plummer: L. C. Waller. (*QST*, Oct. 1937, Vol. 21, No. 10, pp. 31–33: pp. 33–35.)

918. Comparison of Parallel and Series Coupling Circuits for Transmitters [under Varying Conditions of Loading and Frequency].—(*Marconi Review*, Jan./March 1938, No. 68, pp. 31–36: to be contd.)

919. H.F. Power Amplifiers: Calculation of "B" and "C" Types.—Kósa. (*See* 870.)

920. A Five-Kilowatt, Air-Cooled Broadcast Transmitter [using 891-R and 892-R Valves].—J. P. Taylor. (*Communications*, Oct. 1937, Vol. 17, No. 10, pp. 7–9 and 52, 53.)

921. Criticism of "Resistance-Tuned Oscillators" [Resistance Variation stated to be applicable to Generation only, not to Reception: affects Sharpness of Tuning, not the Tuning itself].—E. Bellini: Gordon & Makinson: Cabot. (*Wireless Engineer*, Nov. 1937, Vol. 14, No. 170, pp. 607–608.) *See* 4056 of 1937.

RECEPTION

922. Effects of Tuned Circuits upon a Frequency-Modulated Signal [Carrier tuned to Steep Side of Resonance Curve—Conversion into Amplitude Modulation possible: Carrier tuned to Peak of Curve—Occurrence and Elimination of Non-Linear Distortion: Interference between Two Frequency-Modulated Signals—No Helpful "Demodulation Effect"—Channel Spacing must equal Total Band Width at least].—H. Roder. (*Proc. Inst. Rad. Eng.*, Dec. 1937, Vol. 25, No. 12, pp. 1617–1647.) For a previous paper *see* 2953 of 1937. *Cf.* also Hase, 524 of 1936.

923. On the Ultra-High-Frequency Receiver using Conductor-Core-Coil.—Ohtaka & Hasegawa. (*See* 897.)

924. The Reception of Decimetre Waves.—H. U. Theile. (*Hochf:tech. u. Elek:akus.*, Nov. 1937, Vol. 50, No. 5, pp. 149–157.)

The purpose of this work was the investigation of the connections between oscillating regions, elimination of attenuation, and rectification in the retarding-field valve, and the development of a sensitive receiver for wavelengths down to 10 cm. The wavelengths used were 66, 18.2, 13.4, and 12.2 cm. The emitters used to produce these oscillations are described (§ I 1) with diagrams of the oscillating regions of some of the valves used (Figs. 1, 2). Fig. 3 shows the arrangement of emitter and receiver, which were five metres apart. Reception on 66 cm (§ II 1) took place with the circuit shown in Fig. 4; the oscillation regions of the receiving valve are shown in Fig. 5, the reception spectrum in Fig. 6, the retarding-field valve characteristics in Fig. 7. It is found that reception is possible with attenuation eliminated by means of an oscillation in the receiver of the same wavelength as that received, with weak positive anode voltages. Sensitivity is controlled by emission current, grid and anode voltages. Reception on 13.4 and 18.2 cm (§ II 2) was investigated with a valve whose oscillating regions as a function of filament current are shown in Fig. 8, reception spectrum in Fig. 9. Reception was found to occur with low filament currents. The attenuation elimination by an oscillation in the receiver was found to occur at these wavelengths also. The valve characteristics without (Fig. 11a) and with (Fig. 11b) tuned leads are shown. The rectification was found to depend on voltage and to be due to the curvature of the characteristics. It decreased as the filament current increased, owing to the disturbing effect of the self-oscillation of the receiver. The attenuation could also be eliminated by an oscillation corresponding to a multiple of the emitter wavelength (§ II 2e, Fig. 12). Reception results on 12.2 cm (§ II 3) were similar to those on 13.4 cm.

An investigation of the use of super-regeneration (§ III) showed that the sensitivity could be greatly increased thereby. The optimum wavelength of the auxiliary oscillation lay between 35 and 65 m (Fig. 19). Reception spectra under various conditions are shown in Figs. 16–18. Experiments on 12.2 cm (§ IV) gave good reception of modulated waves up to a distance of 15 km; it appeared that communication might be possible over distances up to 100 km, provided that sender and receiver were visible from one another.

925. SUPERHETERODYNE RECEIVERS FOR ULTRA-SHORT WAVES [for Sight and Sound Programmes: developed in E.I.A.R. Laboratories, Turin].—S. Bertolotti. (*Alta Frequenza*, Nov. 1937, Vol. 6, No. 11, pp. 764–772.)

926. MEASUREMENT OF RECEIVER SET NOISE AND GAIN IN 20 TO 55 MC/S FREQUENCIES [by Standard Signal Generator and by Thermal Agitation Noise Methods: General Agreement: Effects of Radiation Resistance, Feedback, and Shielding].—H. Seki. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 439–443.)

927. SUPER-REGENERATIVE ULTRA-SHORT-WAVE RECEIVERS AND NOISELESS RECEPTION [Special Conditions giving Noiseless State during Absence of Signal, Faint Noise on Arrival of Signal].—S. Uda. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 483–484.) *See* also 470 & 471 of February.

928. REDUCTION OF SELF-RADIATION [and Noise] IN SUPER-REGENERATIVE DETECTION [by Use of Pentode of Small Internal Capacity, oscillating by Retroaction from Plate to First Grid, with Pre-Selector connected to Third Grid: Noise-Reducing Action by Coupling between Third Grid and Oscillating Circuit: etc.].—T. Hayasi. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, p. 480.) If this coupling is large, the noise is actually less when there are no incoming waves.

929. SUPER-REGENERATION WITH REFERENCE TO BROADCAST RECEIVERS [Theoretical Treatment of Amplification, Multiple Resonance, Selectivity, Innate AVC Action, Quality of Reproduction and Characteristic Hiss, Stability: Experimental Confirmation of Theoretical Results: Practical Conclusions].—D. Maurice. (*Wireless Engineer*, Jan. 1938, Vol. 15, No. 172, pp. 4–15.)

930. NOVEL METHOD OF COUPLING [and the Difficulties of "Double" Superheterodyne Receivers].—R. T. Kinross: Beard. (*Wireless Engineer*, Dec. 1937, Vol. 14, No. 171, p. 657.) Criticism of the work dealt with in 477 of February.

931. FREQUENCY-SELECTIVE FEEDBACK APPLIED TO THE DESIGN OF BAND-PASS AMPLIFIERS [Great Improvement of Response Curve of Overcoupled-Transformer I.F. Band-Pass Amplifiers by Negative Feedback: "Almost Ideal" Variable Band Width: Increased Over-All Gain by use of High-Q Coils].—J. D. Brailsford. (*Marconi Review*, Jan./March 1938, No. 68, pp. 10–30.)

932. PAPERS ON PARAMETRIC, DIFFERENTIAL, DUPLEX, AND NEGATIVE FEEDBACK.—(*See* 884/891.)

933. HIGH-FREQUENCY RESISTANCE OF COILS WITH COMPRESSED IRON-POWDER CORES.—J. Hak. (*Rev. Gén. de l'Élec.*, 8th Jan. 1938, Vol. 43, No. 2, pp. 35–44.)

Author's summary:—To calculate the h.f. resistance of a powdered-iron-cored inductance coil, the expressions valid for the apparent resistance of an air-cored coil can be used in part. It is necessary to introduce into these expressions the mean value of the intensity of the magnetic field of the winding, and to complete the calculation by the determination of the apparent resistances corresponding to the losses in the core and the dielectric losses. The expression giving the total apparent resistance can be used directly to determine the "quality factor." By simplifying slightly the equation expressing the reciprocal value of this factor, some relations can be deduced between the losses and apparent resistances, with whose aid the optimum permeability of the core and the optimum frequency of the coil can be found. The most advantageous ratio between copper losses and core losses is 5/3. The optimum frequency for the coil is given by equation 27 or 28: at this frequency the losses in a continuous régime should be equal to the supplementary losses in the copper and in the core (equation 30). The expressions giving the apparent resistances allow the factor of quality of a coil, as a function of frequency, to be calculated with ease; they also serve for the pre-determination of certain values—optimum effective permeability, number of wires in a stranded conductor—if it is required to construct a coil whose maximum factor of quality must be reached at a given frequency.

934. TELEDYNAMIC CONTROL BY SELECTIVE IONISATION AND THE APPLICATION TO RADIO RECEIVERS.—Seeley, Deal, & Kimball. (*Communications*, Nov. 1937, Vol. 17, No. 11, p. 40: summary only, from I.R.E. Rochester Meeting.) Accompanied by the remark that it "appears to be one of the outstanding developments in remote control for home radio receivers, and we dare say that it will be incorporated in commercial units early next year."

935. AUTOMATIC TUNING CONTROL BY MEANS OF A QUARTZ CRYSTAL [to keep Intermediate Frequency from Varying more than a Few Cycles per Hour: Quartz-Controlled "Frequency Selector" has Output varying with Frequency: This Output is used to govern Variable-Mu Frequency-Control Valve].—K. Mizokami & T. Fujita. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 443–444.)

936. ELECTRICAL AUTOMATIC "SHARP TUNING" [Automatic Tuning Correction: Survey of Methods, and Necessary Precautions].—H. Oltze. (*Funktech. Monatshefte*, Dec. 1937, No. 12, pp. 363–371.)

937. A MUTING SYSTEM FOR RECEIVERS [for Silent Tuning (Interstation Noise Suppression) of AVC Receivers: Discussion of Previous Systems and Their Disadvantages: a New System using One Type 6L7 Pentode to give Muting and A.F. Amplification].—C. P. Healy & A. L. Green. (*AWA Tech. Review*, Oct. 1937, Vol. 3, No. 2, pp. 62–82.)

"In a modification of the system it is possible also to apply AVC bias to the 6L7 valve and thus to correct for a rising slope in the AVC characteristic of the carrier-frequency stages, but the addition of the third feature increases the liability to distortion."

938. NEW CIRCUITS FOR "CRACK KILLING" [from British and American Patents of Silent Tuning Devices].—O. Köhler. (*Funktech. Monatshefte*, Nov. 1937, No. 11, pp. 351–356.) Including devices with glow-discharge and electron-ray tubes: the use of grid current and of d.c. retroaction (Fig. 10): and the blocking of the detection-*cum*-AVC diode by negative bias (Fig. 11).

939. TUNING DRIFT [and Its Reduction by adapting the Franklin Master-Oscillator Circuit to the Frequency-Changing Circuit of Superheterodynes].—E. L. Gardiner. (*Wireless World*, 6th Jan. 1938, Vol. 42, pp. 6–8.)

940. NOTE ON LARGE-SIGNAL DIODE DETECTION [and Its Distortion: Theory and Experiment show Close Connection between Criterion for Avoidance of "Non-Tracking" and Condition for Max. Detected Signal: Discussion and Suggested Explanation of Experimental Deviations for Very Low and Very High Modulation Percentages].—S. Bennon. (*Proc. Inst. Rad. Eng.*, Dec. 1937, Vol. 25, No. 12, pp. 1565–1573.) By "non-tracking" is meant the failure of the diode to become conducting for each peak.

941. FREQUENCY CHANGERS IN ALL-WAVE RECEIVERS.—Strutt: Herold. (*See* 993.)

942. *Wireless World* FOUR-BAND SUPER-SIX.—W. T. Cocking. (*Wireless World*, 9th & 16th Dec. 1937, Vol. 41, pp. 576–579 & 607–609.)

943. REGULATED PLATE SUPPLIES [Comments on "Battery Performance from the R.A.C. Power Supply"].—Grammer. (*QST*, Nov. 1937, Vol. 21, No. 11, pp. 46–47.) *See* 3654 of 1937.

944. MODERN TRENDS IN CABINETRY.—L. Winner. (*Communications*, Oct. 1937, Vol. 17, No. 10, pp. 20–21: photographs only.)

945. MOTOROLA RADIO PLANT LIGHTING INSTALLATION [the "Light-Hood" Indirect System].—M. R. Matteson. (*Communications*, Nov. 1937, Vol. 17, No. 11, pp. 14–15.)

946. INTERFERENCE SUPPRESSION: ALPHABETICAL TABLE OF CONNECTIONS AND VALUES.—(*Radio, B., F. für Alle*, Nov. 1937, No. 189, Supp. pp. 209–220.) Part 14 of the supplement "Schule des Funktechnikers I".

947. ELECTRICAL CONDITION OF INSULATORS [Disturbances in High-Power Amplifiers due to Presence of Insulating Materials unintentionally Charged (by Accidental Friction, etc.): French Experimental Investigation].—(*Electrician*, 17th Dec. 1937, Vol. 119, p. 726: paragraph only.) "Rubber is a particularly serious offender, acquiring at times a tension of 1000 volts and causing serious disturbances in the operation of amplifiers."

948. MINIMUM NOISE LEVELS OBTAINED ON SHORT-WAVE RADIO RECEIVING SYSTEMS [Noise Level in Absence of Atmospherics and Man-Made Interference is Several Decibels above Thermal Agitation Noise: apparently due to Interstellar Radiations: Measurements on Diathermy Apparatus Interference].—K. G. Jansky. (*Proc. Inst. Rad. Eng.*, Dec. 1937, Vol. 25, No. 12, pp. 1517–1530.)

949. PROBLEMS IN WIRELESS COMMUNICATION [Telegraphic & Telephonic Reception Difficulties].—W. F. Rawlinson. (*Journ. I.E.E.*, Jan. 1938, Vol. 82, No. 493, pp. 84–87.) Including some data on lightning.

950. DIVERSITY RECEPTION [for Fading Elimination].—Griffiths. (*See* 965.)

951. DETERMINATION OF FREQUENCY BAND FOR COMMERCIAL SHORT-WAVE RADIOTELEGRAPH RECEIVER [Relationships between Reception Speed and Frequency Band, Modulated Frequency and Frequency Band, Total Receiver Gain and Band Width, etc.].—M. Morita & H. Seki. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 431–438.)

952. EXPERIMENTS ON EXTRACTING THE CARRIER FROM MODULATED WAVES [after Reception].—Kimura & Goto. (*See* 1238.)

953. DIFFERENCE BETWEEN THE RST AND OLD SYSTEMS OF SIGNAL-STRENGTH REPORTING: EDITORIAL. (*QST*, Oct. 1937, Vol. 21, No. 10, p. 7.) *See* 506 of February.

AERIALS AND AERIAL SYSTEMS

954. COMPARISON BETWEEN THE PARABOLIC REFLECTOR OF WIRE NETTING, USED AS AN ELECTRIC WAVE RADIATOR, AND THE USUAL BEAM ANTENNA: A PREPARATORY EXPERIMENT.—K. Morita & K. Hayasi. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 478–479.)

The wire mesh chosen allowed a little finger to pass: larger mesh gave too great a transparency, smaller mesh gave a wind pressure almost as high as that against a copper-plate reflector. In previous tests the netting had been found to give only about 9% less reflection than the copper-plate reflector, and the present experiments showed that the measured gain with the netting reflector was much nearer the calculated gain than was the case with the beam system, whose measured gain was actually lower than that of the netting, even after much more difficult adjustment. *See* also 955, below.

955. BEAM ANTENNA AND PARABOLIC REFLECTOR.—K. Morita & K. Hayasi. (*Electrot. Journ.*, Tokyo, Jan. 1938, Vol. 2, No. 1, pp. 16–20.)

Among other differences between this paper and the shorter work dealt with above (954), the measured gain of the beam aerial is here given as 13.3 db instead of 10.1 db, and is therefore just above that of the copper-plate reflector and well above that of the netting reflector. The longer paper also includes results with a cylindrical parabolic reflector: from preliminary tests the authors consider this likely to be the best of all for decimetre waves.

956. ULTRA-SHORT-WAVE COAXIAL VERTICAL HALF-WAVE RADIATOR.—Bell Tel. Laboratories. (*Communications*, Dec. 1937, Vol. 17, No. 12, p. 29: photograph and description only.)

957. AERIALS FOR ULTRA-SHORT WAVES: A REVIEW OF AERIALS SUITABLE FOR TELEVISION AND 2.5–10 METRE RECEPTION.—K. Jowers. (*Television*, Nov. 1937, Vol. 10, No. 117, pp. 681–683 and 703.)

958. EXPERIMENTS WITH UNDERGROUND ULTRA-HIGH-FREQUENCY ANTENNA FOR AIRPLANE LANDING BEAM.—Diamond & Dunmore. (*Proc. Inst. Rad. Eng.*, Dec. 1937, Vol. 25, No. 12, pp. 1542–1560.) Already dealt with in 3708 of 1937.

