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Editorial

A Classic Experiment

WHEN a condenser is charged in the ordinary way, the total electric displacement within the dielectric space may be regarded as made up of two components, one being that which would exist in the absence of the material dielectric —the Maxwellian displacement—and the other, a less debatable item, that due to elastic displacements of the molecular constituents. Assuming for simplicity a plate condenser of large area in which the electric field may be assumed uniform, let the charge per square cm on the plates be σ, then in the absence of a material dielectric the electric field strength would be $\mathcal{E}_1 = 4\pi\sigma$ (adopting the absolute electrostatic system of units in which $\kappa_0 = 1$). With a material dielectric of dielectric constant κ, there will be an elastic displacement or polarisation causing surface charges of $\sigma(1 - 1/\kappa)$ of opposite sign to the charges on the plates. These may be regarded as producing an electric force in the dielectric space of $\mathcal{E}_2 = 4\pi\sigma(1 - 1/\kappa)$ and the resultant electric force will be $\mathcal{E}_3 = \mathcal{E}_1 - \mathcal{E}_2 = 4\pi\sigma/\kappa$, which exists throughout the dielectric and maintains the molecular displacement $\sigma(1 - 1/\kappa)$. Hence, the ratio of the molecular displacement to the resultant electric force is $(\kappa - 1)/4\pi$, and that of the resultant electric field $\mathcal{E}_3$ to the initial electric field $\mathcal{E}_1$ is $1/\kappa$, the charge being assumed constant.

If a metal disc or cylinder be rotated about its axis in an axial magnetic field, a radial electromotive force will be induced and charges will gather on the outer and inner surfaces and throughout the mass until they produce throughout the metal an electric force exactly equal and opposite to that due to the rotation in the magnetic field. It simplifies the problem to assume a long cylinder and neglect the end effects. If the magnetic flux passing through the metal cylinder be ϕ and the cylinder be rotated at n revolutions per second, the P.D. between the outer surfaces will be $n\phi 10^{-8}$ volts.

But what will happen if the cylinder be made of some dielectric material with thin metal coatings on the outside and inside? At first sight this does not look a very difficult question to answer, but in the Philosophical Transactions of the Royal Society for 1905 (A. vol. 204, p. 121) there is an account of an elaborate experiment carried out by Prof. H. A. Wilson in the Cavendish Laboratory to settle what was then regarded as a debatable question. The result obtained was regarded as confirming the views of H. A. Lorentz and Larmor and disproving Hertz's form of

Maxwell's theory. It must be remembered that at that time scientists discussed the relative merits of fixed and moving ethers. Wilson rotated an ebonite cylinder at speeds up to 12,000 revolutions per minute inside a water-cooled solenoid capable of producing a magnetic field strength of 200, and measured the resulting P.D. on a quadrant electrometer. Brushes rubbed on brass liners inside and outside the ebonite cylinder.

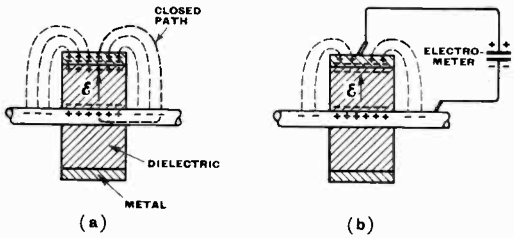
When such a dielectric is rotated the electronic constituents of the molecules will, owing to their rotation in the magnetic field, experience the same radial force as did those in the metal, and this will cause an elastic displacement of these constituents and the production of surface charges of opposite sign at the outer and inner surfaces. These charges will not be so large as in the case of the metal cylinder, because, instead of entirely neutralising the induced radial force, they can only reduce it to the value corresponding to the elastic displacement throughout the dielectric. The displacement increases until a state of equilibrium is attained. Just as the speed of a shunt motor increases until the back E.M.F. just falls short of the applied P.D. by sufficient to drive the necessary current through the armature resistance, so the displacement increases until the back electric force just falls short of the induced electric force by sufficient to maintain the displacement. Whether the rotating cylinder be of metal or dielectric the induced $\mathcal{E}_1$ is the same, but whereas in the former case σ increases until $\mathcal{E}_1 - \mathcal{E}_2 = 0$, in the latter case σ only reaches such a value that $\mathcal{E}_1 - \mathcal{E}_2 = \mathcal{E}_3$, where, as we have already seen, $\frac{\mathcal{E}_3}{\mathcal{E}_1} = \frac{1}{\kappa}$. Hence the surface charge, to which $\mathcal{E}_2$ is proportional, is reduced in the ratio

$$\frac{\mathcal{E}_1 - \mathcal{E}_3}{\mathcal{E}_1} = 1 - \frac{1}{\kappa}.$$

For two outwardly similar cylinders the P.D. between the terminal surfaces will be proportional to the charges on them and independent of the nature of the generator within the cylinder. Hence in the case of the dielectric cylinder the P.D. should be $n\phi\left(1 - \frac{1}{\kappa}\right)10^{-8}$ volts.

This is not strictly correct. Wilson actually found that the P.D. was less than this, viz. $n\phi\left(1 - \frac{1}{\kappa}\right)10^{-8} - Q/C$, where Q and C are the charge and capacitance of the condenser, as if the cylindrical condenser were in series with a generator with an E.M.F. of $n\phi(1 - 1/\kappa)$. Wilson also showed that this is theoretically correct. In the rotating cylinder $\mathcal{E}_1$ acts only on the molecular constituents whereas in the ordinary condenser it also acts on the space. The displacement corresponding to $\mathcal{E}_2$ causes a difference between the charges on the dielectric and on the metal ring so that they cannot be exactly equal as shown in the figures.

The measurement of the P.D., however, leads to difficulties and introduces important differences between the metal and dielectric cylinders. In the case of the metal cylinder, the capacitance of the quadrant electrometer and of the wires connecting it to the brushes does not affect the reading since electrons continue to flow until the whole



is charged to the P.D. of $n\phi 10^{-8}$ volts. With the dielectric cylinder, however, conditions are very different since there is only a limited charge which must be distributed between the cylinder and the electrometer with a consequent drop of P.D. This is illustrated in the figure in which the dielectric cylinder is mounted directly on the shaft and surrounded by a metal ring, the thickness of which is greatly exaggerated. In (a) the P.D. between the outer ring and the shaft will be $n\phi 10^{-8}(1 - 1/\kappa) - Q/C$ volts, the positive displacement charge on the surface of the dielectric being partly neutralised by a negative charge on the inside of the metal ring, leaving a positive charge on its outer surface. In (b) a part of this positive charge passes to the electrometer, thus lowering the charge and the potential of the metal ring. If the charge were constant the potential would be reduced in the same ratio as the capacitance is increased, but things are not quite so simple, since the removal of a part of the charge from the metal ring reduces the back electric force $\mathcal{E}_2$ in the dielectric and thus allows the induced electric force $\mathcal{E}_1$ to produce a greater displacement. In the case of the metal cylinder $\mathcal{E}_1$ and $\mathcal{E}_2$ were exactly equal and opposite; if the surface charge on the cylinder in that case were Q_1 then in the case of the dielectric cylinder alone the surface charge would be reduced to Q_2, but if now the electrometer be connected, although the total molecular displacement and therefore the total charge be increased to Q_3, a part of this will go to charge the electrometer and only a part will remain on the metal ring. Prof. Wilson shows that the external capacitance C' of the cylinder together with the wires and electrometer may be regarded as in series with the internal capacitance C, so that