959. ON THE RADIATION FIELD OF A PERFECTLY CONDUCTING BASE-INSULATED CYLINDRICAL ANTENNA OVER A PERFECTLY CONDUCTING PLANE EARTH, AND THE CALCULATION OF RADIATION RESISTANCE AND REACTANCE [Theoretical Solution depending on Integral Equation: First Approximation: Radiation Impedance of Receiving Aerial not the Same as for Transmitting Aerial: Tables: Summary of Formulae].—L. V. King. (*Phil. Trans. Roy. Soc. Lond.*, Series A, 2nd Nov. 1937, Vol. 236, No. 768, pp. 381–422.)

960. ON THE CALCULATION OF THE FIELD PRODUCED BY AN AERIAL [and the Difference between the Expressions for Electromagnetic Field obtained by the Dipole Integration Method and the Retarded Potentials Method: Particular Adaptability for Special Purposes].—D. Graffi. (*Alta Frequenza*, Nov. 1937, Vol. 6, No. 11, pp. 730–738.) A long communication prompted by Fubini-Ghiron's letter (2962 of 1937). For the work of Grosskopf, also referred to, *see* 3304 of 1937.

961. ON THE CALCULATION OF THE RADIATION OF A STRAIGHT AERIAL AT CLOSE DISTANCE.—P. Riazin [Ryazin]. (*Tech. Phys. of USSR*, No. 10, Vol. 4, 1937, pp. 866–884: in French.) The Russian version was dealt with in 4080 of 1937. *See* also 962, below.

962. ON THE ELECTROMAGNETIC FIELD OF A VERTICAL HALF-WAVE AERIAL ELEVATED ABOVE A PLANE EARTH.—P. Ryazin. (*Journ. of Tech. Phys.* [in Russian], No. 18/19, Vol. 7, 1937, pp. 1871–1879.)

Further development of the work dealt with in 961, above. Starting from formula (1), in which the field of a Hertz vector for the case of an elementary (infinitely small) dipole is expressed through a Bessel function of zero order, formulae (4a), (4c) and (4d) are derived determining the field due to a finite dipole in a uniform non-conducting space. These formulae are similar to those arrived at by a different method in the previous work referred to above. The method proposed in the present paper is then used for determining the field due to the vertical component of the electric vector of a dipole raised over a plane earth of finite conductivity. It is shown that for the same constants of the surrounding medium, this field is equivalent to that of the Hertz vector of two elementary dipoles located at the ends of the dipole.

963. THEORY OF LOOP ANTENNAS WITH LEAKAGE BETWEEN TURNS [in connection with Use in Field-Strength Measurement: Analysis Methods for Measurement of Loop Gain (Q-Value): Effect of Leakage upon Q: etc.].—P. B. Taylor. (*Proc. Inst. Rad. Eng.*, Dec. 1937, Vol. 25, No. 12, pp. 1574–1594.)

964. REMOTE RECEIVING ANTENNAS [used by American Airlines: with about Half a Mile of Coaxial Cable to Receiver at Airport].—V. J. Andrew. (*Communications*, Dec. 1937, Vol. 17, No. 12, pp. 23–24.)

965. DIVERSITY RECEPTION [for Fading Elimination: B.B.C. & Marconi Company's Tests 1927–1930, and B.B.C. Tatsfield Tests still proceeding].—H. V. Griffiths. (*Wireless World*, 13th Jan. 1938, Vol. 42, pp. 31–34.)

966. RADIO TOWER LIGHTING AND MARKING.—A. R. Nilson. (*Communications*, Nov. 1937, Vol. 17, No. 11, pp. 13–15.)

967. HOW LONG IS A QUARTER WAVELENGTH? SOME PRACTICAL FIGURES FOR THE VELOCITY OF WAVE PROPAGATION IN ANTENNAS AND TRANSMISSION LINES.—J. N. A. Hawkins. (*QST*, Nov. 1937, Vol. 21, No. 11, pp. 32 and 96, 98.)

968. MATCH AND MIS-MATCH: SOME PERTINENT [Practical] POINTERS ON TRANSMITTER LOADING AND ANTENNA FEED SYSTEMS IN GENERAL.—S. W. Seeley. (*QST*, Nov. 1937, Vol. 21, No. 11, pp. 24–25 and 76, 78, 80, 82, 84.)

969. CONCENTRATED DIRECTIONAL ANTENNAS FOR TRANSMISSION AND RECEPTION: ROTATABLE LOOPS AND ANTENNA-REFLECTOR SYSTEMS OF REDUCED DIMENSIONS.—J. L. Reinartz: B. T. Simpson. (*QST*, Oct. 1937, Vol. 21, No. 10, pp. 27–30.)

970. MAKING THE MOST OF DIRECTIVE ANTENNAS: PRACTICAL POINTERS ON OPERATING A NUMBER OF ANTENNAS IN LIMITED SPACE.—D. C. Wallace. (*QST*, Nov. 1937, Vol. 21, No. 11, pp. 35–37 and 106, 108.)

971. STUDY OF THE FLEXIBILITY OF [Overhead] LINES, AND OF THEIR REPRESENTATION BY EQUIVALENT ELECTRICAL CIRCUITS.—R. Demogue. (*Ann. des Postes, T. et T.*, Dec. 1937, Vol. 26, No. 12, pp. 1068–1102.)

VALVES AND THERMIONICS

972. THE TEMPERATURE OF ELECTRONS IN A MAGNETIC FIELD.—A. Slutzkin. (*Journ. of Tech. Phys.* [in Russian], No. 18/19, Vol. 7, 1937, pp. 1862–1870.) A German version of this paper was dealt with in 133 of January.

973. ELECTROSTATIC FIELD AND CAPACITY BETWEEN TWO SEGMENTS OF ANODE OF SPLIT-ANODE MAGNETRONS.—Uda, Utida, & Sekimoto. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, p. 483.)

974. PAPERS ON MAGNETRONS OF SPECIAL TYPE.—Ito & Katsurai: Morita. (*See* 899 & 900.)

975. A THERMAL METHOD FOR MEASURING EFFICIENCIES AT ULTRA-HIGH FREQUENCIES APPLIED TO THE MAGNETRON OSCILLATOR.—Kohler. (*See* 1105.)

976. A NEW ELECTRON OSCILLATOR ["Osaka Tube"].—Okabe & others. (*See* 898.)

977. A NEW HIGH-POWER TRIODE [R.C.A.833: Max. Input 1250 Watts up to 30 Mc/s: Reduced Input up to 100 Mc/s: Amplification Factor 35]. (*QST*, Nov. 1937, Vol. 21, No. 11, p. 90.)

978. MODERN DESIGN OF THE 849 [Types 849 A and H (Latter for Frequencies up to 30 Mc/s): Abandonment of Fallacious Principle of Small Plate/Grid Gap, with Its Practical Defects: Filament/Grid Gap kept Small].—R. Lord. (*Communications*, Dec. 1937, Vol. 17, No. 12, pp. 15 and 43.)

979. METAL-ANODE VALVES WITH COPPER RADIATING FINS FOR AIR COOLING: TYPES 891-R & 892-R.—Taylor. (*See* 920.)

980. PAPERS ON ELECTRON MULTIPLIERS.—Seki & Kiyono: Astaf'ev. (*See* 1073 & 1074.)

981. THE PASSAGE OF SLOW ELECTRONS THROUGH METAL FOILS [and the Connection with Secondary Emission].—Katz. (*See* 1075.)

982. SECONDARY ELECTRON EMISSION: PART I—SECONDARY ELECTRON EMISSION OF METALS [Electropositive Elements have Smaller Secondary Emission than Metals with High Work Function: Interpretation of Results].—Bruining & de Boer. (*Physica*, Jan. 1938, Vol. 5, No. 1, pp. 17–30: in English.) A preliminary communciation was dealt with in 2971 of 1937.

983. [Secondary] FIELD EMISSION FROM STRATIFIED CATHODES ON IRRADIATION BY ELECTRONS [Investigations on Malter's "Anomalous" ("Field") Emission from Cathode consisting of Al Under Layer, Al-Oxide Intermediate Layer, and Cs-Oxide Surface Layer].—H. Mahl: Malter. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 18, 1937, pp. 559–563.)

For a preliminary communication *see* 3703 of 1937. Malter's idea of a positive surface charge is confirmed. For an Al-oxide layer of 2000 Å thickness it ranges from 10–40 v. The phenomenon of secondary field emission is not limited to this particular cathode, but occurs whenever the surface of a metallic cathode covered with a thin insulating layer is sufficiently positively charged, by secondary emission, on bombardment by a beam of electrons. *Cf.* also 149 of January.

984. ANOMALOUS EMISSION FROM NICKEL DUE TO A COATING.—Zernov. (*See* 1078.)

985. THERMIONIC EMISSION CHARACTERTISTICS OF THORIATED MOLYBDENUM [Richardson Constants for Complete and Incomplete Monatomic Thorium Film].—P. Grauwin. (*Comptes Rendus*, 27th Dec. 1937, Vol. 205, No. 26, pp. 1375–1377.)

986. THE TEMPERATURE VARIATION OF THE WORK FUNCTION OF CLEAN AND OF THORIATED TUNGSTEN [No Difference between Temperature Coefficients: Effect of Internal Reflection of Electrons].—A. L. Reimann. (*Proc. Roy Soc.*, Series A, 19th Nov. 1937, Vol. 163, No. 913, pp. S 1—S 2: abstract only.)

987. ACCOMMODATION COEFFICIENTS OF THE NOBLE GASES AND THE SPECIFIC HEAT OF TUNGSTEN [Semi-Classical Theory: Heats of Adsorption of Helium and Neon on Tungsten: Explanation for Excess Specific Heat of Tungsten above Classical Value].—W. C. Michels. (*Phys. Review*, 15th Nov. 1937, Series 2, Vol. 52, No. 10, pp. 1067–1073.)

988. THE INFLUENCE OF THE CRYSTAL LATTICE STRUCTURE ON THE EMISSION FROM HOT CATHODES.—B. Mrowka. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 18, 1937, pp. 572–574: *Physik. Zeitschr.*, 1st Dec. 1937, Vol. 38, No. 23, pp. 998–1000.) A fuller treatment is appearing in *Ann. der Physik*. For a discussion of the thermodynamical aspect by Schottky see *ibid.*, No. 1, Vol. 19, 1938, pp. 19–20, and 1st Dec. 1937, No. 23, pp. 1024–1025.

989. VACUUM DETERMINATION IN INDIRECTLY HEATED RECEIVING VALVES, BY ION-CURRENT MEASUREMENT.—G. Herrmann & I. Runge. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 19, 1938, pp. 12–19.)

"While there is an extensive literature on the ionisation manometer with tungsten cathode, data on the corresponding phenomena in indirectly heated valves hardly exist. Since, however, it is of interest to the valve manufacturer to be able to determine the actual pressure in a sealed-off valve, it seems worth while to us to investigate the variation, with pressure, of the so-called 'vacuum factor' (ratio of ion current to electron current) in indirectly heated valves. This relation will also be treated theoretically, in order that the influence of the valve design may be taken into account in the case of valves not actually tested. For this purpose [in addition to 3 commercial and one experimental—cylindrical electrode—indirectly heated valves] some tungsten-cathode valves were included, since even for this type no satisfactory previous comparison between observation and calculation was found to exist."

The tests were carried out at pressure from 10^{-2} to 10^{-5} Tor (1 Tor = 1 mm Hg) and the proportionality of vacuum factor to pressure was confirmed. The proportionality factor for the indirectly heated valves was some ten times smaller than that for the tungsten-filament type, which was itself a full ten times smaller than the theoretical value given for a similar valve in Barkhausen's *Elektronenröhren*, Vol. 1. Sections 2–5 deal with the attempted calculation of the various vacuum factors by the use of the Engel-Steenbeck curve of differential ionisation. The proportionality factors thus obtained agreed well with the measured values in the case of the tungsten-cathode valves but were 3–4 times too large for the indirectly heated valves. This discrepancy is explained by consideration of the ion paths in the two types of valve; the explanation was confirmed by an experiment showing that in indirectly heated valves the vacuum factor for a given pressure increases with the absorbing surface of the grid, *i.e.* with decreasing pitch and increasing number and thickness of struts, etc.

990. ELECTRICAL LOSSES IN THE SOCKETS AND BASES OF VALVES [with Measurements of Capacities and Equivalent Resistances at 16.2 and 8.6 m].—(*Alta Frequenza*, Nov. 1937, Vol. 6, No. 11, p. 756: short summary of *Philips Setmakers' Bulletin* paper.)

991. EQUIVALENT NETWORKS FOR NEGATIVE-GRID TRIODES [including at Ultra-High Frequencies].—F. B. Llewellyn. (*Bell Lab. Record*, Oct. 1937, Vol. 16, No. 2, pp. 39–42.)

992. OSCILLATOR AND DETECTOR REGIONS OF THE TRIODE VACUUM TUBE.—Ohtaka & Hasegawa. (*See* 1233.)

993. FREQUENCY CHANGERS IN ALL-WAVE RECEIVERS [including the EH2 Hexode with Suppressor Grid].—Strutt: Herold. (*Wireless Engineer*, Nov. 1937, Vol. 14, No. 170, p. 606.) Reply to Herold (4106 of 1937). Reference is made to the EH2 (hexode frequency changer with suppressor grid) "in which the disadvantages of existing hexode constructions are much reduced."

994. ONE METHOD OF DECREASING NON-LINEAR DISTORTION [Push-Pull Circuit, with Its Valve-Matching Difficulties, replaced by One Triode containing (in Same Bulb) a Small Auxiliary Correcting Triode using Same Filament: 10 db Distortion Improvement].—I. Tanimura. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 342–343.)

995. NEW VALVES FOR TELEVISION AND RADIO CONSTRUCTORS.—(*Television*, Oct. 1937, Vol. 10, No. 116, pp. 626 and 628.)

996. NEW TUBES FOR CARRIER SYSTEMS.—J. O. McNally. (*Bell Lab. Record*, Sept. 1937, Vol. 16, No. 1, pp. 17–20.)

997. NOTE ON A TRANSMITTING PENTODE OF ONE KILOWATT EFFECTIVE POWER [Type P. 1000].—R. Warnecke & R. Deroche. (*Bull. de la S.F.R.*, Oct. 1937, Vol. 11, No. 4, pp. 113–122.)

998. THE USE OF A NAME [Plea for Complete Designation of a Valve by Inclusion of Maker's Name].—L. B. Turner. (*Wireless Engineer*, Dec. 1937, Vol. 14, No. 171, p. 657.)

999. "LES TUBES À VIDE ET LEURS APPLICATIONS: VOL. II—LES AMPLIFICATEURS" [Book Review].—H. Barkhausen. (*Rev. Gén. de l'Élec.*, 13th Nov. 1937, Vol. 42, No. 20, p. 610.) For a review of Vol. I *see* 144 of January.

1000. YET ANOTHER USE FOR THE MAGIC EYE [6E5 Electron-Ray Indicator as Balance Indicator for Resistance-Coupled Push-Pull or Phase-Inverting Audio Amplifier].—A. H. Taylor. (*QST*, Oct. 1937, Vol. 21, No. 10, pp. 42 and 116, 118.)

1001. VIBRATIONAL TUBE ANALYSIS [Vibration Platform and C-R Oscillograph Equipment].—A. B. Oxley. (*Communications*, Nov. 1937, Vol. 17, No. 11, p. 33: summary only, from I.R.E. Rochester Meeting.)

DIRECTIONAL WIRELESS

1002. EXPERIMENTS WITH UNDERGROUND ULTRA-HIGH-FREQUENCY ANTENNA FOR AIRPLANE LANDING BEAM.—Diamond & Dunmore. (*See* 958.)

1003. THE DEVELOPMENT OF A NEW TYPE OF RADIO BEACON [for Ships and Aircraft: Phase Meter as Bearing Indicator].—M. Okada. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 429–430.)

A modulated carrier is passed to an Adcock aerial by a goniometer with continuously driven rotor (R r.p.m.): a " phase-standard " carrier of the same wavelength but different note, further modulated by a frequency $2R/60$ (actually 15 c/s), is radiated from a vertical aerial. The bearing indicator, a specially designed phase meter, not described, gives a direct reading of the phase difference between these two sets of signals. " from the average value of current obtained by allowing a given current to flow during the period between the instant that the a.c. voltage from the vertical antenna passed zero voltage and the instant that the a.c. voltage from the Adcock antenna passed zero voltage." By choosing suitable values for the note frequencies and R, it is theoretically possible to carry on telephonic communication simultaneously. Successful tests are mentioned.

1004. DIRECTION-FINDING IN THE AIR [Limitations of " Homing " System, & Methods of Overcoming Them].—(*Wireless World*, 20th Jan. 1938, Vol. 42, pp. 53–55.)

1005. THE AUTOMATIC RADIO COMPASS [Type R.C. 5E, with 1-ft Loop driven at 300 r.p.m.]. —Le Matériel Téléphonique. (*Communications*, Oct. 1937, Vol. 17, No. 10, pp. 34–35.)

1006. CONSIDERATIONS IN THE PLACING OF DIRECTION-FINDING APPARATUS.—Mingins. (In paper dealt with in 833, above.)

1007. A FILTER FOR AIRWAY RANGE SYSTEMS [for Simultaneous Reception of Beacon and Telephony Signals].—Boghosian. (*Bell Lab. Record*, Nov. 1937, Vol. 16, No. 3, pp. 88–90.)

ACOUSTICS AND AUDIO-FREQUENCIES

1008. LOUDSPEAKER REPRODUCTION OF CONTINUOUS-SPECTRUM INPUT [Method of Response Measurement using Random Movement of Electrons (in Resistance or Valve), linearly amplified, as Testing Input: Comparison with Usual Methods: Advantages].—F. H. Brittain & E. Williams. (*Wireless Engineer*, Jan. 1938, Vol. 15, No. 172, pp. 16–20.)

1009. RESONANCE IN CRYSTAL BEAMS OF SODIUM-AMMONIUM SEIGNETTE [Rochelle] SALT.—Mandell. (*See* 1136.)

1010. DIPHONIC LOUDSPEAKER FOR MICROPHONIC SOUND SYSTEMS.—R. C. Miner. (*Bell Lab. Record*, Oct. 1937, Vol. 16, No. 2, pp. 53–55.)

1011. A TALK-BACK AND LOUDSPEAKER CONTROL SYSTEM.—P. S. Gates. (*Communications*, Nov. 1937, Vol. 17, No. 11, pp. 18–19.)

1012. ON THE EXPERIMENTAL DETERMINATION OF PARAMETERS OF COMPLEX SYSTEMS [with Application to Amplifiers, M.C. Microphones, etc.].—Kharkevich. (*See* 854.)

1013. CHOOSING THE CONNECTING LINK BETWEEN CRYSTAL GENERATOR [Microphone, Gramophone or Vibration Pickup, etc.] AND AMPLIFIER.—C. K Gravley. (*Communications*, Nov. 1937, Vol. 17, No. 11, p. 11.)

1014. CARBON POWDER AT LOW TEMPERATURES [in connection with Microphone Behaviour in North Manchukuo].—S. Takata. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 416–418.)

1015. LOW-COST MICROPHONE FOR VARIED APPLICATION [Type 633A].—R. N. Marshall. (*Bell Lab. Record*, Nov. 1937, Vol. 16, No. 3, pp. 80–84.)

1016. THE " MACHINE GUN " MICROPHONE [Highly Directional, for Outside Broadcasts].—(*Bell Lab. Record*, Oct. 1937, Vol. 16, No. 2, p. 52: photograph only.)

1017. DISC RECORDING: EQUIPMENT AND ITS QUALITY REQUIREMENTS: RECORD PROCESSING.—T. L. Dowey. (*Communications*, Oct. & Nov. 1937, Vol. 17, Nos. 10 & 11, pp. 17–19 and 58: pp. 24, 26, 28, 30 and 32.)

1018. INSTANTANEOUS-RECORDING NEEDLES.—R. H. Ranger. (*Communications*, Dec. 1937, Vol. 17, No. 12, pp. 16–17.)

1019. MAGNETIC SOUND RECORDING WITH "FILMS" AND " RING HEADS " [Film of Non-Magnetic Carrier with Ferromagnetic Powder Layer (Pfleumer) used with Ring-Shaped Recording and Erasing Heads both on Same Side of Film (Schüller): Quantitative Examinations of Various Components of Complete System, with Applications to Practical Design]—H. Lübeck. (*Akust. Zeitschr.*, Nov. 1937, Vol. 2, No. 6, pp. 273–295.) For Schüller's paper *see* 196 of 1936.

1020. A REVIEW OF IMPROVEMENTS IN CINEMA SOUND REPRODUCTION SINCE 1928.—T. Wadsworth. (*Journ. I.E.E.*, Jan. 1938, Vol. 82, No. 493, pp. 10–19.) Chairman's Address to Wireless Section.

1021. NEW PATHS IN ELECTRICAL MUSIC [Reasons for Small Sales of Trautonium, Neo-Bechstein Piano, etc: Need for Systematic Investigations on Building-Up Processes: etc.].—K. A. Wiedamann. (*Funktech. Monatshefte*, Dec. 1937, No. 12, p. 372.)

1022. EFFECTS OF NON-LINEAR DISTORTION AND INDUCTION NOISES UPON SPEECH ARTICULATION [and the Use of Compressor and Expandor], *and* THE NON-LINEAR DISTORTION OF COMPANDOR UTILISING THE MUTUAL CONDUCTANCE.—Yosida, Takahasi, & Kamiyosiwara: Degawa. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 378–379: pp. 380–381.)

1023. ONE METHOD OF DECREASING NON-LINEAR DISTORTION [replacing Push-pull Circuits]. —Tanimura. (*See* 994.)

1024. PLATE-RESISTANCE CONTROL IN VACUUM TUBES AS AUDIO GAIN CONTROL MEANS. —Barber. (*See* 880.)

1025. A 10-WATT SPEECH AMPLIFIER WITH VOLTAGE-REGULATED PLATE SUPPLY: HIGH-GAIN UNIT FOR USE WITH CRYSTAL OR CARBON MICROPHONES.—G. Grammer. (*QST*, Nov. 1937, Vol. 21, No. 11, pp. 15–17 and 116, 118.) Further development of the work dealt with in 3654 of 1937: *see* also 943, above.

1026. NULL METHODS FOR THE PRECISE MEASUREMENT OF CROSS-TALK.—Y. Kanaya. (*Nippon. Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 358–359.)

1027. HIGH-FREQUENCY TRANSMISSION CHARACTERISTICS OF COAXIAL CABLES [and Measurements of Cross-Talk between Two Similar Parallel Lengths].—Sadakiyo, Ogawa, & Yamanaka. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 377–378.)

1028. NON-LOADED CABLE CARRIER TELEPHONE SYSTEM INSTALLED BETWEEN ANTUNG AND MUKDEN [260 km].—Matsumae, Shinohara, & Tokiwa. (*Electrot. Journ.*, Tokyo, Nov. 1937, Vol. 1, No. 6, pp. 171–175.)

1029. THE HARMONIC PRODUCER.—C. H. Bidwell. (*Communications*, Dec. 1937, Vol. 17, No. 12, pp. 19–22 and 24, 41.) On the development due to Peterson, Manley, & Wrathall (3771 of 1937).

1030. A LOW-DISTORTION AUDIO-FREQUENCY OSCILLATOR [Theory of Negative-Resistance Oscillators: Conditions for Small Harmonic Content: Characteristics of Turner's "Kallirotron" are Ideal: an Oscillator based on This, with Automatic Amplitude Control: Frequency Drift not above 0.04 c/s at 1000 c/s].—H. J. Reich. (*Proc. Inst. Rad. Eng.*, Nov. 1937, Vol. 25, No. 11, pp. 1387–1398.) *Cf.* 1717 of 1937 and reference "4" at foot of p. 1389 of present paper.

1031. DESIGN AND INVESTIGATION OF A SOUND-DAMPED ROOM [for Acoustic Measurements instead of in Open Air, at Siemens & Halske Laboratory: Reflection-Free Walls alone are Not Enough (Field Distortion due to Diffraction): Design of Room of Vital Importance].—W. Janovsky & F. Spandöck. (*Akust. Zeitschr.*, Nov. 1937, Vol. 2, No. 6, pp. 322–331.)

1032. THE ACOUSTIC INSULATION OF CONTROL CABINS FOR AIRCRAFT ENGINES [in Engine Works, close to Test Benches].—I. Katel. (*Génie Civil*, 25th Dec. 1937, Vol. 111, No. 26, pp. 544–546.)

1033. REDUCTION OF NOISE TRANSMITTED ALONG WATER PIPES [Tap Hisses, Pump Hum, etc.].—J. E. R. Constable. (*Engineering*, 26th Nov. 1937, Vol. 144, p. 612.)

1034. THE INFLUENCE OF THE SOUND ABSORPTION ON THE TRANSMITTED SOUND INTENSITY IN MEASUREMENTS [by the Two Practical Methods] OF THE NOISE OF FOOTSTEPS.—W. Pfeiffer. (*Akust. Zeitschr.*, Nov. 1937, Vol. 2, No. 6, p. 336.)

1035. DYNAMIC BEHAVIOUR OF SOUND VIBRATION INSULATING MATERIALS [Measurement of Mechanical Impedance of Rubber, Cork, etc.: Comparison of Behaviour of Such Materials with Electric Line Theory].—H. Böhme. (*Akust. Zeitschr.*, Nov. 1937, Vol. 2, No. 6, pp. 303–321.)

1036. THE THEORETICAL DERIVATIONS OF THE REVERBERATION LAWS [leading to a New Method of Measuring the Absorption Factor ("Schluckgrad") of Sound-Absorbing Materials (and Its Variation with Angle at Low Frequencies—Never previously Measured)].—H. & L. Cremer. (*Akust. Zeitschr.*, Nov. 1937, Vol. 2, No. 6, pp. 296–302.) Conclusion of the work referred to in 582 of February.

1037. WOOD-WOOL LIGHT-WEIGHT SLABS FOR BUILDING AND ACOUSTICAL PURPOSES.—German Heraklith Company. (*Akust. Zeitschr.*, Nov. 1937, Vol. 2, No. 6, pp. 332–335.)

1038. ON ACOUSTIC RADIATION TENSIONS [involved in Effects of Pressure of Sound Waves on Partitions].—A. D. Fokker. (*Physica*, Jan. 1938, Vol. 5, No. 1, pp. 31–38: in French.)

To explain the effects of such pressure, the calculation of tensions must be carried out to the second approximation, involving a knowledge of the potential elastic energy up to terms of the third order inclusive. The writer deals first with isotropic solids and later extends his treatment to crystals.

1039. THE MONAURAL THRESHOLD [Determination of Change of Threshold Intensity in One Ear when Note of Fixed Subliminal Intensity is sounded in the Other].—J. W. Hughes. (*Prov. Roy. Soc.*, Series A, 19th Nov. 1937, Vol. 163, No. 913, p. S 36: abstract only.)

1040. THE RESPONSE OF THE COCHLEA TO TONES OF LOW FREQUENCY.—Wever, Bray, & Willey. (*Journ. of Tech. Phys.* [in Russian], No. 17, Vol. 7, 1937, pp. 1791–1792: summary of paper in *Journ. Exper. Psychol.*, 1937, pp. 336–349.)

1041. THE DIFFRACTION OF LIGHT BY SUPERSONIC WAVES.—S. M. Rytov. (*Bull. de l'Acad. des Sci. de l'URSS, Série Physique*, No. 2, 1937, pp. 223–259: in Russian.) Will appear in French (with preface by Brillouin) in the Paris *Actualités Scientifiques et Industrielles* (Hermann).

1042. DIFFRACTION OF LIGHT BY ULTRASONIC WAVES: OBLIQUE INCIDENCES [Experimental Results agreeing with Raman-Nath Theory].—S. Parthasarathy. (*Current Science*, Bangalore, Nov. 1937, Vol. 6, No. 5, pp. 215–216.)

1043. DIFFRACTION OF LIGHT BY ULTRASONICS AT OBLIQUE INCIDENCE [Experimental Verification of Theory].—F. Levi. (*Nature*, 4th Dec. 1937, Vol. 140, pp. 969–970.)

1044. SUPERSONIC WAVES IN GASES [Complex Theory, including Effect of Discontinuities: Pressure in Jets containing Shock Waves].—D. Riabouchinsky. (*Comptes Rendus*, 6th Dec. 1937, Vol. 205, No. 23, pp. 1115–1117.) Continuation of work referred to in 3471 of 1936.

1045. THE RADIATION TENSIONS OF THE TRANSVERSAL INERTIA AND VISCOSITY WAVES IN LIQUIDS (Theory giving Values of Component Tensions].—R. Lucas. (*Comptes Rendus*, 29th Nov. 1937, Vol. 205, No. 22, pp. 1044–1047.)

1046. CORRECTION TO THE PAPER :—" SOME INTERFERENCE PHENOMENA WITH SUPERSONIC WAVES " [Corrected General Expression for Phase Velocity of Combination Wave].—Schreuer & Osterhammel. (*Zeitschr. f. Physik*, No. 7/8, Vol. 107, 1937, p. 560.) *See* 205 of January.

1047. ULTRASONIC INTERFEROMETRY FOR LIQUID MEDIA [Theory for Liquid Media with Large ρv compared with Gases: Method of obtaining Absorption Coefficient and " Effective " Reflection Coefficient at Liquid/Metal Boundary: Measurements for Water].—F. E. Fox. (*Phys. Review*, 1st Nov. 1937, Series 2, Vol. 52, No. 9, pp. 973–981.)

1048. MEASUREMENT OF THE VELOCITY IN LIQUIDS BY A RESONANCE METHOD.—C. Sǎlceanu. (*Comptes Rendus*, 13th Dec. 1937, Vol. 205, No. 24, pp. 1219–1221.)

1049. ON ANOMALOUS VIBRATIONAL SPECTRA [Conditions of Instability of Elastic Continuum].—M. Blackman. (*Proc. Roy. Soc.*, Series A, 19th Nov. 1937, Vol. 163, No. 913, p. S 18: abstract only.)

1050. DETERMINATION OF THE RELAXATION TIME FOR THE VIBRATIONAL ENERGY OF CARBON DIOXIDE [from Measurements of Absorption of Sound: Possibility of Two Relaxation Times].—A. van Itterbeek & P. Mariëns. (*Nature*, 13th Nov. 1937, Vol. 140, pp. 850–851.)

1051. THE DIRECTIVE EFFECT OF AN ACOUSTIC FIELD ON SUSPENSIONS OF NON-SPHERICAL PARTICLES [Calculations].—R. Pohlman. (*Zeitschr. f. Physik*, No. 7/8, Vol. 107, 1937, pp. 497–508.)

1052. SPLITTING OF THE HAEMOCYANIN MOLECULE BY ULTRASONIC WAVES.—S. Brohult. (*Nature*, 6th Nov. 1937, Vol. 140, p. 805.)

1053. THE DISPERSION OF INDANTHRENE COLOURS IN THE FIELD OF ULTRASONIC WAVES.—Zezjulinskij & Tumanskij. (*Journ. of Tech. Phys.* [in Russian], No. 18/19, Vol. 7. 1937, pp. 1922–1923.)

1054. REMARK ON THE POTENTIAL DIFFERENCES, IN SOLUTIONS, PRODUCED BY SUPERSONIC WAVES [Debye's Theoretical Statement hitherto difficult to Confirm Experimentally: Silver Iodide Sol should give 10 Times Greater Effect than Ordinary Solutions].—A. J. Rutgers. (*Physica*, Jan. 1938, Vol. 5, No. 1, p. 46: in German.)

1055. INTERNAL FRICTION OF WIRES [Maximum at Certain Transverse Vibration Frequency: Thermoelastic Effect: Calculations from Young's Moduli].—C. Zener. (*Nature*, 20th Nov. 1937, Vol. 140, p. 895.)

1056. SUPERSONIC HORN USED ON GERMAN HIGHWAYS.—(*Electronics*, Oct. 1937, Vol. 10, No. 10, p. 49.)

PHOTOTELEGRAPHY AND TELEVISION

1057. THE PRACTICAL POSSIBILITIES OF TELEVISION IN CONNECTION WITH HUMAN PSYCHO-PHYSIOLOGY [Comparison of Curve of " Satisfaction " with Curve of " Technical and Economic Difficulty," leading (by Analogy to Sound Broadcasting) to Suggested Satisfactory Compromise].—C. Pistoia. (*Alta Frequenza*, Nov. 1937, Vol. 6, No. 11, pp. 719–729.)