$$V = EC/(C + C') \text{ where } E = n\phi 10^{-8}(1 - 1/\kappa)$$

It might be thought that the E.M.F.—that is the line integral of the electric force—around a closed path such as that shown dotted in the Figure (a) would be equal to $n\phi 10^{-8}$ volts in all cases, and that only its distribution would vary. In the case of the metal cylinder there is no internal resultant force, and the whole of the integrated voltage is external, but it would be more in accordance with electrical engineering language to say that the E.M.F. induced by the rotation in the magnetic field is equal to $n\phi 10^{-8}$ volts; all other electric forces, being due to charges, which for this purpose may be regarded as static, must give zero resultant when integrated around a closed path. In the dielectric cylinder, however, there are no charges free to move from the inner to the outer surface and thus integrate the electric force $\mathcal{E}_1$ acting upon them. Both theory and experiment show that the closed path in Fig. (a) may be regarded as made up of two condensers in series, the internal and the external, the former of which contains a source of E.M.F. equal to $n\phi 10^{-8}(1 - 1/\kappa)$. It is interesting to note that the same results would be obtained if the cylinder were replaced by a number of concentric conducting cylinders with air spaces between so that of the total radial depth, a fraction $1 - 1/\kappa$ was occupied by conductor and the remaining $1/\kappa$ by air. Not only would the induced E.M.F. be $n\phi 10^{-8}(1 - 1/\kappa)$ but the condenser, having its radial depth reduced to $1/\kappa$, and having its dielectric constant reduced in the same ratio, would have the same capacitance.

G. W. O. H.

The "turnstile" aerial at W2XCR, formerly W2AG, the 600-watt, 110-Mc/s station of C. R. Runyon, at Yonkers, New York, which uses Major Edwin H. Armstrong's system of frequency modulation. Articles in the May 11th and 18th issues of "The Wireless World" describe reception tests on some of the twelve American stations using frequency modulation.

Pentode and Tetrode Output Valves*

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SUMMARY.—An attempt has been made, by investigating the static and dynamic characteristics of screen-grid valves, to lay down the requirements that the static characteristic of such a valve must fulfil, in order to ensure a minimum of distortion in the output under all circumstances.

To meet these requirements it is necessary to suppress secondary emission and to make the deflection of the electron paths in the grids as small as possible. The passage of secondary electrons between two electrodes is subjected to closer examination, an enquiry being made into the possibility of preventing this passage of electrons by the use of two methods of suppression: a space charge and a suppressor grid. The optimum effect is obtained by the co-operation of both these expedients, the more potent of the two being the suppressor grid. By judicially planning the geometrical positions of the electrodes, deflection of the electron paths can be reduced to small magnitudes.

§ 1. External Load Circuit

IN determining the requirements, which should be fulfilled by the characteristics of screen-grid output valves in order to avoid distortion as much as possible, we must first consider the load circuit into which the valve is to deliver its energy.

It is usual to draw a straight line in a set of anode current/anode voltage characteristics, to represent the load where the valve delivers its energy to a resistance (line a in Fig. 1), in order to indicate how the anode current and voltage vary when an A.C. voltage is applied to the control grid. The slope of this line is a measure of the resistance used. This resistance is generally given such a value that, at full swing of the valve, the energy absorbed in the resistance is a maximum. The corresponding line for a given screen-grid output valve is generally one that passes approximately through the bend of the particular anode current/anode voltage curve which applies when the control grid voltage is nil. This resistance is approximately $R_a = \frac{V_a}{I_a}$, where V_a and I_a are the D.C. anode voltage and D.C. anode current respectively. Sometimes, for instance with tetrodes, a smaller resistance may be recommended, giving less distortion but at a lower efficiency. The loud speaker, to which the output valve is to deliver its energy, is usually connected via a transformer with such a ratio of turns that its input impedance tallies as closely as possible with this optimum resistance value. The impedance of a loud speaker, however, is not constant for all frequencies and even a good one shows very wide variations for

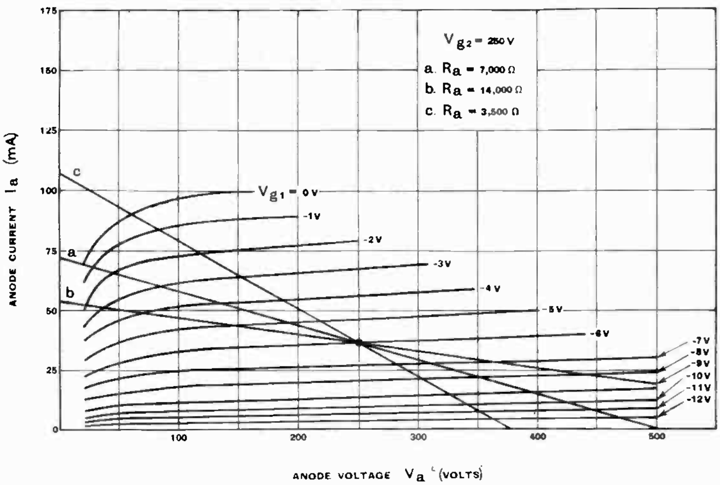

Fig. 1.—$I_a - V_a$ *characteristic, using as parameter the control grid voltage* (V_{g1}). *Line a gives the dynamic characteristic in the case of a resistance load (resistance line) at maximum output. The resistance lines b and c apply respectively for large and small resistance values.*

*MS. accepted by the Editor, February, 1939.

the different frequencies in the audible range; this is plainly shown by the curve a for such a loud speaker as given in Fig. 2(a). For higher frequencies the impedance increases considerably. The primary of the transformer is often shunted by a condenser, thus diminishing the impedance and hence also the sensitivity to high frequencies (curve a_1 in Fig. 2(a)).

Curves b and b_1 show the corresponding variation of impedance with frequency for a speaker with an additional damping ring which has been inserted to keep the impedance constant over a larger range of frequencies. Even then the impedance may still vary by a factor of about 4. For this

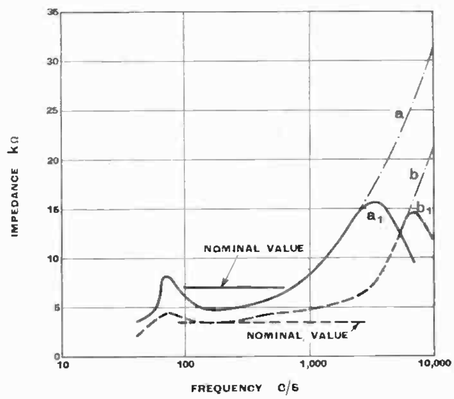

Fig. 2(*a*).—*Impedance characteristic of a loud speaker and its transformer as a function of frequency. a is the curve for a good moving-coil speaker ; a_1 the curve with a condenser of* 2,000 $\mu\mu F$ *across the primary of the output transformer ; b and b_1 the curves for a speaker with a special damping ring.*

reason it will not be sufficient to indicate the load by only one line on the current characteristics. We cannot, therefore, simply have one particular load characteristic extending as far as the sharp bend of the I_a/V_a characteristic at $V_{g1} = 0$ volt, thus giving a wide swing of the anode voltage. Output measurements with one matching resistance, as sometimes given in published data, are therefore incomplete and entail the risk of making too favourable an estimate, because in practice a frequency variation, with an accompanying impedance variation, causes a rapid decline of output for a given distortion. Hence, in order to have a proper criterion for the quality of an output valve, the dependence of distortion upon the value of the load impedance should be taken into account. Considering the phase angle of the load in the anode circuit, the angle may also be seen to be