Thanks to a very important human quality—a high degree of " contentability "—the curve of " satisfaction," after a rapid initial rise, tends rather flatly to its maximum. Thus in the broadcasting of music the point *D* (Fig. 1) may be taken to represent the reproduction of all frequencies up to the audible limit (say 18 000 c/s), *C* all frequencies up to 10 000 c/s, and *B*, the satisfactory compromise actually attained, all up to about 6000 c/s. The writer's discussion of the television problem (in the course of which he refers to the July 1937 meeting, in Paris, of the International Committee on Acoustics to consider the psycho-physiological bases of television) leads to the conclusion that here point *C* represents something like 1000 elements per cm², 650 scanning lines, receiver spot section of 0.03 mm², modulation band 0–6 Mc/s, and carrier frequency about 100 Mc/s. Such a system is unattainable at present, and in any case would be impracticably expensive: but point *B*, the suggested satisfactory compromise, is already possible. The corresponding values for this point are 320 per cm², 360 lines, 0.06 mm², 2 Mc/s, and about 50 Mc/s respectively. The size of picture considered is 20×25 cm², viewed at about 120 cm.

1058. THE PROBLEM OF STEREOSCOPIC AND COLOUR TELEVISION [and the Possibilities of the Polarised Light Method and the Mains-Driven Spectacles System—Right and Left Eye alternated in Synchrony].—A. Kruckow. (*Funktech. Monatshefte*, Dec. 1937, No. 12, Supp. p. 95.)

1059. BRITISH TELEVISION—AS AMERICA SEES IT.—W. Grimditch. (*Television*, Jan. 1938, Vol. 11, No. 119, p. 12.) *Cf.* 604 & 605 of February.

1060. SCOPHONY DEMONSTRATION ON B.B.C. TELEVISION: SYNCHRONISING DIFFICULTIES OVERCOME.—(*Television*, Jan. 1938, Vol. 11, No. 119, pp. 23 and 25.)

1061. FREQUENCIES AND STANDARDS [1937 Work of RMA Television Committee].—A. F. Murray. (*Communications*, Nov. 1937, Vol. 17, No. 11, pp. 20–22.)

1062. Television Economics.—A. N. Goldsmith. (*Communications*, Oct. 1937, Vol. 17, No. 10, pp. 10 and 50, 51.)

1063. New Television Receiving Studios in Berlin [in Adolf Hitler Platz].—(*Funktech. Monatshefte*, Dec. 1937, No. 12, Supp. p. 97.) "Owing to the rapid development of television, the previous studios in the Rognitzstrasse, for reception of the Berlin transmissions, have become too small and inconvenient."

1064. Television Exhibit at the Berlin Radio Show.—(*Alta Frequenza*, Nov. 1937, Vol. 6, No. 11, pp. 773–778.)

1065. Three Big Prizes awarded to German Television [at the Paris World Exposition].—(*Funktech. Monatshefte*, Dec. 1937, No. 12, Supp. p. 95.)

1066. Figure of Merit for Television Performance [Sectionalised Test Chart].—A. V. Bedford. (*Communications*, Nov. 1937, Vol. 17, No. 11, p. 12: summary only, from I.R.E. Rochester Meeting.)

1067. A New Italian Television Journal of International Character: *Televisione: Revista del Centro Internazionale di Televisione dell' I.C.E.* [International Institute for Educational Cinematography].—(Published every 2 months by the International Television Centre of the Institute, Rome, Villa Torlonia, Via Lazzaro Spallanzani 1a.)

No. 1, Vol. 1 (Aug. 1937) contains the first instalment of an article in Italian (with summaries in French, English, & German) by Banfi, on "Standardisation in Television": a short note in German (with Italian, French & English summaries) by von Ardenne on "Ultra-Short-Wave Possibilities" (urging the practicability, now that so many u.s.w. transmitters are in action, of a trial of his multiple-modulation suggestion for a single ultra-short wave, using several longer-wave carrier frequencies, dealt with in 1931 Abstracts, pp. 165, 330–331, 331, & elsewhere): a paper in French (with Italian, English, & German summaries) by Yanouchevsky on "Time and Frequency" (and their respective standards). The Patents Section in this issue (pp. 48–56) consists of summaries (English) of 35 American patents for the 1st six months of 1937.

1068. "Television, Theory and Practice" [Book Review].—J. H. Reyner. (*Electrician*, 17th Dec. 1937, Vol. 119, p. 734.)

1069. "La Télévision et ses Progrès" *and* "Technique de la Radiodiffusion et de la Télévision."—Hémardinquer: Ory, Chamagne. (At Patent Office Library, London: Cat. Nos. 78 140 & 78 163.)

1070. Theory and Performance of the Iconoscope [including the Image-Multiplier Model, with about 10 Times Greater Sensitivity].—Zworykin, Morton, & Flory. (*Journ. I.E.E.*, Jan. 1938, Vol. 82, No. 493, pp. 105–114.)

1071. A Characteristic of the Iconoscope-Type Cathode-Ray Transmitter [Distortion and Low Sensitivity (about 5% of That theoretically Attainable) attributed to Drop of Photoelectric Potential caused by Cathode Ray: an Inherent Fault].—Takayanagi, Horii, & Suzuki. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 327–331.)

The great drop in sensitivity at the longer wavelengths, here confirmed as arising at low potentials with photocells made with the same sensitive material as the iconoscope, explains the fact that the iconoscope has a high response to sunlight (containing much ultra-violet radiation) and a low response to incandescent light.

1072. A New Principle for Image Scanning in Television [Abolition of Farnsworth Screen (guarding the Anode) with Its One Small Aperture: All the Electron Trajectories, except One, deflected by a Moving "Dispersive" Field].—J. Loeb. (*Rev. Gén. de l'Élec.*, 8th Jan. 1938, Vol. 43, pp. 33–34.)

1073. The Synchronising Effect of an Oscillating Type of Electron Multiplier.—T. Seki & T. Kiyono. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 352–355.)

Experiments with two parallel wires (accelerating electrode) near axis of cylindrical secondary-electron emitter. During one half cycle of an applied 50 Mc/s voltage, electrons from inner surface are accelerated towards wires, pass between them and are repelled, during next half cycle, so as to strike opposite side of cylinder, setting free secondary electrons.

1074. On the Characteristics of Electron-Multipliers.—S. A. Astaf'ev. (*Journ. of Tech. Phys.* [in Russian], No. 18/19, Vol. 7, 1937, pp. 1888–1894.)

The operation of an electron multiplier is examined and the following points are discussed. (1) Volt/ampere characteristics of the last and intermediate stages, and also the overall characteristic, *i.e.* the curve showing the relationship between the output current I_0 and the total voltage applied to the tube; (2) amplification characteristics (I_0 against photocurrent); and (3) modulation of the photocurrent. The discussion is illustrated by experimental curves relating to various types of multiplier, and optimum conditions are established: various practical suggestions are made.

1075. The Passage of Slow (0–200 Volt) Electrons through Metal Foils [Specially Prepared Silver Films are "Surprisingly Penetrable": Practically No Loss or Change of Direction for Small Primary Energies: for Increasing Energies, Percentage of Electrons retaining Their Original Energy decreases: Importance of Pre-Treatment: etc.].—H. Katz. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 18, 1937, pp. 555–558: *Physik. Zeitschr.*, 1st Dec. 1937, Vol. 38, No. 23, pp. 981–984.) Researches undertaken in view of the recently attained importance of the subject: "the amount of secondary emission is largely dependent on how many of the released electrons arrive at the surface."

1076. SECONDARY ELECTRON EMISSION.—Bruining & de Boer. (*See* 982.)

1077. "SECONDARY FIELD EMISSION" FROM STRATIFIED CATHODES IRRADIATED BY AN ELECTRON BEAM.—Mahl: Malter. (*See* 983.)

1078. ANOMALOUS EMISSION FROM NICKEL DUE TO A COATING (FORMED IN THE MANUFACTURING PROCESS).—D. V. Zernov. (*Journ. of Tech. Phys.* [in Russian], No. 17, Vol 7, 1937, pp. 1787–1788.)

For Malter's work, here referred to, *see* 2188 and 3498 of 1936. It is reported in this preliminary communication that during experiments with an electron-ray commutator (Fig. 1), for scanning in television receivers, the following effect was observed. During the evacuation of the tube some of the nickel electrodes were partially covered with a thin film, the chemical composition of which was not definitely established but which is believed to be boron trioxide (B_2O_3). When the tube was connected into the circuit it was found that while the secondary electron current from the clean electrodes remained normal, the current from the coated electrodes was several hundred times greater. The latter current would not start without bombardment of the electrode by primary electrons, but once having started would continue even after the priming current had been switched off: observations were kept on for 15 minutes and no diminution of the current was detected.

1079. PHOTOCELLS WITH A HIGHLY SELECTIVE SENSITIVITY [Caesium/Antimony Cathodes].—P. I. Lukirski & N. N. Lusheva. (*Journ. of Tech. Phys.* [in Russian], No. 18/19, Vol. 7, 1937, pp. 1900–1904.)

A report on the development of vacuum photocells in which the light-sensitive layer is made of a mixture of caesium and antimony. The sensitivity curves of these cells have a sharply pronounced peak on a band from 4500 Å to 5500 Å, and their maximum sensitivity (at 5000 Å), with daylight illumination, is approximately 20 times that of the $Cs\text{-}Cs_2O\text{-}Ag$ cells. Another property of these cells is that under intensive illumination (of the order of 0.1 lumen and higher) they do not show any saturation effects, with the result that by applying a sufficiently high voltage their sensitivity can be made as high as several hundreds of mA/lumen. A number of experimental curves are shown and a theoretical interpretation of the properties of the cells is offered.

1080. AN EQUIVALENT CIRCUIT OF THE PHOTOELECTRIC CELL.—T. Sakamoto & M. Kamazawa. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 325–326.)

1081. A PHOTOELECTRIC CELL CIRCUIT WITH A LOGARITHMIC RESPONSE [using the Koechel Relation $\log F = KI_p$ (based on Properties of Thermionic Emission): Photocell Cathode connected to "Floating Grid" of Triode with High Resistance in Plate Circuit].—J. Russell. (*Review Scient. Instr.*, Dec. 1937, Vol. 8, No. 12, pp. 495–496.)

1082. THE SURFACE PHOTOELECTRIC EFFECT [Expression for Probability of Ejection of an Electron: Expansion in Power Series, in Terms of Electron Energy after Ejection, leads to Series of Distinctive Functions expressing Current in Terms of Frequency and Stopping Potential: Nature of Potential Barriers: Comparison with Experimental Results].—W. V. Houston. (*Phys. Review*, 15th Nov. 1937, Series 2, Vol. 52, No. 10, pp. 1047–1053.)

1083. THE NORMAL ENERGY DISTRIBUTION OF PHOTOELECTRONS FROM SODIUM [Theory reformulated by including Effect of Contact Potential: Apparent Stopping Potential at 0°K independent of Cathode Work Function: Experimental Determination of Normal Energy Distribution: Variation with Changes of Anode Potential Barrier, etc.].—C. F. J. Overhage. (*Phys. Review*, 15th Nov. 1937, Series 2, Vol. 52, No. 10, pp. 1039–1047.)

1084. CONTACT POTENTIAL OF CLEAVAGE FACE OF ZINC CRYSTAL CLEAVED IN VACUUM [Variation with Time: Initial Rise corresponding to Decrease in Work Function: Possibility of Method of Measuring Photoelectric Properties].—F. B. Daniels & M. Y. Colby. (*Phys. Review*, 1st Dec. 1937, Series 2, Vol. 52, No. 11, p. 1200.)

1085. LIGHT VALVES [using Reflecting or Refracting Surface whose Properties are Varied by Charge from C-R Beam].—Myers & Goodenough. (*Marconi Review*, Jan./March 1938, No. 68, pp. 39–40: Patent summary.) *Cf.* 4210 of 1937, and 1086, below.

1086. AN ELECTRONIC LIGHT RELAY FOR LARGE PICTURES ["Suspensoid" Cell (Film of "Oildag") scanned by Modulated Cathode-Ray is given a Modulated Transparency to Beam from Constant Light Souce].—W. H. Stevens. (*Television*, Dec. 1937, Vol. 10, No. 118, pp. 716 and 718.) *Cf.* 1085, above.

1087. PAPERS ON CATHODE RAYS, ELECTRON BEAMS, ETC.—(*See* under "Subsidiary Apparatus & Materials.")

1088. A NEW TELEVISOR FOR EASY HOME CONSTRUCTION [embodying Tyers Scanning & Synchronising Systems].—S. West: Tyers. (*Television*, Oct. 1937, Vol. 10, No. 116, pp. 582–589.) *See* also 1090, below.

1089. THE DESIGN OF THE G.E.C. TELEVISION RECEIVER, MODEL BT 3701.—D. C. Espley & G. W. Edwards. (*Television*, Nov. 1937, Vol. 10, No. 117, pp. 663–667.) *See* alsc 3801 of 1937.

1090. A BRIDGE CIRCUIT AS AMPLITUDE FILTER [for Television Synchronising Signals].—(*Funktech. Monatshefte*, Dec. 1937, No. 12, Supp. pp. 93–94.) Based on the publications of Tyers (3809 of 1937), West, and Espley & Edwards (1088 & 1089, above).

1091. Experimental Miniature Television, *and* A Picture on a One-Inch Tube.—(*Television*, Oct. 1937, Vol. 10, No. 116, pp. 599–600: Nov. 1937, No. 117, pp. 668–669.) Continued from 3808 of 1937.

1092. The Mullard Miniature Cathode-Ray Tube for Operation at Low Voltages [300–800 Volts: 7 cm Screen Diameter].—(*Television*, Nov. 1937, Vol. 10, No. 117, pp. 670 and 674.)

1093. Baird Scanning Equipment and Cathovisor Tube [Type 15 WM2, 15-Inch Magnetically Focussed].—(*Television*, Oct. & Nov. 1937, Vol. 10, Nos. 116 & 117, pp. 601–602 & 667.)

1094. Alkali Halide Phosphors with Heavy Metal Content [Absorption Spectra: Atomic Complexes responsible for Absorption and Emission].—R. Hilsch. (*Physik. Zeitschr.*, 15th Dec. 1937, Vol. 38, No. 24, pp. 1031–1034.)

1095. The Frequency Spectrum of Saw-Tooth Waves [with Various Fly-Back Times].—von Ardenne. (*Television*, Jan. 1938, Vol. 11, No. 119, pp. 35 and 36.) Based on a section in the writer's book "Television Reception" (3862 of 1936): *see* also 1710 of 1937, and 598 of February.

1096. How Cossor Television Receivers are Tested.—(*Television*, Jan. 1938, Vol. 11, No. 119, pp. 24–25.)

1097. The "Monoscope" [for Testing the Various Units of a Television System].—C. E. Burnett. (*Communications*, Nov. 1937, Vol. 17, No. 11, p. 12: summary only, from I.R.E. Rochester Meeting.)

1098. A Unique Method for High-Fidelity Television Transmitters [applicable also to U.S.W. Sound Transmitters: "Transmission-Line Modulation"].—W. N. Parker. (*Communications*, Nov. 1937, Vol. 17, No. 11, p. 12: summary only, from I.R.E. Rochester Meeting.) *Cf.* Banerjee & Singh, 3395 of 1937.

1099. An Analysis of Admittance Neutralisation by means of Negative Transconductance Tubes [for Wide-Band Resistance Coupled Amplifiers in Television, etc., to extend Frequency Range over which Coupling Impedances remain Constant: Improvement over Conventional Inductance-Compensated System].—E. W. Herold. (*Proc. Inst. Rad. Eng.*, Nov. 1937, Vol. 25, No. 11, pp. 1399–1413.) Using the special "negative transconductance tube" dealt with in 77 of 1936.

1100. Concentric-Pair [Coaxial] Cables [Survey of English, German, and American Types: the French Choice of Construction for the Paris/Bordeaux Cables: Attractions and Defects of the English Design, from French Viewpoint: Economic Aspect of Coaxial Cables: etc.].—L. Simon. (*Ann. des Postes, T. et T.*, Nov. 1937, Vol. 26, No. 11, pp. 937–964.)

1101. Coaxial Cables, *and* General Complementary Remarks on Coaxial Cables.—E. M. Deloraine. (*Bull. de la Soc. franç des Élec.*, Oct. 1937, Vol. 7, No. 82, pp. 1045–1056: pp. 1057–1078.)

1102. Coaxial Cable Television Transmission [New York/Philadelphia].—(*Communications*, Nov. 1937, Vol. 17, No. 11, pp. 9–11.) *See* also 608 of February.

1103. A Synchronising System by Multiple Frequencies [for Picture Transmission by Single-Sideband Carrier over Telephone Lines, and Other Purposes, where Single-Frequency Synchronisation is Not Sufficiently Exact].—M. Kobayashi. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 457–459.)

1104. An Experiment on Facsimile Transmission [Reception on Two Sheets of Paper with Carbon Paper between, fed (at Same Speed as Photocell Scanner at Transmitter) between Helix Drum (Same Speed as Transmitter Drum) and Printing Bar pressed by Signals against Helix Point of Contact].—T. Morikawa. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, p. 460.)

MEASUREMENTS AND STANDARDS

1105. A Thermal Method for measuring Efficiencies at Ultra-High Frequencies applied to the Magnetron Oscillator [Thermocouple built into Magnetron Envelope, within about ⅜ Inch of Plate: Increase of Filament D.C. Resistance on Starting of Oscillation (Impact of Returning Electrons): Efficiencies for Dynatron-Type Oscillations, and Comparison with Photometric Method: etc.].—H. W. Kohler. (*Proc. Inst. Rad. Eng.*, Nov. 1937, Vol. 25, No. 11, pp. 1381–1386.)

1106. An Electrodynamic Ammeter for Use at Frequencies from One to One Hundred Megacycles [and Higher: Currents 1–5 Amperes: primarily for the Checking of Thermoammeters].—H. M. Turner & P. C. Michel. (*Proc. Inst. Rad. Eng.*, Nov. 1937, Vol. 25, No. 11, pp. 1367–1374.) On the principle given in 1934 Abstracts, p. 509, top of l-h column.

1107. The Electro-Optical Method for measuring Alternating Currents and Voltages, by means of a Photocell.—M. M. Sliozberg. (*Journ. of Tech. Phys.* [in Russian], No. 18/19, Vol. 7, 1937, pp. 1850–1853.)

In this method the current to be measured is passed through a transformer to the secondary of which is connected a lamp. The light of the lamp is passed through a colour filter on to a barrier-layer selenium photocell, and the photocurrent is observed on a galvanometer. In this way any variation in the primary current can easily be detected. A description is given, with a number of curves and tables, of a model on this principle, and it is pointed out that this model is equivalent to a meter with a scale divided into over 2000 divisions in place of the usual 25 or so. Full-scale deflection is obtained on the galvanometer by varying the primary current from 125 mA to 250 mA.

1108. FRICTIONAL DISPERSION OF THE DIELECTRIC CONSTANTS OF ORGANIC LIQUIDS [measured in Ultra-Short-Wave Region down to 10 cm: the Sudden Transition Point].—E. Plötze. (*Zeitschr. f. tech. Phys.*, No. 12, 1937, Vol. 18, p. 588: short summary only.)

1109. MEASURING METHODS IN THE DECIMETRE-WAVE REGION [Short Survey].—E. C. Metschl. (*Funktech. Monatshefte*, Nov. 1937, No. 11, pp. 333-335.)

1110. METHODS OF MEASUREMENT FOR SPARK-GENERATED MICRO-WAVES.—Awaya & Kurobe. (*See* 903.)

1111. A METHOD OF MEASURING HIGH-FREQUENCY FIELD INTENSITY BY MEANS OF THE FREE [Horizontal] VIBRATION PERIOD OF A ROD CONDUCTOR [hung by a String: Sensitivity constant within Range from D.C. to U.S.W. Frequencies: for Measurement of Large U.S.W. Currents].—K. Awaya. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 454-455.)

1112. THE USE OF LOOP AERIALS FOR FIELD-STRENGTH MEASUREMENT.—Taylor. (*See* 963.)

1113. MEASUREMENT OF RECEIVER SET NOISE AND GAIN IN 20 TO 55 Mc/s FREQUENCIES.—Seki. (*See* 926.)

1114. PARALLEL-RESONANCE METHODS FOR MEASUREMENT OF HIGH IMPEDANCES AT HIGH FREQUENCIES [" Susceptance Variation " and " Conductance-Variation " Methods].—D. B. Sinclair. (*Communications*, Nov. 1937, Vol. 17, No. 11, p. 40: summary only, from I.R.E. Rochester Meeting.)

1115. A NEW BRIDGE FOR THE DIRECT MEASUREMENT OF IMPEDANCES.—A. Serner. (*Ann. des Postes, T. et. T.*, Dec. 1937, Vol. 26, No. 12, pp. 1060-1067.) French version of the *Wireless Engineer* paper (1911 of 1937.)

1116. AN INEXPENSIVE BRIDGE FOR CAPACITANCE AND CONDUCTANCE MEASUREMENTS.—L. E. Herborn. (*Bell Lab. Record*, Nov. 1937, Vol. 16, No. 3, pp. 91-94.)

1117. NUMERICAL DETERMINATIONS OF INDUCTANCES, AND THEIR APPLICATION TO THE CALCULATION OF THE LEAKAGE INDUCTANCE OF TRANSFORMERS.—P. Bunet. (*Bull. de la Soc. franç. des Élec.*, Nov. 1937, Vol. 7, No. 83, pp. 1087-1120.)

1118. MAGNETIC FIELD OF A SYMMETRICAL BUNDLE OF PARALLEL WIRES CARRYING EQUAL CURRENTS [equally spaced on Infinite Cylinder: Calculations: Quickly Applied Primary Winding for Ring Specimens].—C. G. Dunn & G. L. Clark. (*Phys. Review*, 1st Dec. 1937, Series 2, Vol. 52, No. 11, pp. 1167-1169.)

1119. THE DESIGN OF MUTUAL INDUCTANCES OF PRESCRIBED PROPERTIES [Theory: Design of Circular Self-Inductance of Rectangular Winding Cross-Section: Two Coaxial Coils: Various Typical Coil Arrangements: Tables, Nomograms, Numerical Examples, etc.].—H. H. Wicht. (*Arch. f. Elektrot.*, 4th Nov. 1937, Vol. 31, No. 11, pp. 701-731.)

1120. IMPROVED CONTINUOUSLY VARIABLE SELF AND MUTUAL INDUCTOR [and Two New General Theorems concerning a Pair of Mutually Inductive Coils].—H. B. Brooks & A. B. Lewis. (*Journ. of Res. of Nat. Bur. of Stds.*, Nov. 1937, Vol. 19, No. 5, pp. 493-516.)

1121. THEORY AND CONSTRUCTION OF A PHASE COMPENSATOR: ITS APPLICATION TO MEASUREMENTS ON THE NEW ARTIFICIAL LINE OF THE INSTITUT MONTEFIORE.—Fourmarier & Listray. (*Bull. de la Soc. franç. des Élec.*, Sept. 1937, Vol. 7, No. 81, pp. 947-967.)

1122. HIGH-FREQUENCY ATTENUATOR [for Tests on Wide-Band Apparatus (Coaxial Cable, etc.)].—S. A. Levin. (*Bell Lab. Record*, Nov. 1937, Vol. 16, No. 3, pp. 99-101.)

1123. THE MEASUREMENT OF AMPLIFICATION AND PHASE DISPLACEMENT IN AMPLIFIERS [with Cathode-Ray Oscillograph: Technique suitable for Production Tests].—P. E. Klein. (*Funktech. Monatshefte*, Nov. 1937, No. 11, pp. 341-343.)

1124. THE MEASUREMENT OF PHASE DIFFERENCE BETWEEN HARMONIC OSCILLATIONS OF DIFFERENT FREQUENCIES, *and* ON A METHOD OF MEASURING THE PHASE DISPLACEMENT INTRODUCED BY H.F. AMPLIFIERS [with Description of a " Phase Deviometer "].—E. Schegolev: C. Viller. (*Tech. Phys. of USSR*, No. 10, Vol. 4, 1937, pp. 827-840: pp. 841-849: both in English.) Methods developed in connection with Mandelstam & Papalexi's measurements of propagation velocity (836, above).

1125. ERRORS PRODUCED IN MODULATION MEASUREMENT BY VACUUM-TUBE VOLTMETER.—T. Sakamoto & M. Kamazawa. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 326-327.)

1126. SOME NEW METHODS OF MEASURING MAGNETIC FIELD STRENGTH.—G.W.O.H: Groszkowski: Boucke. (*Wireless Engineer*, Dec. 1937, Vol. 14, No. 171, pp. 639-640.) Editorial on Groszkowski's paper (313 of January) and on a method, due to Boucke, depending on the incremental permeability of the small iron-powder core of a toroidal exploring coil.

1127. METHOD OF MEASURING A MAGNETIC FIELD BY MEANS OF THE INITIAL CURRENT OF A DIODE.—A. Giacomini. (*Alta Frequenza*, Nov. 1937, Vol. 6, No. 11, pp. 712-718.)

Using commercial types of diodes and triodes (grids directly connected with cathodes), the method provides a simple way of measuring fields between about 10 and 250 gauss: the accuracy can be brought to within 0.5%. Any one type of valve covers, however, only a part of this total range: thus the "acorn" RCA 955 covers a useful range of about 75 to 150 gauss. Specially designed valves would give better results. The whole circuit consists only of the valve, a filament-heating source, and a microammeter for measuring the initial current. Tests over 10 hours have shown that the emission velocity does not vary enough to modify the $I_i = f(B)$ curve on which the method depends: this is thanks to the absence of current of such a value as would alter the structure of the emitting layer.

1128. HIGH-FREQUENCY PERMEABILITY OF THIN FILMS OF ELECTROLYTICALLY DEPOSITED IRON [measured by Change of Wavelength at Fixed Frequency on Lecher Wires covered with Film: Thickness of Film giving Unit Permeability].—S. Procopiu & G. d'Albon. (*Comptes Rendus*, 27th Dec. 1937, Vol. 205, No. 26, pp. 1373–1375.)

1129. DIFFRACTION PATTERNS OF SILICON IRON CRYSTALS OSCILLATING MAGNETOSTRICTIONALLY [Similar Action of Magnetostriction and Piezoelectric Oscillations].—G. W. Fox & H. T. Hurley. (*Phys. Review*, 15th Nov. 1937, Series 2, Vol. 52, No. 10, p. 1077.)

1130. ULTRA-SHORT-WAVE QUARTZ-CRYSTAL OSCILLATOR [Criticism of Straubel's Insistence on Tourmalin: Perfectly Satisfactory Quartz Plates with Fundamentals of 9.6 m—6.8 m (and probably 6 m) for use with Acorn Valve in Pierce Circuit].—I. Koga. (*Electrot. Journ.*, Tokyo, Jan. 1937, Vol. 2, No. 1, p. 21.)

1131. QUARTZ PLATES FOR FREQUENCY SUB-STANDARDS.—S. C. Hight. (*Bell Lab. Record*, Sept. 1937, Vol. 16, No. 1, pp. 21–25.)

1132. CHANGES IN THE LATTICE OF PIEZOELECTRIC CRYSTALS PRODUCED BY STATICAL ELECTRIC POTENTIAL DIFFERENCE [Data for Quartz cut Perpendicular to Electric Axis].—V. Dolejšek & M. Jahoda. (*Comptes Rendus*, 10th Jan. 1938, Vol. 206, No. 2, pp. 113–115.)

1133. RADIAL AND TORSIONAL VIBRATIONS OF ANNULAR QUARTZ PLATES [Theoretical and Experimental Study: Fundamental Radial Frequency of Full Plate higher than that of Annular Plate, Torsional Frequency lower: Figures of Nodal Lines].—A. Záček & V. Petržílka. (*Phil. Mag.*, Jan. 1938, Series 7, Vol. 25, No. 166, pp. 164–175.)

1134. THE EQUIVALENT CIRCUIT CONSTANTS AND FREQUENCY FLUCTUATIONS OF QUARTZ CRYSTALS.—Yokoyama, Hojo, & Simada. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 321–322.)

1135. ON A QUARTZ CRYSTAL FILTER [Crystal Cut giving Single Resonance Point, and Small Temperature Coefficient, between 50 kc/s and 250 kc/s].—S. Matumae & S. Yonezawa. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 333–335.)

1136. RESONANCE IN CRYSTAL BEAMS OF SODIUM-AMMONIUM SEIGNETTE [Rochelle] SALT [Experiments with Longitudinal Oscillations: Analogy with Coupled Circuits: Change in Wavelength with Change in Breadth and Thickness].—W. Mandell. (*Proc. Roy. Soc.*, Series A, 7th Dec. 1937, Vol. 163, No. 914, p. S 57: abstract only.)

1137. A METHOD OF MEASURING LOW FREQUENCIES [Condenser-Charging Principle].—I. Takahashi. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 355–356.) For previous uses of this principle, in various forms, *see* for example 2314, 2711, & 3086, all of 1937.

1138. THE CONTROL OF A.C. NETWORKS ON THE TIME-CONTROLLED [Synchronous Clock] SYSTEM.—G. August. (*E.T.Z.*, 30th Dec. 1937, Vol. 58, No. 52, pp. 1395–1398.)

1139. MEASURING POTENTIOMETER FOR HIGH IMPULSIVE VOLTAGES: II—THE CAPACITY POTENTIOMETER.—Raske. (*See* 1157.)

1140. THE ZERO-SHUNT VALVE A.C. POTENTIOMETER.—J. J. Dowling. (*Phil. Mag.*, Jan. 1938, Series 7, Vol. 25, No. 166, pp. 184–188.)

"The use of the zero-shunt in the anode circuit of a detector valve enables the p.d. across an impedance carrying an alternating current to be balanced against the p.d. across an adjustable resistance in which the same a.c. flows. Measurements are possible of impedances, phase angle, frequency, etc., at high or low frequency and with considerable precision."

1141. A SIMPLE D.C. MEASURING TRANSFORMER WITH TRUE CURRENT-TRANSFORMING PROPERTIES [for Shunt-less Measurement of High or High-Voltage D.C. Currents].—W. Krämer. (*E.T.Z.*, 9th Dec. 1937, Vol. 58, No. 49, pp. 1309–1313.)

1142. A HIGH-VOLTAGE METER WITH ABSOLUTE CALIBRATION [by Superposition of Weights] AND THREE-FILAMENT SUSPENSION.—H. Winkelbrandt. (*Arch. f. Elektrot.*, 9th Oct. 1937, Vol. 31, No. 10, pp. 672–681.)

1143. THE CREST VOLTMETER FOR IMPULSE VOLTAGE [Experiments with Ordinary A.C. Crest Voltmeter modified by Use of Ballistic Galvanometer].—Nishi, Honda, & others. (*Electrot. Journ.*, Tokyo, Nov. 1937, Vol. 1, No. 6, pp. 189–190.)

1144. AN OIL-IMMERSED GENERATING VOLTMETER.—Thomas. (*Review Scient. Instr.*, Nov. 1937, Vol. 8, No. 11, pp. 448–449.)

1145. FUNDAMENTAL ELECTRICAL MEASUREMENTS [I.E.E. Lecture].—F. E. Smith. (*Journ. I.E.E.*, Dec. 1937, Vol. 81, No. 492, pp. 701–706 and Plates.)

1146. THE ABSOLUTE MEASUREMENT OF RESISTANCE BY THE METHOD OF ALBERT CAMPBELL.—L. Hartshorn & N. F. Astbury. (*Phil. Trans. Roy. Soc. Lond.*, Series A, 18th Nov. 1937, Vol. 236, No. 769, pp. 423–471.)

1147. The Natural Unit of Current and the Faraday Constant.—L. Laboccetta. (*La Ricerca Scient.*, 15th/30th Sept. 1937, Series 2, 8th Year, Vol. 2, No. 5/6, pp. 362–364.)

1148. Meter and Instrument Section: Chairman's Address.—H. C. Turner. (*Journ. I.E.E.*, Jan. 1938, Vol. 82, No. 493, pp. 20–25.)

1149. Symbols [Unsatisfactory Usual Definitions of Electric Force, Electromotive Force, etc.].—Hartshorn. (*See* 1216.)

SUBSIDIARY APPARATUS AND MATERIALS

1150. The New Cathode-Ray Oscillograph of the Siemens & Halske Company.—Waarz & Klein. (*Rev. Gén. de l'Élec.*, 11th Dec. 1937, Vol. 42, No. 24, pp. 757–758.)