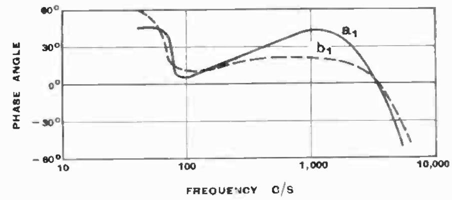

Fig. 2(*b*).—*Phase angle characteristic as a function of frequency for a load comprising the speaker and its transformer and a parallel condenser of* 2,000 $\mu\mu F$.

largely dependent upon frequency. In Fig. 2(b) we have plotted, for the same loud speakers as in Fig. 2(a), the phase angle of the loud speaker with a transformer and a condenser connected in parallel, as a function of frequency. On account of the phase shift between voltage and current, the dynamic anode current/anode voltage characteristic for one frequency will not be a straight line but an elliptical figure, covering a certain area of operation. If several frequencies are present at a time, the area covered will consequently be greater. We

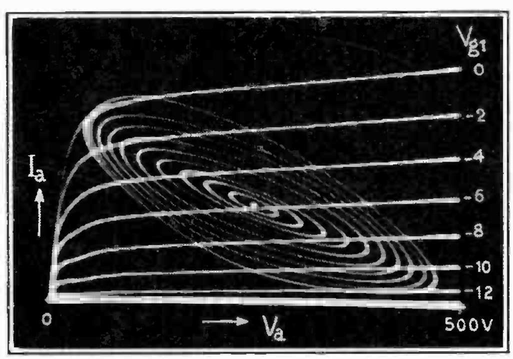

Fig. 3.—*Photograph, taken with the aid of a cathode-ray tube, of dynamic load characteristics for different A.C. grid voltages of a pentode output valve, on the graph of the $I_a - V_a$ characteristics. The elliptical shape of the dynamic curves is caused by the phase shift of the loud speaker. Distortion can be seen as deformation of the pure elliptical shape.*

must therefore investigate what part of the characteristics will be covered and what influence the shape of these characteristics has upon the distortion of the output and upon the maximum output which the valve can give.

§ 2. Dynamic Characteristics

Fig. 3 gives a photograph, obtained with the aid of a cathode-ray tube, which shows the dynamic load characteristics of a pentode output valve on the graph of the $I_a - V_a$ characteristics. These elliptical figures were obtained with a loud speaker serving as anode load. An A.C. voltage of a given frequency and of increasing amplitude was applied to the control grid of the output valve during operation. It is evident from this figure, in contrast to Fig. 1, that a particularly large area of the $I_a - V_a$ graph is traversed at the higher amplitudes.

In practice, however, there is not only the one frequency present, but a complex wave form, containing a large number of frequencies simultaneously. In order to find out how far the swept area is influenced by such a complex waveform, we have given in Fig. 4 (a), (b), (c) and (d) by way of illustration four photographs of figures which are produced on the cathode-ray tube, when two A.C. voltages of different frequencies are simultaneously applied to the control grid. Fig. 4(a) was obtained with two voltages

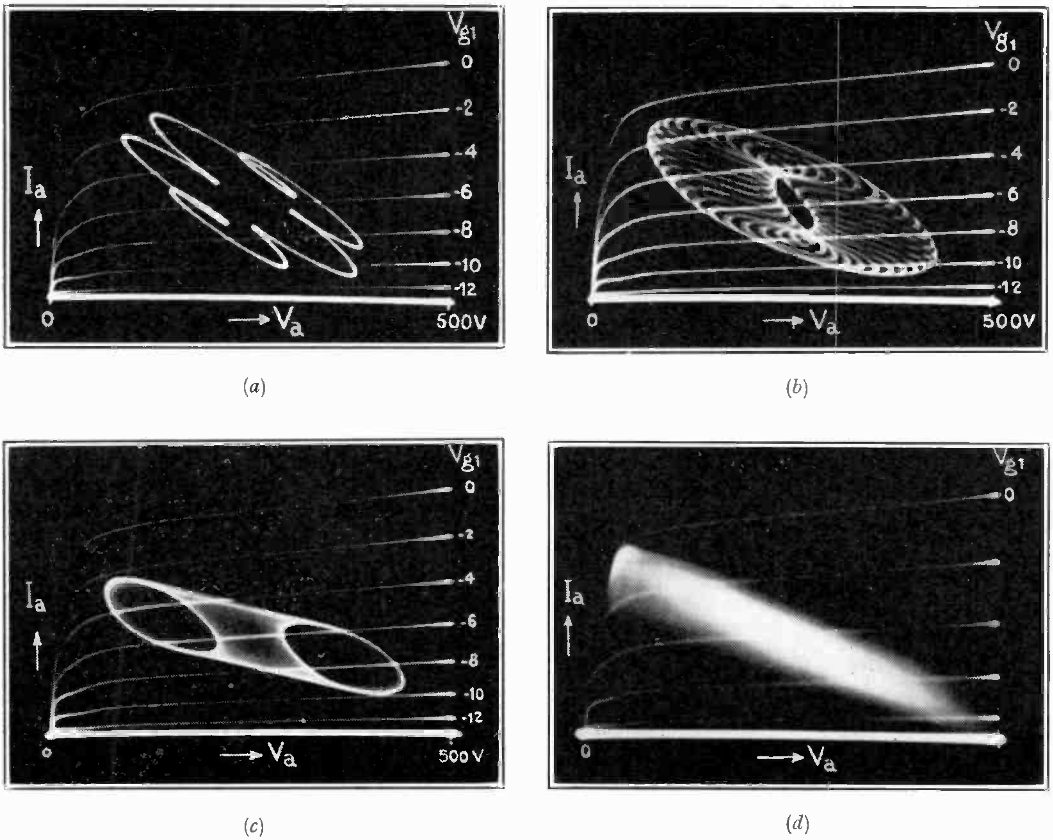

Fig. 4.—*Photographs taken with the aid of a cathode-ray tube, of dynamic load characteristics on the graph of the* $I_a - V_a$ *characteristics.* (a) *On the control grid are two A.C. voltages whose frequencies differ by a factor* 6. (b) *Ditto, with frequencies differing by a factor* 30. (c) *Same as* (b), *but with phase-shift equal to nil at the highest frequency.* (d) *A music signal has been operating on the control grid for some time, so that on the photograph it can be seen how very wide is the region traversed by the dynamic characteristics. This considerable width does not show up to full advantage in the photograph owing to predominance of the small amplitudes.*

differing in frequency by a factor 6. On account of the fact that the loud speaker causes a phase-shift for both frequencies, the resulting dynamic figure is very broad and covers a large area. This is still more plainly shown by Fig 4(b), corresponding to a similar case in which the frequencies differed by a factor 30. As can be seen from Fig. 2(b), the phase-shift for a speaker transformer, which is shunted by a condenser, may become nil at a certain frequency. Fig. 4(c) gives the dynamic load characteristic for a case in which two voltages having different frequencies are simultaneously applied to the control grid, and in which no phase-shift is caused by the loud speaker for the higher of the two. Here, again, the figure clearly shows how the widening is brought about by joining together the straight lines and elliptical figures. In practice the voltage across the loud speaker during the reproduction of music will be made up of a large number of simultaneous voltages of differing frequencies which, at any considerable intensity, cover a large portion of the field of the $I_a - V_a$ curves as shown in Fig. 4(d). This photograph is the result of a long exposure during which music and speech signals had been applied to the control grid of the valve.

What can be learnt from these curves? It is obvious that, when designing a screen-grid output valve and judging its performance, we must consider almost the entire area of the $I_a - V_a$ characteristics. It is reasonable to assume, however, that the portion of the graph for low anode current and low anode voltage is hardly ever used. We will revert to this later on. Fig. 3 shows that for very small amplitudes the dynamic characteristic is an ellipse, whereas at larger amplitudes a certain deforma-tion of this figure is noticeable.

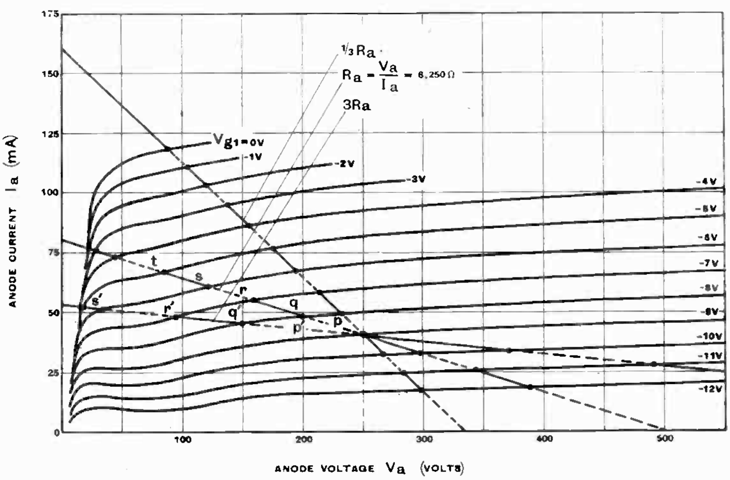

Fig. 5.—$I_a - V_a$ *characteristics for a "beam tetrode," using the control grid voltage as parameter. For normal load resistance* $\frac{V_a}{I_a} = R_a$, $p = q = r = s = t$; *hence litte distortion. For* $3R_a$, p' *and* $r' \gg q'$ *and* s'; *this means distortion.*

We can investigate thereasons for this with the aid of the $I_a - V_a$ characteristics. If these curves in the observed area were parallel straight lines which were equidistant for equal increments of the negative grid bias, no deformation of the ellipse would occur until the dynamic curves touched the horizontal or the vertical axis. It is, however, not possible to achieve characteristics of this form, for the simple reason that the relation between the anode current and the voltage of the control grid follows a 3/2 power law, so that the lines can never be equidistant.

Nevertheless, it will be a desirable characteristic from the point of view of distortion, if the $I_a - V_a$ curves are made as equidistant as possible; in other words, the $I_a - V_{g1}$ curve should be as straight as possible and show *as sharp a bottom bend as possible* (absence of "tail.") When using two valves in push-pull it is sometimes recommended that the $I_a - V_{g1}$ curve be a quadratic one, thus making the bottom bend less sharp, as the push-pull operation can then be used to neutralise the quadratic component of the distortion caused by the bottom bend. Such a valve could not be used alone, as it would give too much distortion, chiefly quadratic.

In order to judge distortion in the case of radio apparatus covering a bandwidth of 8 kilocycles, we must attribute approximately the same nuisance value to the 2nd and 3rd harmonics (see article on this subject by Ir. Heins van der Ven accepted for future publication in this journal).

If, for large anode currents, the valve has a low internal resistance, the $I_a - V_a$ curves will no longer run parallel but will show a fanlike distribution, as the internal resistance

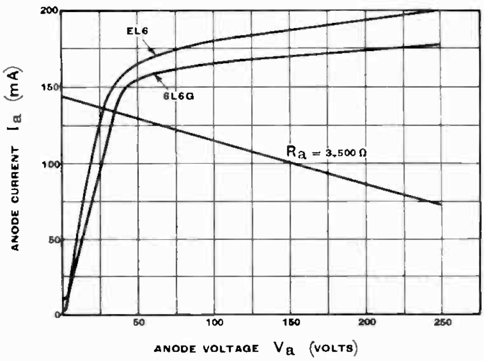

Fig. 6 (*a*).—*Anode current-anode voltage characteristics for a tetrode and for a pentode, with zero control grid voltage. Secondary emission in both valves is completely suppressed.*

is, e.g. dependent upon the anode current. As this may cause distortion, it is desirable to have a *high internal resistance* (with respect to the loud speaker impedance). The variation of the internal resistance has then practically no influence. Should a low internal resistance be desired in certain cases, it will be better to obtain it by means of an inverse back-coupling.

Moreover, we wish to see straight lines for these $I_a - V_a$ characteristics. To achieve this result we must of course *completely suppress secondary emission in the region used*[1]*, as it may cause very great deviations. This point is all the more important because secondary emission may sometimes cause a deviation in the middle of the characteristic, so that deformation of the dynamic curve and hence distortion may occur even at low amplitudes. This is particularly the case if the $I_a - V_a$ curve, when distorted by secondary emission, is intersected by the dynamic curve at a small angle, i.e. when the load resistance is high.

We have drawn in Fig. 5 a set of $I_a - V_a$ curves for a beam tetrode, inserting the resistance lines for normal load R_a, for $1/3\ R_a$ and for $3\ R_a$.

* A bibliography will be published at the end of the concluding instalment.

The various $I_a - V_a$ curves, plotted at a negative control grid voltage ascending by 1 volt for each curve, cut the resistance line into sections. No distortion occurs when these sections are equal.

It will be seen clearly that the normal R_a meets this requirement fairly well, the cut-off sections being $p = q = r = s = t$. For $3\ R_a$, however, p' and r' are greater than q' and s'. This represents distortion due to residual secondary emission.

With a smaller load resistance ($1/3\ R_a$) there is less trouble in this respect.

In the tetrode it is practically impossible to suppress secondary emission over the whole region used. We can, however, achieve this in the pentode, as has been done in some of the newer types. Figs. 6 (a) and 6 (b) give an illustration of this. For low control grid voltage and consequently high anode currents (Fig. 6a), secondary emission in both valves has been completely suppressed. For high control grid voltage and low anode currents (Fig. 6b), secondary emission in the tetrode causes deflection of the characteristic up to much higher anode voltages.

In Fig. 7 the efficiency of a good pentode and tetrode has been plotted for different anode impedances, at constant phase angle

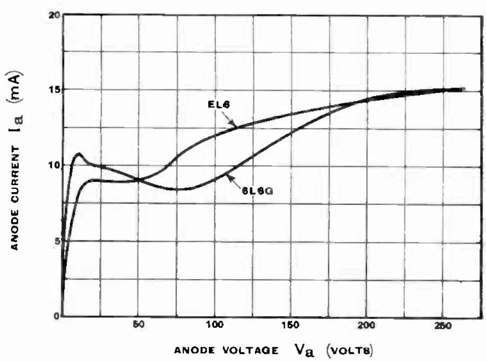

Fig. 6 (*b*).—*Ditto for the same valves with a control grid voltage, so that at $V_a = 250$ volts I_a is 15 mA. Secondary emission has been suppressed in the pentode at a much lower anode voltage.*

with $\cos\phi = 0.7$ and 5 per cent. distortion. The pentode gives a much better characteristic.