1151. New Cathode-Ray Tubes [Series 325 & 326].—Glass. (*Bell Lab. Record*, Dec. 1937 Vol. 16, No. 4, pp. 110–113.)

1152. A Complete Oscilloscope with I.F. Input Amplifier.—Anderson. (*QST*, Dec. 1937, Vol. 21, No. 12, pp. 36–37 and 102, 104.)

1153. Space-Charge Limitation on the Focus of Electron Beams, *and* Negative-Ion Components of the Cathode Ray [Their Presence and Detection, Sources and Effect].—L. B. Headrick & B. J. Thompson: C. H. Backman & C. W. Caranahan. (*Communications*, Nov. 1937, Vol. 17, No. 11, pp. 12 and 22, 33: p. 33: summaries only, from I.R.E. Rochester Meeting.)

1154. Statical Measurements on Electron Beams [Effect of Probe: Probe Electrometer].—Stehberger. (*Ann. der Physik*, Series 5, No. 7, Vol. 30, 1937, pp. 621–634.)

The electron beam [" Wendelstrahl "] considered is of low velocity and travels through a strong longitudinal magnetic field. The tube used for induction measurements with a probe is shown in Fig. 1. It is found that passage of current between the beam and the probe can be rendered almost negligible, since the diffuse, scattered radiation from the beam is confined to its immediate neighbourhood. The inductive action of the space charges on the probe is discussed (§ II); a " Wendelstrahl " electrometer is designed (§ III; scheme Fig. 6) which employs deviation of the beam in a transverse electric field (Fig. 5) produced by a condenser. The characteristic curves of the electrometer are investigated.

1155. The Second-Order Aberrations of Orthogonal Systems [in Electron Optics: Theory of Trajectories].—Cotte. (*Comptes Rendus*, 6th Dec. 1937, Vol. 205, No. 23, pp. 1145–1147.) *See* also 663 of February.

1156. Papers on the Electron Microscope.—Krause: Beischer. (*See* 1274.)

1157. Measuring Potentiometer for High Impulsive Voltages: II—The Capacity Potentiometer [with Design of Internal Potentiometer for Cathode-Ray Oscillograph].—W. Raske. (*Arch. f. Elektrot.*, 4th Nov. 1937, Vol. 31, No. 11, pp. 732–748.)

For I *see* 668 of February. Here, errors occurring in measurements with a capacity potentiometer are first discussed (§ B); the flattening of the impulse wave front may be diminished by lessening the wave impedance of the leads and the capacity to earth of the potentiometer. The development of an internal potentiometer for a cathode-ray oscillograph is described; its range can be varied from outside by an electrically-movable iris-stop (Fig. 13). Electrolytic measurements of the potential distribution are given (Figs. 9, 10). A high-voltage porcelain lead-in insulator of small self-capacity is described (Fig. 11). The scheme of the high-voltage oscillograph is shown in Fig. 17; reference is made to its calibration at 50 c/s.

1158. Quantitative Measurements on the Decay of Phosphorescence of Zinc Phosphor at Different Temperatures.—Antonov-Romanovskij. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 25th Oct. 1937, Vol. 17, No. 3, pp. 95–98: in French.) For earlier work *see* 3210 of 1935.

1159. Study of the Fluorescence in a Layer of Thickness comparable with the Wavelength.—Baryšanskaja. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, 25th Oct. 1937, Vol 17, No. 3, pp. 99–102: in French.)

1160.—A Two-Stage Oscillograph Amplifier [Amplification of 10^6 over Range 10–10^4 c/s: Mains-Driven].—Dykes. (*Wireless Engineer*, Dec. 1937, Vol. 14, No. 171, pp. 641–646.)

1161. Oscillograph Amplifier Design [for Saw-Tooth Time-Base Signals].—(*Communications*, Oct. 1937, Vol. 17, No 10, pp. 26–27 and 46, 47.)

1162. " Der Kathodenstrahloszillograph im neuzeitlichen Unterricht " [in Modern Education: Book Review].—Weiss. (*Physik. Zeitschr.*, 1st Dec. 1937, Vol. 38, No. 23, p. 1025.)

1163. Low-Pressure Measurements by Means of the Ionisation Gauge [Pressures 10^{-1}–10^{-6} mm].—Healey & Reed. (*AWA Tech. Review*, Oct. 1937, Vol. 3, No. 2, pp. 35–48.)

1164. Vacuum Determination in Indirectly Heated Receiving Valves, by Ion-Current Measurement.—Herrmann & Runge. (*See* 989.)

1165. A New Charcoal Trap for Oil Vapours.—Anderson. (*Review Scient. Instr.*, Dec. 1937, Vol. 8, No. 12, pp. 493–495.)

1166. Rectifier Types and Applications [Survey, with Literature References to Recent Work].—Porter. (*Communications*, Dec. 1937, Vol. 17, No. 12, pp. 11–14 and 42, 43.)

1167. On the Striking Process in Grid-Controlled Rectifiers with Liquid Cathodes.—Schmidt. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 18, 1937, pp. 480–485.)

1168. Carrier Laws for Mercury-Vapour-Rectifier Arcs: Reply to Klarfeld.—von Engel & Steenbeck: Klarfeld. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 18, 1937, pp. 491–492.) A reply to Klarfeld's criticisms (3469 of 1937).

1169. Grid-Controlled Hot-Cathode Converter Tubes with Several Control Electrodes.—Jacobi & Kniepkamp. (*E.T.Z.*, 18th Nov. 1937, Vol. 58, No. 46, pp. 1233–1237.)

1170. Investigations of the Sparks of the Electrolytic Valve Action [Breakdown Voltages, etc.].—Güntherschulze & Betz. (*Zeitschr. f. Physik*, No. 5/6, Vol. 107, 1937, pp. 347–353.)

1171. "Ferranti Electrolytic Condensers."—Pirie. (At Patent Office Library, London: Cat. No. 78 090: 34 pp.)

1172. Science Library Bibliographical Series No. 357: Copper-Oxide Rectifiers.—(Pub. by Science Museum, South Kensington, London, S.W.7.)

1173. Electron Diffraction Studies of Cuprous Oxide.—Germer. (*Phys. Review*, 1st Nov. 1937, Series 2, Vol. 52, No. 9, pp. 959–967.)

1174. Electrical and Optical Behaviour of Semiconductors: XIII — Measurements on Oxides of Cd, Ti, Sn: XIV—Magnetic Measurements on Cuprous Oxide [Study of Effects of Occluded Oxygen].—Bauer: Hommel. (*Ann. der Physik*, Series 5, No. 5, Vol. 30, 1937, pp. 433–455: pp. 467–480.)

1175. Paper on the Temperature/Conductivity Formula of Oxide Semiconductors.—Meyer & Neldel. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 18, 1937, pp. 588–593: *Physik. Zeitschr.*, 1st Dec. 1937, Vol. 38, No. 23, pp. 1014–1019.) For the practical applications of such semiconductors *see* 500 & 677 of February.

1176. Metallic Electrical Resistance Materials [Survey, including Isabellin, Megapyr, Kanthal (A1), etc.].—Schulze. (*E.T.Z.*, 23rd & 30th Dec. 1937, Vol. 58, Nos. 51 & 52, pp. 1361–1364 & 1386–1390.)

1177. On the Transfer of Heat through Wires from Electro-Thermal Apparatus.—B. M. Tareev. (*Journ. of Tech. Phys.* [in Russian], No. 18/19, Vol. 7, 1937, pp. 1848–1849.)

For the work of Batsch & Meissner, here referred to (on the importance of the thermal resistance of insulating materials, and on its measurement) *see* 3883 of 1936. In various heat measurements in which electro-thermal apparatus is used as a source of heat, it is essential to take into account the amount of heat lost by conduction through the power-supply leads connected to this apparatus. In the present paper equation (4) is derived showing the temperature gradient in a wire, and methods are indicated for determining the amount of heat lost by radiation from the surface of the wire.

1178. Present Status of Synthetic Resins in the Electrical Field.—Barringer. (*Gen. Elec. Review*, Dec. 1937, Vol. 40, No. 12, pp. 554–557.)

1179. Notes on Steatite-Type High-Frequency Insulation.—Thurnauer. (*QST*, Nov. 1937, Vol. 21, No. 11, pp. 33–34 and 98, 102, 106.)

1180. Drilling Glass, Porcelain, and Pyrex.—Loney & Gilliam. (*QST*, Oct. 1937, Vol. 21, No. 10, pp. 41–42.)

1181. "Glastechnische Fabrikationsfehler" [Manufacturing Failures in Glass Technique: Book Review].—(*Zeitschr. f. tech. Phys.*, No. 12, Vol. 18, 1937, p. 600.)

1182. Infra-Red Spectrum and Structure of Silicates and Glasses.—Matossi. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 18, 1937, pp. 585–588: *Physik. Zeitschr.*, 1st Dec. 1937, Vol. 38, No. 23, pp. 1011–1014.)

1183. Accidental Charges on Insulators (particularly Rubber) causing Disturbances in Amplifiers.—(*See* 947.)

1184. The Radiation Emitted by Solid Dielectrics Electrified by Friction [No Fluorescence].—Perrier. (*Comptes Rendus*, 10th Jan. 1937, Vol. 206, No. 2, pp. 107–109.)

1185. Recent Progress in Insulation Research.—Whitehead. (*Elec. Engineering*, Nov. 1937, Vol. 56, No. 11, pp. 1346–1352.)

1186. Electric Breakdown of Solid and Liquid Insulators [Survey of Recent Work].—von Hippel. (*Journ. of Applied Physics*, Dec. 1937, Vol. 8, No. 12, pp. 815–832.)

1187. The Equilibrium and Electric Strength of Two-Phase Water-Liquid Dielectrics.—Lazarev & Nigmatulina. (*Journ. of Tech. Phys.* [in Russian], No. 18/19, Vol. 7, 1937, pp. 1913–1921.)

1188. The Movements of Thread- and Dust-Particles in Various Hydrocarbons under Electric Tension, and the Effect of Dampness, Air, and the Presence of Threads on the Breakdown Resistance of Oil.—Conradi. (*Arch. f. Elektrot.*, 9th Oct. 1937, Vol. 31, No. 10, pp. 667–671.) *See* also 363 of 1937.

1189. Discussion on "The Dielectric Strength of Non-Inflammable Synthetic Insulating Oils."—Clark. (*Elec. Engineering*, Oct. 1937, Vol. 56, No. 10, pp. 1299–1301.) *See* 3508 of 1937.

1190. The Dependence of the Glow- [Corona-] Discharge Voltage of Condensers on the Frequency.—G. Weber. (*Funktech. Monatshefte*, Nov. 1937, No. 11, pp. 338–339.)

Condensers of various shape with various dielectrics were tested in the frequency range $10^5 - 2 \times 10^7$ c/s, being connected in an 800-watt oscillator circuit. The discharge (voltages 0.5—3 kV) was watched with the naked eye, after tests (with a receiver tuned to the oscillator wavelength) had shown that no discharge could be detected before the visible discharge set in—usually at the edges of the "burnt on" metal coating. Measurements were repeated on different days, so as to allow for variations in dielectric moisture-content, atmospheric humidity, temperature, and pressure, all of which affect the onset of the discharge. It was found that the discharge voltage decreased with increasing frequency: also that at the lower frequencies the discharge set in gently and gave little light, whereas at high frequencies it set in suddenly and with the accompaniment of marked sound and light phenomena. This looked at first as if there were a different discharge phenomenon at the different frequencies, but the true explanation was found to be the increased current through the discharge at the higher frequencies (in spite of the decreased striking potential).

The voltage of onset was found to vary linearly with the logarithm of the frequency, for all the widely different condensers tested—even for a point-and-plate combination (this latter, incidentally, showed a curious cyclical phenomenon, involving sintering of the dielectric, which is described at some length on p. 339, l-h column). An assumption that the slope of the straight line is a constant of the material or of the design of the condenser was found to be incorrect, for the slope was the same (within the limits of accuracy of the experiments) for all the condensers. This leads to a useful practical formula connecting the required striking voltage for a given frequency with the measured striking voltage at some other frequency.

1191. "WIRTSCHAFTLICHES WICKELN VON FEINDRAHTSPULEN" [Winding of Fine-Wire Coils: Thesis].—Schmidt. (At Patent Office Library, London: Cat. No. 78 027 : 93 pp.) For a summary see *E.T.Z.*, 23rd Dec. 1937, Vol. 58, No. 51, p. 1374.

1192. IMPROVED CONTINUOUSLY VARIABLE SELF AND MUTUAL INDUCTOR.—Brooks & Lewis. (*See* 1120.)

1193 PAPERS ON THE CONDUCTOR-CORE COIL.—Ohtaka & others. (*See* 897.)

1194. LIMITATION OF AIR-GAP IN THE IRON-CORE INDUCTANCE COIL FROM THE STANDPOINT OF MINIMUM LOSS FACTOR.—Nakai. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 320–321.)

1195. LAMINATED IRON-CORE COILS, WITH AIR GAP AT HIGH FREQUENCIES.—Hellmann. (*See* 871.)

1196. EDDY CURRENT SHIELDING IN LAMINATED CORES.—Wrathall. (*Bell Lab. Record*, Sept. 1937, Vol. 16, No. 1, pp. 7–11.)

1197. HIGH-FREQUENCY RESISTANCE OF COILS WITH COMPRESSED IRON-POWDER COILS.—Hak. (*See* 933.)

1198. HIGH-FREQUENCY PERMEABILITY OF THIN FILMS OF ELECTROLYTICALLY DEPOSITED IRON.—Procopiu & d'Albon. (*See* 1128.)

1199. SATURATION MAGNETISATION AND APPROXIMATION LAW OF IRON: CORRECTION.—Steinhaus & others. (*Physik. Zeitschr.*, 1st Dec. 1937, Vol. 38, No. 23, p. 1026.) For reference to this paper *see* 322 of January.

1200. EFFECT OF A LONGITUDINAL MAGNETIC FIELD ON THE THERMOELECTRIC COEFFICIENT OF NICKEL AND OF VARIOUS FERRONICKELS UNDER TENSION.—Simon & Bouchard. (*Comptes Rendus*, 6th Dec. 1937, Vol. 205, No. 23, pp. 1141–1143.)

1201. THE PARAMAGNETIC MAGNETON NUMBERS OF THE FERROMAGNETIC METALS [calculated from Measurements of Magnetic Susceptibility].—Sucksmith & Pearce. (*Nature*, 4th Dec. 1937, Vol. 140, p. 970.)

1202. ON THE ANISOTROPY OF CUBIC FERROMAGNETIC CRYSTALS [Theory: Effect of Interplay between Orbital Valence and Spin-Orbit Interaction].—van Vleck. (*Phys. Review*, 1st Dec. 1937, Series 2, Vol. 52, No. 11, pp. 1178–1198.)

1203. STUDIES ON THE MOMENT AND MOLECULAR FIELD OF FERROMAGNETIC SUBSTANCES.—Néel. (*Ann. de Physique*, Oct. 1937, Series 11, Vol. 8, pp. 237–308.)

1204. PARAMAGNETIC DISPERSION IN IRON ALUM [Extension of Work on Magnetic Inhibition of Susceptibilities at Radio Frequencies].—Brons & Gorter. (*Physica*, Jan. 1938, Vol. 5, No. 1, pp. 60–64.) For previous work *see* 3532 & 3533 of 1937.

1205. INTERPRETATION OF THE PARAMAGNETIC CURIE POINT OF THE RARE EARTHS [Molecular Field arises solely from Spin Interactions: No Interactions between Orbital Moments].—Néel. (*Comptes Rendus*, 4th Jan. 1938, Vol. 206, No. 1, pp. 49–51.)

1206. AN X-RAY INVESTIGATION OF THE CAUSE OF HIGH COERCIVITY IN IRON/NICKEL/ALUMINIUM ALLOYS.—Bradley & Taylor. (*Nature*, 11th Dec. 1937, Vol. 140, pp. 1012–1013.)

1207. "KURZGEFASSTES HANDBUCH ALLER LEGIERUNGEN" [Concise Handbook of All Alloys: Book Review].—Jänecke. (*Zeitschr. V.D.I.*, 27th Nov. 1937, Vol. 81, No. 48, pp. 1391–1392.)