Audition tests have shown that the more suddenly the deflections in the dynamic curves take place, the more disturbing they are to the ear, owing to the occurrence of harmonics of a higher order. The sudden nature of the deflection as a result of positive control grid current is therefore the cause of this particularly annoying distortion. So we must do something to pre-

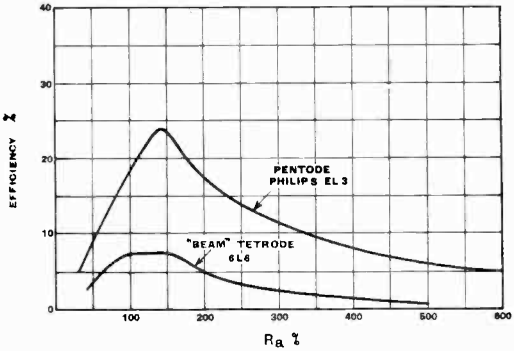

Fig. 7.—*Efficiency characteristic of a good pentode and of a beam tetrode, as a function of the load impedance for* $\cos\phi = 0.7$ *and 5 per cent. distortion. The pentode gives a far more favourable curve.*

$R_a = 100\% = $ *Normal load impedance* $= V_a/I_a$.

vent it. The $I_a - V_{g1}$ characteristic should therefore cover a sufficiently wide field, so that the maximum output is not limited *by distortion due to control grid current* producing numerous higher harmonics, but only by the less troublesome distortion due to gradual curvature of the characteristic. Overloads will not then have such a disagreeable effect.

At higher alternating voltage amplitudes in the anode circuit, the ultimate value of the output energy will in this case be limited by a compression, as it were, of the dynamic curves above and below. It is therefore essential to shift this limitation to as remote a position as possible. Moreover, the distortion caused by this compression of the dynamic curves must be reduced to a minimum. The lower side is limited, as we have seen, by the bottom bend of the $I_a = V_{g1}$ characteristic. The upper side is limited by the $I_a - V_a$ characteristic when the control grid voltage is equal to nil, as the positive control grid current begins at this point. If, by selecting a suitable value for the load impedance, we carry the amplitude a long way forward, it has finally to come as close as possible to the vertical axis.

By providing for a better distribution of current between the anode and screen-grid at low anode voltages we can *make the elbow of the* I_a - V_a *curves occur at low anode voltages.* In this respect, too, some of the new type pentodes are far ahead of their predecessors. The maximum efficiency has been increased and secondary emission suppressed over the entire field of operation. In order to achieve this the effect of a suppressor grid and of space charge had to be submitted to close examination, but it was necessary in the first place to learn more about the nature of secondary emission as it occurs in a screen-grid output valve, and the manner in which it is transmitted to another electrode. This will be dealt with in the next section.

§ 3. Secondary Emission

In order to be able to eliminate the unwanted deformation of the characteristic caused by secondary emission in a screen-grid output valve, it was first necessary to investigate the properties of this secondary emission and the manner in which it can be intercepted by another electrode.

(*a*) It is known that metals have a rather high secondary emission, whereas carbon, for instance, has a low secondary emission. Secondary emission is usually measured by the ratio between the total number of secondary electrons emitted and the number of primary electrons by which it was caused, so that $\delta = I_s/I_p$. This δ depends upon the primary voltage of the electrode from which the secondary emission emanates and the angle at which the primary electrons impinge on the electrode. This angle generally is 90°. Measured by this standard, *Ni* gives for δ a value of 1.2 at a primary voltage of 250 volts, *Cu* at this voltage gives 1.1, *Mo* 1.2, whereas a carbon-coated *Ni* plate yields a δ of 0.34[2,3,4,5,8]. It is therefore obviously desirable to use for the anode a material having a low δ, such as in the latter case.

It is a fact, however, that even with carbon or carbon-coated metals the secondary emission is still unduly high and liable to cause serious deviation of the characteristic. Increased secondary emission in a valve may also be caused by volatilising cathode material, for instance on the carbon coating, or by residual traces of gas [6,7,8].

When, as a result of the bombardment of primary electrons, secondary electrons are liberated, the latter will emerge in different directions,[9 10 11] and with different velocities.[4 8 12 13]

(*b*) The fact that the mean velocity of the secondary electrons is lower than that of the primary electrons, places in our hands a means of suppressing the influence of secondary emission.

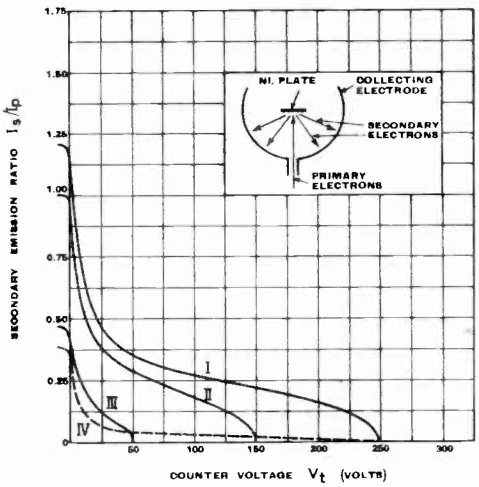

Fig. 8.—*The curves indicate how the ratio of the secondary electron current picked up on the sphere to the primary electron current, varies at different values of the potential difference (counter-voltage) V_t between sphere and plate. Curves I, II and III are for nickel, plotted respectively for a voltage of* 250, 150 *and* 50 *volts on the plate. IV gives the same curve for a carbon-coated plate at* 250 *volts. Inset: electrode arrangement for measurement of the ratio:* $\frac{\text{secondary electron current}}{\text{primary electron current}}$.

$$V_t = V_{plate} - V_{sphere}.$$

By means of a suppressor grid or a space charge between the anode and screen-grid we can create a region of lower potential which can be penetrated by the primary electrons travelling at a high velocity, but which holds back the secondary electrons travelling at a lower velocity. The depth of this region of minimum potential should therefore be determined on the basis of the velocity distribution of the secondary electrons. This velocity distribution is often measured with the help of a specially constructed valve in which the secondary electrons are picked up on a spherical electrode whose counter-potential with respect to the electrode from which the secondary emission originates can be controlled (see inset Fig. 8). We then obtain, for instance, Curves I, II and III in Fig. 8, which indicate the ratio I_s/I_p of the secondary emission picked up on the sphere, with respect to the primary emission current to a metal plate, for different voltages (250, 150 and 50 volts respectively) on this plate and for different values of the potential difference V_t between the sphere and the plate.

Curve IV gives the ratio I_s/I_p for a carbon-coated plate on 250 V, the secondary emission of which is considerably lower. It can be seen that although these different curves have a similar trend, the number of rapid electrons ("reflected electrons") in the case of nickel is proportionately smaller the higher the voltage, whilst for carbon the number is always smaller than for nickel.

Though the low-velocity electrons are predominant in number, suppression of these alone would still permit considerable disturbance due to the number of secondary electrons.

For the case indicated by the above curves, the electrons which emerge at a certain velocity have been measured independently of the direction in which they emerge. Although measurements of the distribution of the direction in which the electrons emerge have only occasionally been carried out and whilst our own investigation is not yet completed, it may be

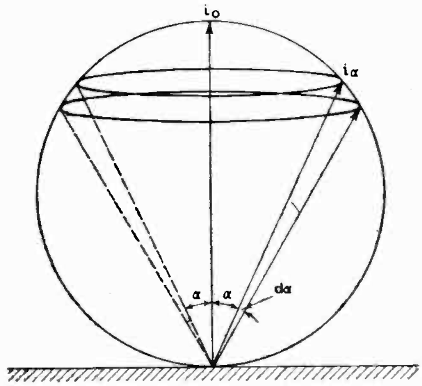

Fig. 9.

taken for granted for a first approximation that the distribution in different directions in the space in which the secondary electrons emerge is governed by Lambert's law of cosines. Assuming this law to apply, we can infer from it the trend of the curve $I_s/I_p = f(V_t)$ for other electrode arrangements. Whether a secondary electron will or will not arrive at the screen-grid is determined by the component of the velocity in the direction of the screen-grid. If secondary electrons are emerging in all directions, the mean velocity perpendicular to the screen-grid in the parallel electrode example will be lower than that shown by Fig. 8.

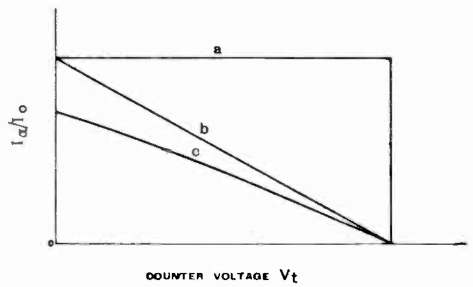

Fig. 10.—*Curve a gives the characteristic of the ratio* $\frac{\text{secondary electron current}}{\text{primary electron current}}$ *for the spherical electrode arrangement, as a function of the counter-voltage, on the assumption that all the secondary electrons have the same velocity v. Curve b, ditto for the parallel electrode example, and Curve c for a cylindrical arrangement as used in practice.*

If we imagine the spherical pick-up electrode to be replaced, for instance, by a flat electrode parallel to the electrode which is being bombarded, conditions will agree more closely with the state of affairs in a screen-grid valve with a flat electrode arrangement. Now an electron emerging at a certain velocity v corresponding to a voltage V_0, at an angle α with the normal, cannot reach the opposite electrode unless its velocity is so great that the counter-voltage V_t can be overcome. This counter-voltage V_t must be equal to or less than $V_0 \cos^2 \alpha$ [14]. Lambert's law of cosines indicates, for a given quantity of emerging electrons, the spatial distribution of electrons emerging at different angles with the normal ($i\alpha = i_0 \cos \alpha$). In that case the total emergent secondary emission current, I_0, is equal to πi_0. We will assume that a certain portion of this, the current I_a, emerges at a smaller angle than α and can just reach the anode. This current, in the space above the secondary emission cathode, is limited by a spatial angle ω equal to an inverted cone with apical angle 2α (Fig. 9). Now $i_a d\omega = 2\pi i_a \sin \alpha d\alpha$, so that there is present in the cone a current

$$I_a = I_0 \int_0^a 2 \sin \alpha \cos \alpha \, d\alpha = I_0 \sin^2\alpha,$$

from which we find:

$$\frac{I_a}{I_0} + \frac{V_t}{V_0} = 1$$

If there were only secondary emission electrons of one velocity v, a spherical arrangement of the pick-up electrode would thus give us line a in Fig. 10. From a certain voltage onward, all the electrons can in this case reach the sphere. For flat arrangements of the electrodes, the above relation gives us line b. It will now be obvious that, for an arrangement consisting of concentric cylindrical electrodes, this line will sag and so intersect the vertical axis at a lower position (line c). We know, however, that electrons of different emergent velocities will occur in practical cases.

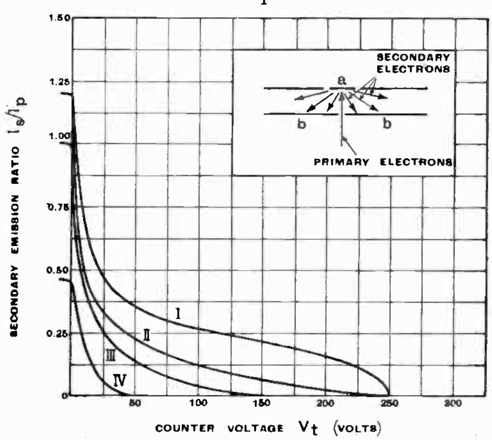

Fig. 11 (*a*).—*Curves II, III and IV give the characteristic of the ratio* $\frac{\text{secondary electron current}}{\text{primary electron current}}$ *as a function of the counter-voltage for a flat parallel arrangement of the Ni plate a and the pick-up electrode b, with a voltage on the plate of* 250, 150 *and* 50 *volts respectively. For the sake of comparison, Curve I is inserted for* 250 *volts and a spherical arrangement. Inset: drawing of the electrode arrangement.*

$$V_t = V_{plate\ a} - V_{collecting\ electrode\ b}.$$

Figs. 11 (a) and 11 (b) show how the counter-voltage curves appear in the parallel electrode example, for a nickel plate and for a carbon-coated plate. These curves are obtained graphically from the curves for the spherical arrangement using Lambert's law of cosines. By way of comparison we have inserted in each figure the curve for a primary voltage of 250 volts as given by the spherical pick-up electrode.

Now what conclusions can we draw from this and what conditions will a counter-voltage formed by a suppressor grid or space charge in a screen-grid output valve be required to fulfil?

(1) Although the secondary emission characteristics of carbon may, for instance, be greatly modified by residual traces of gas or by volatilising cathode material, it is a well-known fact that the choice of anode material plays an important part.

(2) The passage of secondary electrons may also be influenced by the geometrical form of the electrodes (e.g. flat or spherical arrangement), which in turn affects the dimensioning of the suppressor grid or space charge.

(3) The screen-grid output valve cannot be rendered entirely free from secondary or reflected electrons. It is not possible to state in general terms, how much secondary emission is permissible for a given valve at every anode voltage and current, because on the one hand the quality standards of different valves show a wide limit of diversity, and on the other hand the disturbing effect due to secondary emission is manifested differently at different voltages and currents. We shall revert to this question later on. If, however, by way of example, we were prepared to permit the same percentage of secondary electrons with respect to the primary electrons, for a constant current and a variable voltage in all cases, it will be seen from Figs. 11 (a) and 11 (b) that although a fall of the anode voltage will result in a fall of the counter-voltage, the ratio of the counter-voltage to the anode voltage is bound to increase, because at lower anode voltages the proportion of the number of secondary electrons with high velocities increases. It is also evident that the value of 10 to 20 volts which is often stated[15 16] as being the required value for the counter-voltage, will be quite insufficient to nullify the effect of secondary emission under all circumstances.

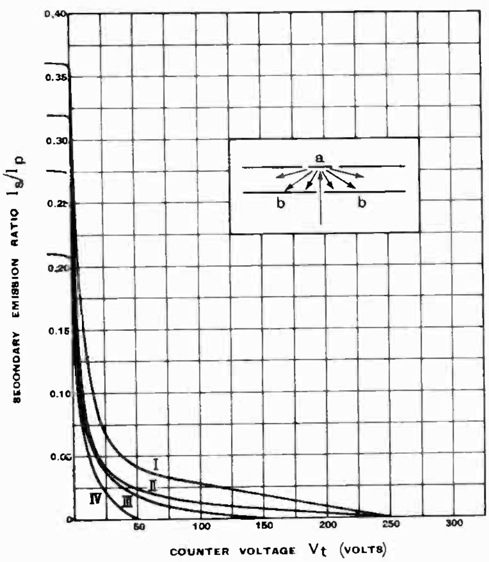

Fig. 11 (*b*).—*Same as 11a, but for a carbon-coated Ni plate a. For the sake of comparison, Curve I is inserted for 250 volts and a spherical arrangement.*

$$V_t = V_{plate\ a} - V_{collecting\ electrode\ b}.$$

In a screen-grid output valve, in which means for suppression of secondary emission are included, the counter-voltage will therefore acquire much greater values than 10-20 V, for instance, at a higher anode voltage. We will make a close examination of these means of suppression.