1208. THE VARIATION OF THE INITIAL SUSCEPTIBILITY WITH TEMPERATURE, AND THE VARIATION OF THE MAGNETOSTRICTION AND REVERSIBLE SUSCEPTIBILITY WITH TEMPERATURE AND MAGNETISATION IN NICKEL.—Kirkham. (*Phys. Review*, 1st Dec. 1937, Series 2, Vol. 52, No. 11, pp. 1162–1167.) Sequel to work referred to in 3187 of 1936 (Siegel & Quimby).

1209. STALLOY: HYSTERESIS LOSS AT HIGH FLUX DENSITIES.—Roberts. (*Electrician*, 1st Oct. 1937, Vol. 119, pp. 385–386.)

1210. VARIATION OF INITIAL PERMEABILITY WITH DIRECTION IN SINGLE CRYSTALS OF SILICON-IRON.—Williams. (*Phys. Review*, 1st Nov. 1937, Series 2, Vol. 52, No. 9, pp. 1004–1005.)

1211. NEW SILICON-STEEL ALLOY "D.S." [including Magnetisation Curves at Low Magnetic Fields].—(*Rev. Gén. de l'Élec.*, 18th Dec. 1937, Vol. 42, No. 25, p. 784.) For Kostomaroff's paper on the special heat treatments applied to the new alloy *see* also 3591 of 1936.

1212. MECHANICALLY SOFT PERMANENT-MAGNET ALLOYS OF COPPER, NICKEL, AND IRON.—Neumann, Büchner, & Reinboth. (*E.T.Z.*, 2nd Dec. 1937, Vol. 58, No. 48, pp. 1301–1302: summary only.)

1213. The Effect of Change of Temperature on the Strength of Permanent Magnets, with Special Reference to Modern Magnet Steels.—Whiffin. (*Journ. I.E.E.*, Dec. 1937, Vol. 81, No. 492, pp. 727–740.)

1214. Heat Treatments and Structural Hardness [including the Connection with the Magnetic Properties].—Guillet. (*Génie Civil*, 4th Dec. 1937, Vol. 111, No. 23, pp. 473–476.)

1215. On the Diamagnetic Susceptibility of Bismuth [Extension of Existing Theory].—Blackman. (*Proc. Roy. Soc.*, Series A, 19th Nov. 1937, Vol. 163, No. 913, p. S 27: abstract only.)

1216. Symbols in Electromagnetism, with Special Reference to Incremental Magnetisation.—G.W.O.H: Sims: Hartshorn. (*Wireless Engineer*, Nov. 1937, Vol. 14, No. 170, pp. 585–586.) For Sim's tentative symbols, here discussed, *see* 1576 of 1937. This Editorial prompts a letter from Hartshorn asking for a further article on definitions of electric force, electromotive force, potential gradient, and potential difference: "I have never yet found definitions of these quantities that would bear close examination" (*ibid.*, Dec. 1937, No. 171, p. 657).

1217. Regulator Systems for Electro-Magnets [combining Voltage-Actuated Element for Rapid Voltage Changes (thus anticipating Field-Current Change) and Current-Actuated Element for Slow Changes].—Anderson & others. (*Review Scient. Instr.*, Dec. 1937, Vol. 8, No. 12, pp. 497–501.)

1218. Theories and Experiments on Constant-Voltage Devices [using One or Two Iron-Cored Transformers, or the Author's Special Three-Limbed Type giving Nearly Perfect Constancy].—Ohtaka. (*Electrot. Journ.*, Tokyo, Dec. 1937, Vol. 1, No. 7, pp. 198–202.)

1219. Regulated Plate Supplies [by AVC Principle].—Grammer. (*See* 943.)

1220. Electrical Accumulators according to Recent Patents.—Jumau. (*Rev. Gén. de l'Élec.*, 18th & 25th Dec. 1937, Vol. 42, Nos. 25 & 26, pp. 785–799 & 819–826.)

1221. Lead-Calcium for Storage Batteries.—Thomas. (*Bell Lab. Record*, Sept. 1937, Vol. 16, No. 1, pp. 12–16.)

1222. "The Battery Book" [Book Review].—Cross. (*Wireless Engineer*, Jan. 1938, Vol. 15, No. 172, p. 22.)

1223. On the Theory of the Leclanché Battery [opening the Way to Future Development].—Jumau: Kächele & others. (*Rev. Gén. de l'Élec.*, 20th Nov. 1937, Vol. 42, No. 21, pp. 651–653.)

1224. Quenching the Spark at Relay Contacts. Okada & Nakane. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 401–405.)

1225. Vibration Studies [Chatter of Relay Contacts, etc.] with the Rapid Oscillograph [using Wager's "Shadow-Oscillogram" Technique].—Hill: Wager. (*Bell Lab. Record*, Sept. 1937, Vol. 16, No. 1, pp. 26–30.)

1226. Resistance of Silver Contacts.—Williams: Windred. (*Electrician*, 19th Nov. 1937, Vol. 119, p. 596.) From the P.O. Research Station, prompted by Windred's letter (4348 of 1937).

1227. The Behaviour of an Osglim Lamp: I—Introduction, Drift, Equilibrium, and A. C. Bridge Measurements [with Differential Equations for Small Oscillations at Audio-Frequencies]: II—Oscillograph Methods, Steady Motion and Relaxational Oscillations [with Theory deduced from Behaviour Equation of Osglim]: III—Osglims in Parallel forming Models of Reciprocal Inhibition.—Richardson. (*Proc. Roy. Soc.*, Series A, 1st Oct. 1937, Vol. 162, No. 910, pp. 293–316: pp. 316–335: 7th Dec. 1937, Vol. 163, No. 914, pp. 380–390.)

1228. The Cathode Region in the Glow Discharge [Energy of Electrons entering Negative Glow corresponds to Entire Cathode Potential Drop: Only Small Fraction of Energy expended in Crookes Dark Space: Possible Mechanism for Cathode Region].—Brewer & Westhaver. (*Journ. of Applied Physics*, Nov. 1937, Vol. 8, No. 11, pp. 779–782.)

1229. Atomic Hydrogen: II—Surface Effects in the Discharge Tube: III—The Energy Efficiency of Atom Production in a Glow Discharge.—Poole. (*Proc. Roy. Soc.*, Series A, 7th Dec. 1937, Vol. 163, No. 914, pp. 415–423: 424–453.)

1230. Gas Discharges under Low- and High-Frequency Alternating Potentials.—Lindenhovius. (*Physica*, Dec. 1937, Vol. 4, No. 11, pp. 1212–1223: in German.)

1231. On the Influence of the Current Density on the Ionisation Processes in the Independent Discharge in Rare Gases.—Schade. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 18, 1937, pp. 595–598: *Physik. Zeitschr.*, 1st Dec. 1937, Vol. 38, No. 23, pp. 1021–1024.)

1232. The After-Production of Electrons [by a Photoelectric Effect] in the Corona Discharge at Low Pressures [Experiments giving Lower Limit for Share of Photo-electrons in Total Current: Relations between Emission of Light, Current Intensity, and Pressure: Method of counting Electrons by Spark Delay].—Christoph. (*Ann. der Physik*, Series 5, No. 5, Vol. 30, 1937, pp. 446–466.) *See* also 1934 Abstracts, p. 32, r-h column.

STATIONS, DESIGN AND OPERATION

1233. Oscillator and Detector Regions of the Triode Vacuum Tube [used in Ultra-Short-Wave Duplex Telephony with Long-Wave (31 kc/s) Control].—Ohtaka & Hasegawa. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, p. 323.) For this system *see* 689 of February.

1234. An Ultra-Short-Wave Radio Link [Belfast/Stranraer 9-Channel Link].—(*Communications,* Oct. 1937, Vol. 17, No. 10, pp. 22 and 58.) *See* also 4364 & 4365 of 1937.

1235. An Ultra-Short-Wave Circuit for Palomar Observatory [over 90 miles, with Intervening Mountains].—Bailey. (*Bell Lab. Record,* Oct. 1937, Vol. 16, No. 2, pp. 48–52.)

1236. New F.C.C. Allocation of the Ultra-High Frequencies [Editorial on Amateur-Radio Aspect].—(*QST.* Dec. 1937, Vol. 21, No. 12, pp. 7–8.)

1237. A Compact 56 Mc/s Portable-Mobile Transmitter-Receiver.—Lawrence. (*QST*, Dec. 1937, Vol. 21, No. 12, pp. 38–39 and 112.)

1238. Experiments on Extracting the Carrier from Modulated Waves [after Reception: for Radio Relaying and Common-Frequency Broadcasting: Method of Reducing the Degree of Modulation, and Method of Automatically Synchronised Local Oscillator].—Kimura & Goto. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 427–429.)

1239. Carrier-Frequency Wire Broadcasting through Telephone Lines [Survey of Problem: Description of Trials in Japan: Conclusions].—Matumae, Wake, & Inokuchi. (*Nippon Elec. Comm. Eng.*, Nov. 1937, Special Issue, pp. 388–394.)

1240. The New Broadcasting Stations of the French State Network.—Barroux. (*Rev. Gén. de l'Élec.*, 13th & 20th Nov. 1937, Vol. 42, Nos. 20 & 21, pp. 619–639 & 657–665.)

1241. The Direct Radiotelephonic Service between France and the United States.—Villem & Aubert. (*L'Onde Élec.*, Nov. 1937, Vol. 16, No. 191, pp. 589–610.)

1242. A Four-Wire Privacy Equipment for Radiotelephone Circuits.—Builder & Brown. (*AWA Tech. Review*, Oct. 1937, Vol. 3, No. 2, pp. 49–61.)

1243. A Multi-Channel Radio Monitoring System.—Hubbard. (*Bell Lab. Record*, Oct. 1937, Vol. 16, No. 2, pp. 62–65.)

1244. Wireless and the Istres–Damascus–Paris Air Race. (*Bull. de la S.F.R.*, Oct. 1937, Vol. 11, No. 4, pp. 123–130.)

1245. . . . 78° North, 72° West: MacGregor Expedition wintering in Greenland, *and* The MacGregor Expedition Transmitter.—Sayre: MacGregor. (*QST*, Dec. 1937, Vol. 21, No. 12, pp. 27–31 and 94: pp. 94, 96, 98.)

GENERAL PHYSICAL ARTICLES

1246. On the Equations of Electromagnetism: I—Fundamental Identifications: II—Field Theory.—Milne. (*Proc. Roy. Soc.*, Series A, 19th Nov. 1937, Vol. 163, No. 913, pp. S 12–S 13: S 14: abstracts only.)

1247. The Maxwell-Lagrange Equations and their Application to the Theory of Models and the Theory of the Free Electron [establishing the Behaviour of the Electron as a Mechanical Mass varying with Its Velocity].—Jochmans & Descans. (*Rev. Gén. de l'Élec.*, 1st Jan. 1938, Vol. 43, No. 1, pp. 5–19.)

1248. The Influence of Magnetic Fields on the Internal Friction of Gases.—Senftleben & Gladisch. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 18, 1937, pp. 580–582: *Physik. Zeitschr.*, 1st Dec. 1937, Vol. 38, No. 23, pp. 1006–1008.)

1249. The State of Equilibrium between Large and Small Ions in a Gas [Theory of Relative Proportions: Experimental Value].—Te-Tchao & Langevin. (*Comptes Rendus*, 29th Nov. 1937, Vol. 205, No. 22, pp. 1049–1051.)

1250. Charge Exchanges in H- and He- Canal Rays in Gases in the Velocity Range 30–200 ekV.—Meyer. (*Ann. der Physik*, Series 5, No. 7, Vol. 30, 1937, pp. 635–649.)

1251. The Destruction of Electronic Space-Charges by Positive Carrier Beams [Variation with Anode Voltage, Number, Velocity, and Effective Position of Carriers: Effect due chiefly to Change of Potential Distribution in Space-Charge Field].—Kienzle. (*Ann. der Physik*, Series 5, No. 5, Vol. 30, 1937, pp. 401–419.)

1252. The Interaction of Atoms and Molecules with Solid Surfaces: X—The Activation of Adsorbed Atoms by Metallic Electrons: XI—The Dispersal of Energy from an Activated Link: XII—Critical Phenomena in a Two-Dimensional Gas.—Lennard-Jones & Goodwin: Lennard Jones: Devonshire. (*Proc. Roy. Soc.*, Series A, 5th Nov. 1937, Vol 163, No. 912, pp. 101–127: 127–131: 132–138.)

1253. A Calculation of the Surface Tension of a Liquid/Vapour Interface in Terms of van der Waals Force Constants.—Fowler. (*Physica*, Jan. 1938, Vol. 5, No. 1, pp. 39–45: in English.)

1254. The Electrical Conductivity of Single Crystals of Tungsten at Low Temperatures in Strong Transversal and Longitudinal Magnetic Fields [Bearing on Explanation of Metallic Conductivity].—Justi & Scheffers. (*Physik. Zeitschr.*, 15th Nov. 1937, Vol. 38, No. 22, pp. 891–896.)

1255. Reciprocals to Ampère's Law [with Law of Equivalent Electric Shells: Applications to Simple Magneto-Electric Theorems].—Carwile. (*Phil. Mag.*, Jan. 1938, Series 7, Vol. 25, No. 166, pp. 175–183.)

1256. PHYSICS IN 1937.—Osgood. (*Review Scient. Instr.*, Dec. 1937, Vol. 8, No. 12, pp.458–472.)

MISCELLANEOUS

1257. THE METHOD OF IMAGES FOR CALCULATING ELECTRIC AND MAGNETIC FIELDS [Images distributed on Riemann Surface: Combination with Method of Conformal Transformation: Fields of Windings round Iron Cores: Finite Permeability or Dielectric Constant: Conditions at Interface of Two Media: etc.].—Meyerovitz. (*Phil. Mag.*, Jan. 1938, Series 7, Vol. 25, No. 166, pp. 66–90.)

1258. A FUNCTIONAL TRANSFORMATION RELATING TO THE THEORY OF HARMONIC FUNCTIONS [permitting Passage from Two-Dimensional Potential to Three-Dimensional Potential with Axial Symmetry: Application to Physical Problems such as Calculation of Capacity of Condenser formed by Two Thin Coaxial Discs].—Delsarte. (*Comptes Rendus*, 18th Oct. 1937, Vol. 205, No. 16, pp.645–646.)

1259. THE SIMILITUDE RELATIONS PUT IN THE FORM OF DIMENSIONAL EQUATIONS [and Application to a Relay Problem].—Rougé. (*Bull. de la Soc. franç. des Élec.*, Oct. 1937, Vol. 7, No. 82, pp. 973–978.)

1260. THE ISOGRAPH—A MECHANICAL ROOT-FINDER: AND ITS MECHANISM.—Dietzold: Mercner. (*Bell Lab. Record*, Dec. 1937, Vol. 16, No. 4, pp. 130–134: pp. 135–140.)

1261. METHODS FOR THE AUTOMATIC DETERMINATION OF, AND ADJUSTMENT TO, THE MAXIMA AND MINIMA CONDITIONS FOR PHYSICAL QUANTITIES [*e.g.* Automatic Tuning Correction].—Knopfmacher. (*E.T.Z.*, 4th Nov. 1937, Vol. 58, No. 44, p. 1200: summary only.)

1262. THEORY OF AUTOMATIC STEP-BY-STEP ELECTRICAL CONTROL DEPENDENT ON THE DEFLECTION [Theory based on Calculus of Differences: Stability Condition, leading to Design and Adjustment of Regulator].—Lang. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 18, 1937, pp. 318–322.)

1263. A PHOTO-THYRATRON SYSTEM FOR TELEMETERING.—Kovalevskaya. (*Izvestiya Elektroprom. Slab. Toka*, No. 7, 1937, pp. 31–44.) Depending on the frequency variation of a thyratron oscillator caused by a photocell whose illumination is controlled by the moving coil of the meter.

1264. INSTALLATIONS AND EQUIPMENT FOR CARRIER CURRENT TRANSMISSIONS [Technical Principles guiding Choice of Plant, with reference to Type of Coupling to Line, Use of Single or Double Wave Transmission, etc: General Electric Company's Telephony System: Experiments to improve Terminal Apparatus in Simplicity and Safety: etc.].—Bossa. (*Alta Frequenza*, Oct. 1937, Vol. 6, No. 10, pp. 654–675.)

1265. SYSTEM OF SIGNALLING FOR RAILWAYS.—Chireix. (*Rev. Gén. de l'Élec.*, 30th Oct. 1937, Vol. 42, No. 18, pp. 573–574.)