The two expedients, already mentioned, are generally adopted in practice for the suppression of secondary emission in screen-grid valves, viz., a suppressor grid and a space charge. We will now investigate the nature of these two expedients and examine how, in connection with the above, they will suppress secondary emission. Both expedients are already described in the original pentode patent[1]. The suppressor grid was adopted first and is still in use, because, as we shall see later, it possesses valuable properties. The space charge, too, has been employed in beam power output valves [15], the space charge being used in combination with the electrostatic effect of "beam plates," which, in a similar manner to the suppressor grid, create a minimum of electrostatic potential and thus supplement the action of the space charge. Space charge has, moreover, been turned to account in improved new type pentodes. We will now investigate what counter-voltage the space charge can cause for the purpose of suppressing secondary emission.

§ 4. Space Charge

Using Poisson's equation $\frac{d^2V}{dx^2} = 4\pi\rho$ for an ideal tetrode, Calpine and others [17, 18, 19, 20, 21, 22] investigated the potential minimum

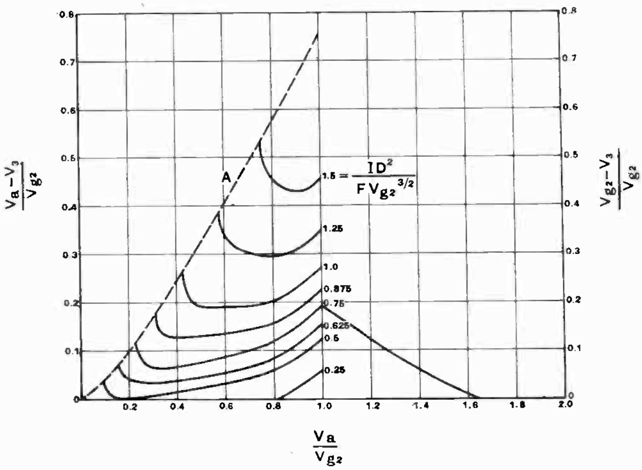

Fig. 12.—*Characteristic of the counter-voltage, due to space charge, between the screen-grid and anode in a tetrode, as a function of the anode voltage. The counter-voltage is the difference between the voltage on the electrode whose potential is lowest, and the lowest potential V_3 in the space. The parameter is $\frac{ID^2}{FV_{g2}^{3/2}}$ which, for a specific case with constant D, F and V_{g2}, is equal to the current passing between the screen-grid and the anode.*

which is created by a space charge between the anode and screen-grid. It was assumed that the current I emerges as a beam of uniform density from the screen-grid into the space between the screen-grid and anode, the electron velocities in the direction of the anode being equal. The screen-grid and anode are situated in parallel planes. The following relation is then obtained between the voltages at the screen-grid (V_{g2}), at the anode (V_a) and at the point of minimum potential (V_3)[18]:

$$\frac{ID^2}{FV_{g2}^{3/2}} = K\left[\sqrt{1 + 3\left(\frac{V_3}{V_{g2}}\right)^{1/2} - 4\left(\frac{V_3}{V_{g2}}\right)^{3/2}} + \sqrt{\left(\frac{V_a}{V_{g2}}\right)^{3/2} + 3\left(\frac{V_3}{V_{g2}}\right)^{1/2}\frac{V_a}{V_{g2}} - 4\left(\frac{V_3}{V_{g2}}\right)^{3/2}}\right]^2$$

where F is the area of cross-section of the beam, D the distance between the anode and screen-grid, K a constant and equal to $\frac{1}{9\pi}\sqrt{\frac{2e}{m}}$. For the suppression of secondary emission it is important to examine the characteristic curve corresponding to the difference between the anode voltage and the voltage at the potential minimum, as this difference constitutes the counter-voltage by means of which secondary emission is to be repelled. Having inserted numerical values in the above formula, we plotted a graphical representation of this difference $V_a - V_3$ for various anode voltages and currents, as we wished to know the value of this counter-voltage for all points on the anode voltage/anode current characteristic.

The resulting graph is shown in Fig. 12, in which the characteristic for $\frac{V_a - V_3}{V_{g2}}$ has been plotted as a function of $\frac{V_a}{V_{g2}}$ at various values of $\frac{ID^2}{FV_{g2}^{3/2}}$.

These curves are bounded on the left by line A, which indicates the limit of the gradual trend of V_3; as $\frac{V_a}{V_{g2}}$ decreases, the potential minimum suddenly acquires zero value and electrons return to the screen-grid. Such a point is described as a virtual cathode. On the right, all the lines but one are interrupted at a point $\frac{V_a}{V_{g2}} = 1$. The region $\frac{V_a}{V_{g2}} < 1$ is in fact the most important, because the secondary emission of the anode—which draws far more current—will be many times greater than that of the screen-grid and hence be more likely to cause disturbing effects. To illustrate the trend of space charge in the region $\frac{V_a}{V_{g2}} > 1$, we have extended one of the curves. We shall thus concern ourselves chiefly with the region in which $\frac{V_a}{V_{g2}}$ lies between 0 and 1.

From the above figure a number of general conclusions might be drawn concerning the application of this counter-voltage $V_a - V_3$ in the screen-grid output valve, bearing in mind, however, that the above curves refer to an ideal case. In practice a slight deviation may occur as a result of the space charge of the secondary electrons. The fact that this deviation is rather small, will be explained next.

We suppose the anode emits an infinite number of secondary electrons which have a velocity so high that they are repelled exactly before the potential minimum and return to the anode. This minimum will then be situated very close to the anode.

The primary electron current I_2 which is necessary to form this potential minimum may be calculated and compared with the primary current I_1 which forms this potential minimum in the absence of secondary emission. In practice the value of the primary current will be between I_1 and I_2. As the secondary emission ratio of the usually carbon-coated anode is low, the practical value lies near I_1. If $V_{g2} = 250$ V, $V_a = 50$ V; $V_3 = 40$ V and the distance anode-screen-grid is 5 mm, $I_1 = 47.4$ mA/cm² and $I_2 = 33.3$ mA/cm². Besides that, the velocity components of the electrons in the beam in the direction of the anode have different values, mainly due to deflection occurring at the screen-grid. If this velocity component is small, the electrons will remain for a longer period in the space between the screen-grid and anode and will thus intensify the space charge. However, as long as no electrons are returning, the potential characteristic will not deviate greatly on this account, and the general trend will be maintained. On the other hand, the point at which electrons return and a virtual cathode is formed, will necessarily undergo a deviation, since electrons of lower velocity return first. Fig. 12 shows that even at a low value of the quotient $\frac{ID^2}{FV_{g2}^{3/2}}$, the potential characteristic for the case $\frac{V_a}{V_{g2}} < 1$ sags, as it were, and the counter-voltage (exactly: counter voltage proportion) $\frac{V_a - V_3}{V_{g2}}$ then has a positive value; for higher or lower values of this ratio $\frac{V_a}{V_{g2}}$, the counter-voltage may rapidly decrease to nil. At very low values of $\frac{V_a}{V_{g2}}$ and higher values of the quotient $\frac{ID^2}{FV_{g2}^{3/2}}$ the virtual cathode can be formed and the screen-grid current rapidly increases at the expense of the anode current. Before this happens the counter-voltage has acquired a minimum value and may even vanish. The potential curves have been plotted in Fig. 13 for different anode voltages and we can clearly follow the course of the sag (counter-voltage). This minimum value is most critical at the point at which the passage of secondary electrons to the screen-grid will occur first, and the position of this point differs considerably from the point at which, in a normal tetrode with little space charge, the characteristic shows the maximum deviation due to secondary emission, viz. at $V_{g2} = V_a$. We can best illustrate