1266. CARRIER TELEPHONE SYSTEMS: APPLICATION TO RAILROAD CIRCUITS.—Affel. (*Bell Tel. System Monograph* B-1007: 12 pp.)

1267. PRESENT TENDENCIES OF POWER DEVELOPMENT AND THEIR REPERCUSSIONS UPON TELECOMMUNICATION SYSTEMS.—Frost. (*P.O. Elec. Eng. Journ.*, April 1937, Vol. 30, Part 1, pp. 1–14.)

1268. COUPLING BETWEEN PARALLEL EARTH-RETURN CIRCUITS UNDER D.C. TRANSIENT CONDITIONS [Tests on Locations giving Large Range of Earth Resistivity].—Gould. (*Bell S. Tech. Journ.*, Oct. 1937, Vol. 16, No. 4, pp. 578–579: summary only.)

1269. ON THE PRINCIPLE OF THE "RESISTANCE" METHOD OF RADIO PROSPECTING.—Fritsch. (*E.T.Z.*, 18th Nov. 1937, Vol. 58, No. 46, pp. 1241–1242.)

1270. A METHOD OF GEOPHYSICAL PROSPECTING USING SKY-WAVE FIELD PATTERNS.—Mingins. (In paper dealt with in 833, above.)

1271. GEOPHYSICAL PROSPECTING: A REVIEW OF METHODS USED ON THE RAND.—Reichenbach. (*South African Engineering*, Sept. 1937, Vol. 48, No. 9, pp. 236–238.)

1272. THE WIRELESS PILOT [Tests with Wireless Direction Finder linked to "P.B." Automatic Pilot of Puss Moth Aeroplane: Applications].—Furnival. (*Marconi Review*, Jan./March 1938, No. 68, pp. 3–9.)

1273. RADIO CONTROL OF MODEL AIRCRAFT: DETAILS OF A SIMPLE SYSTEM [using Ultra-Short Waves].—Hull & Bourne. (*QST*, Oct. 1937, Vol. 21, No. 10, pp. 9–13 and 62, 64.)

1274. THE MAGNETIC ELECTRON MICROSCOPE AND ITS BIOLOGICAL APPLICATIONS [to Colloidal Investigations], *and* THE ELECTRON MICROSCOPE AS AN AID TO COLLOID RESEARCH. Krause: Beischer. (*Naturwiss.*, 17th Dec., 1937, Vol. 25, No. 51, pp. 817–825: pp. 825–829.)

1275. 13 PHYSIKER- UND MATHEMATIKER-TAGUNG, BAD KREUZNACH, 19–24 Sept. 1937 [Summaries].—(*E.T.Z.*, 30th Dec. 1937, Vol. 58, No. 52, pp. 1391–1395.) *See* also the whole of *Zeitschr. f. tech. Phys.*, Nos. 11 & 12, Vol. 18, 1937. Many of the papers have been dealt with separately in these Abstracts.

1276. PUBLICATIONS OF THE AUSTRALIAN RADIO RESEARCH BOARD.—(*Journ of Council for Sci. & Indust. Res. of Australia*, Nov. 1937, Vol. 10, No. 4, pp. 336–337 and 354–355.)

1277. INAUGURAL ADDRESS [by New I.E.E. President: including Possibilities of Closer Cooperation between Engineering Institutions].—Lee. (*Journ. I.E.E.*, Jan. 1938, Vol. 82, No. 493, pp. 1–9.) *See* also *ibid.*, p. 115.

1278. A PHOTOELECTRIC CELL CIRCUIT WITH A LOGARITHMIC RESPONSE.—Russell. (*See* 1081.)

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.

AERIALS AND AERIAL SYSTEMS

475 348.—Short-wave wireless aerial with a coupling device which prevents the flow of signal frequencies along the outer sheath of the feed-line.

E. C. Cork and J. L. Pawsey. Application date 17th March, 1936.

475 855.—Ultra-short-wave aerial comprising a series of coaxial dipoles with a central feed-line of graduated impedance.

Telefunken Co. Convention date (Germany) 22nd April, 1936.

DIRECTIONAL WIRELESS

475 027.—Radio-navigation system in which a moving craft takes bearings on a number of fixed land beacons, means being provided for automatically compensating for any turning movements of the craft relatively to the beacons.

H. J. Sjostrand. Application date 9th March, 1936.

475 090.—Direction-finding receiver in which a balanced modulator is used to reverse the cardioid curve produced by combining the voltage picked up on a frame and non-directional aerial (divided out of No. 474 972).

G. G. Kruesi. Convention date (U.S.A.) 8th February, 1935.

475 853.—Wireless beam system for assisting an aviator to land in fog.

Telefunken Co. Convention date (Germany) 9th April, 1936.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*).

475 028.—System of automatic selectivity control in which the control voltages are derived from a pentode valve in the low-frequency side of the set.

Murphy Radio and G. B. Baker. Application date 11th March, 1936.

475 064.—Tuning indicator in which the critical point is determined by the cessation of low-frequency "beats" due to the mistuned condition of the circuits.

E. K. Cole and G. Bradfield. Application date 20th May, 1936.

475 121.—Tuning indicator for an all-wave set with an optical system which can be varied for coarse and fine adjustments.

Ferranti and A. W. Edwards. Application dates 14th May, 1936 and 24th February, 1937.

475 129.—Preventing undesired capacity effects in valve receivers or amplifiers by a screen which is fed with a high-frequency potential derived from another point in the circuit.

Kolster-Brandes and H. K. Robin. Application date 15th May, 1936.

475 172.—Wireless receiver and loud speaker combined with a clock, the hands of which move over the loud speaker diaphragm.

G. Briggs. Application dates 14th May and 7th October, 1936.

475 379.—Tuning indicator including a "light-permeated transparent rod" used as a pointer.

Radiowerk Horny A-C. Convention date (Austria) 19th February, 1936.

475 400.—Multi-grid amplifier in which negative feed-back is applied to one grid separate from the grid receiving the input signals.

Standard Telephones and Cables (assignees of S. T. Meyers and I. G. Wilson). Convention date (U.S.A.) 20th June, 1936.

475 420.—Two-port stator or rotor condenser for coupling a pair of tuned circuits forming a band-pass input to a wireless receiver.

The Mullard Radio Valve Co. and R. G. Clark. Application date 18th May, 1936.

475 446.—Electrical lines or networks suitable for "volume" expansion and contraction, and for similar automatic regulation of the amplitude of signal currents.

Telefunken Co. Convention date (Germany) 30th September, 1935.

475 463.—Wireless receiver characterised by the use of valve rectifiers and amplifiers which operate on a comparatively low anode voltage.

S. S. Sastry. Application date 16th February, 1937.

475 469.—Amplifying circuit in which negative feed-back is applied through the medium of a pentode valve.

N. V. Philips' Lamp Co. and L. W. Meyer. Application date 2nd April, 1937.

475 490.—Electric wave-filter having constant impedance, high stage-gain, and uniform amplification over a wide range of frequency.

W. S. Percival. Application date 21st February, 1936.

475 531.—Frequency-changing circuit comprising a back-coupled valve to which a master frequency is applied.

Standard Telephones and Cables and B. B. Jacobsen. Application date 22nd May, 1936.

475 532.—Tuning control which is adjustable to one or other of a number of predetermined positions, and is immune from displacement by vibration, particularly for aircraft wireless sets.

Standard Telephones and Cables; S. G. Knight; and E. I. Staples. Application date 22nd May, 1936.

475 643.—Automatic tuning control capable of operating over a wide band of frequencies.

N. V. Philips' Lamp Co. Convention date (Germany) 27th July, 1936.

475 722.—Varying the selectivity of a wireless receiver by differentially combining voltages which are derived from points of high and low resonance.

F. H. Beaumont and Milnes Radio Co. Application date 10th May, 1937.

476 087.—Tuning dial in which the station names are projected on an enlarged scale, each waverange section being individually adjustable.

Ideal Werke Akt-Ges fur drahtlose Telephonie. Convention date (Belgium) 16th March, 1936.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception.

475 008.—Television system specially adapted for distribution over line wires.

Standard Telephones and Cables (assignees of M. W. Baldwin, Junr.). Convention date (U.S.A.) 18th December, 1935.

475 013.—Method of synchronising in picture-transmission, teleprinter, or telewriter systems.

Siemens and Halske Akt. Ges. Convention date (Germany) 5th February, 1936.

475 032.—Interlaced scanning system with means for minimising any lack of register when televising a continuously-moving film.

G. E. Condliffe. Application date 9th April, 1936.

475 046.—Telvision system in which the synchronising impulses consist of rapid excursions of potential from a fixed datum occurring at the "line" frequency.

Baird Television; L. R. Merdler; and A. H. Gilbert. Application date 11th May, 1936.

475 189.—Scanning system in which the frame synchronising impulses are each split up into (*a*) preparatory and (*b*) an actuating signal.

Telefunken Co. Convention date (Germany) 15th May, 1935.

475 473.—Preventing the type of interference which produces a false distribution of brightness in television systems utilising transmitter tubes of the Iconoscope type.

Telefunken Co. Convention date (Germany) 28th April, 1936.

475 517.—Television "relayer" in which a transient image sent over a low-frequency channel is reconstituted and then scanned at a different speed.

Baird Television and V. Jones. Application date 21st May, 1936.

475 595.—Means for transforming a sinusoidal frequency into unilateral impulses of reduced frequency, particularly for synchronising in television.

Radio-Akt D. S. Loewe. Convention date (Germany) 27th July, 1935.

475 715.—Cathode-ray television system in which an optical image is projected on one layer or screen of photo-emissive material, whilst a scanning stream of electrons is made to traverse a second adjacent sensitive screen.

Electrical Research Products Inc. Convention date (U.S.A.) 4th March, 1936.

475 768.—"Balanced" detector, supplied with a local source of oscillations, for signals covering a wide band of frequencies, such as television.

Standard Telephones and Cables (assignees of Le Materiel Telephonique). Convention date (France) 5th May, 1936.

475 928.—Method of converting an electron image of a picture to be televised into signal currents by utilising the effect of secondary emission.

Electric and Musical Industries and H. G. Lubszynski. Application date 20th May, 1936.

475 971.—Light-valve, particularly for use in television, in which the refractive medium is traversed by high-frequency compressional waves.

M. J. Goddard. Application date 9th June, 1936.

475 999.—Arrangement for effecting "optical multiplication" in mechanical scanning devices used in television.

R. G. Wilson and W. D. Silver. Application date, 3rd February, 1937.

476 067.—Amplifiers of the double-sided output type, particularly adapted for handling television signals, including signal components of substantially "zero" frequency.

The General Electric Co., and D. C. Espley. Application dates 22nd July 1936 and 8th June. 1937.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

475 048.—Constant frequency oscillation-generator of the magnetron type, in which the external coil is fed from the same source as the anode of the valve so as to offset fluctuations in the supply voltage.

Baird Television and R. J. H. Forman. Application date, 11th May, 1936.

475 105.—Keying a wireless transmitter by varying the potential of the screen grid of a tetrode or other multigrid valve.

Marconi's W. T. Co. and D. F. George. Application date 12th May, 1936.

475 239.—System of multiplex signalling in which the different conversations are recorded or stored up on a photo-sensitive surface before being transmitted consecutively.

F. C. P. Henroteau. Convention date (Belgium) 16th January, 1937.

475 310.—High-frequency transmission line including an amplifier with negative feed-back and gain control.

Standard Telephones and Cables (assignees of S. Doba, Junr.). Convention date (U.S.A.) 11th December, 1935.

475 397.—Short-wave radio transmitting valve with a series resonant circuit in the grid circuit to suppress harmonics.

Telefunken Co. Convention date (Germany) 2nd May, 1936.

475 530.—Thermionic oscillation-generator in which the frequency is stabilised against fluctuations in the supply voltage.

Standard Telephones and Cables; B. B. Jacobsen; and V. J. Terry. Application date 22nd May, 1936.

475 621.—Modulating system in which a constant-current choke is combined with means for varying the radio-frequency losses in accordance with the applied signal.
Marconi's W. T. Co. (assignees of F. E. Terman). Convention date (U.S.A.) 9th March, 1936.

475 673.—Thermionic oscillation-generator comprising four or more valves arranged with their anode-grid paths in series.
Telephone Manufacturing Co. and L. H. Paddle (addition to 450 967). *Application date 30th June,* 1936.

475 718.—Multiplex signalling system in which one carrier wave is modulated by a number of intermediate frequencies which, in turn, carry the signals
L. Pungs. Convention date (Germany) 21st February, 1936.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

474 834.—Method of preparing metal-hydride electrodes capable of giving copious secondary-emission.
Baird Television and E. B. King. Application date 11th May, 1936.

475 047.—Use of a positively-biased grid to "help the electrons through" in a cathode-ray tube of the image-dessecting type.
Baird Television; V. Jones; and P. W. Willans. Application date 11th May, 1936.

475 100.—Photo-sensitive electrode consisting of a surface of silver Telluride covered with a layer of caesium-tellurium compounds.
Baird Television and A. K. Denisoff. Application date 12th May, 1936.

475 106.—Electron "beam" valve wherein a number of electron "jets" are projected from a single cathode through an arrangement of slotted electrodes.
Marconi's W.T. Co. and E. O. Smith. Applicasion date, 12th May, 1936.

475 376.—Ultra-short-wave amplifier and generator in which focussing electrodes are used to control the flow of the electron stream.
Standard Telephones and Cables (assignees of R. A. Heising). Convention date (U.S.A.) 3rd October, 1935.

475 457.—Construction of a transmitting valve capable of generating ultra-short waves at a high level of energy.
Marconi's W.T. Co. (communicated by the Telefunken Co.). Application date 31st December, 1936.

475 480.—Method of fitting water-cooled transmitting valves with thoreated cathodes.
The British Thomson-Houston Co. Convention date (Germany) 20th June, 1936.

475 521.—Flexible cathode mounting for directly-heated valves suitable for battery-driven sets.
N. V. Philips' Lamp Co. Convention date (Holland) 3rd August, 1935.

475 527.—Construction of deflecting-magnet for a cathode-ray tube.
Fernseh Akt. Convention date (Germany), 23rd May, 1935.

475 539.—Construction of deflecting coils, substantially trapezoidal in cross-section, for use with a cathode-ray tube.
Fernseh akt (addition to 475 527). *Convention date (Germany) 24th October,* 1935.

475 620.—Indirectly-heated cathode structure for a valve in which the emissive surfaces are shaped like a double convex lens.
Telefunken Co. Convention date (Germany) 3rd March, 1936.

475 665.—Forming the stub-end, and sealing the leading-in wires to the electrodes of a thermionic valve.
M.O. Valve Co. and C. J. Smithells. Application date 2nd June, 1936.

475 769.—Secondary-emission electrode systems for high-powered oscillation-generators, particularly of the magnetron type.
Telefunken Co. Convention date (Germany) 2nd April, 1936.

475 772.—Preventing the chemical constituents of the fluorescent screen of a cathode-ray tube from shortening the effective "life" of the cathode.
N. V. Philips' Lamp Co. Convention date (Holland) 14th April, 1936.

475 807.—Photo-sensitive tube, comprising a heated cathode, a conical shielding member with an outer ring, anode, and a photo-electric layer deposited on the inner wall of the glass bulb.
Baird Television and E. B. King. Application dates 25th May and 20th August, 1936.

SUBSIDIARY APPARATUS AND MATERIALS

475 088.—Compact rectifier and transformer unit for supplying power to a wireless set. (Divided from No. 472 046).
G. W. Johnson. Application date, 11th March, 1936.

475 104.—Temperature-compensated tuning inductance.
Marconi's W.T. Co. and D. A. Bell. Application date 12th May, 1936.

475 275.—Wave filter comprising a symmetrical network of impedances and mechanically-vibrating coupling devices, such as piezo-electric crystals.
Standard Telephones and Cables (assignees of W. P. Mason). Convention dates (U.S.A.) 2nd and 27th July, 1935.

475 482.—Method of cutting piezo-electric crystal rods so that the longitudinal axis coincides with the axis with the minimum modulus of elasticity.
The British Thomson-Houston Co. Convention date (Germany) 29th June, 1936.

475 492.—Electromagnetic pick-up in which the axis of percussion of the armature and needle coincides substantially with the axis of rotation.
Telefunken Co. Convention date (Germany) 12th April, 1935.

475 582.—Mixture of zinc salts used to prepare a white-light fluorescent screen for a cathode-ray tube.
S. T. Henderson. Application date 22nd May, 1936.