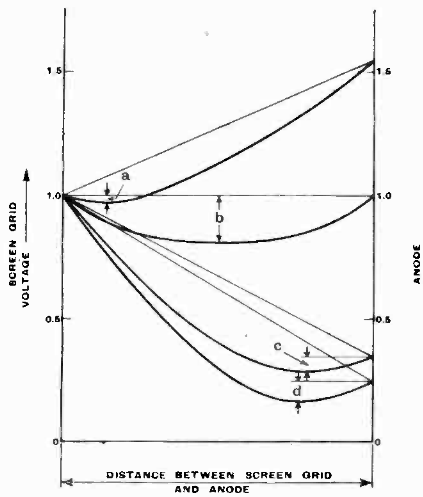

Fig. 13.—*Characteristic of potential between screen-grid and anode for a flat electrode arrangement, at different voltages, in a case where* $\frac{ID^2}{FV_{g2}^{3/2}} = 0.75$. *The dip in the potential characteristic is due to space charge.*

this by a set of curves (Fig. 14) plotted for a special valve. The electrode structure is shown diagrammatically in the inset. Only the current flowing to one small anode was measured, thereby avoiding "side effects" which may be caused when secondary electrons emerging obliquely along the sides of the electron beam succeed in reaching the screen-grid. The current was controlled by varying the negative potential on the 1st grid. From the occurrence of secondary emission, indicated by the dip in the anode current characteristic, we can follow the course of the counter-voltage caused by sagging of the potential characteristic. With increase of current, secondary emission will only become possible in the region of low anode voltages, where it will finally vanish also when the minimum value of the counter-voltage is sufficient (curve for $V_{g1} = -6$ volts). On further increase of current the characteristic shows a rounding-off at lower anode voltages, and the elbow at which the electrons return to the screen-grid is shifted to higher voltages.

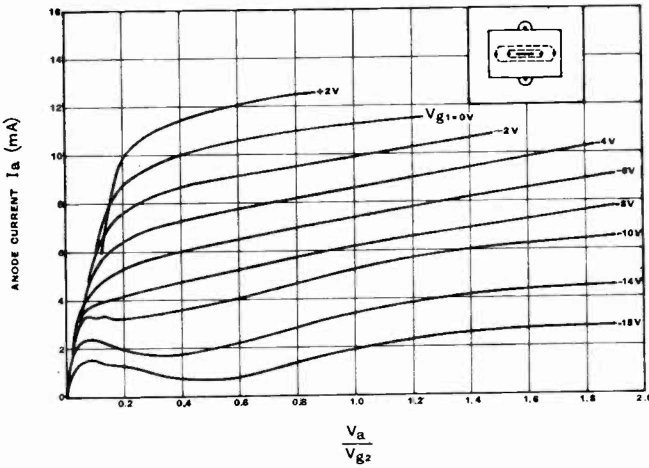

Fig. 14.—$I_a - V_a$ characteristics of a tetrode of special construction. At a negative control grid voltage of 6 volts, the counter-voltage due to space charge is practically sufficient to suppress secondary emission. In the curves for a higher control grid voltage and hence for a lower current, secondary emission is manifested at increasingly high values of the anode voltage. Inset: drawing of the electrode arrangement.

How can these considerations be utilised in practice? In the design of a tetrode output valve, the V_{g2} and V_a and the maximum value of I_a are pre-determined. According to the material selected for the anode and the corresponding counter-potential necessary for the suppression of secondary emission, we assign to $\frac{D^2}{F}$ a value that will yield a sufficient counter-voltage over the entire graph. And although the square of the distance appears in this ratio, it is not altogether correct to speak of a "critical distance" as is sometimes done[23], since other factors such as current, voltage and current density might equally well be termed critical factors. For an output valve it is not sufficient, as we have already seen (§ 2), to ensure that one of the anode current characteristics (e.g. the Fig. 14 curve for $V_{g1} = -6$ volts) is undeformed by secondary emission. It can be seen from Figs. 12 and 14 that even a small drop in current may again precipitate this unwanted phenomenon. If we wish the secondary emission to be eliminated over a large part of the anode current/anode voltage characteristics, we must ensure a sufficient counter-voltage for curves with a much lower current value than I_{max}. The drawback remains, however, that secondary emission is not suppressed for very small currents. On the other hand, if we do obtain a sufficient counter-voltage with small currents, the drawback is that with larger currents the virtual cathode is formed at increasingly high anode voltages. The elbow of the characteristic then shifts to the right in the figure and the maximum output drops. In practice we must therefore accept a compromise. Another practical difficulty is that in most valves the current density on either side of the cathode is not exactly the same, owing to slight differences which are always inherent in the structure of the electrodes. It sometimes happens that one of the two halves carries twice as much current as the other half.

In the type of valve known as the "beam tetrode" an attempt has been made to overcome all these difficulties by the use of "beam plates" which intercept the secondary electrons circulating around the beam when the current has a high density and the potential characteristic shows a pronounced sag,[15 16], whereas in the case of small currents and high anode voltages the beam plates create a minimum of electrostatic potential, thus acting in a similar manner to a suppressor grid. The beam plates thus being a kind of suppressor grid with a high pitch, their action at different points in the electron beam is very unequal and hence this expedient does not effectively do away with the above drawbacks. The name "beam plates" is misleading, as it suggests that the plates assist in forming the electron beam. Actually, however, the electron beam in beam tetrodes is governed by the shape of the cathode and grids. The plates would therefore be more appropriately described as "suppressor plates," as their action in restraining the secondary electrons can best be compared with that of a suppressor grid.

Conclusion : Space charge *alone* is not a suitable means of suppressing secondary emission in output tetrodes. Either the secondary emission is insufficiently suppressed, or the elbow of the characteristic is shifted too far towards the higher anode voltages and efficiency thus becomes too low.

A serviceable solution is achieved by the use of additional plates which repel the secondary electrons in a similar manner to the suppressor grid and which also supplement the action of the space charge. The above drawbacks are, however, still present to a certain extent, as the suppressor grid effect is never absolutely complete. An advantage of this construction[15] is that very few electrons can be deflected by these "beam plates" in such a manner that they return to the screen-grid. This used to happen in older type pentodes as a result of less accurate dimensioning of the suppressor grid, thereby creating in the $I_a - V_a$ characteristic an elbow which was too round and which occurred when the anode voltage was too high. We will investigate this in our next Section and see how this trouble has been avoided in the new type pentodes.

(To be concluded.)

Theory and Application of Electron Tubes

By HERBERT J. REICH, Ph.D. Pp. 670 and 512 illustrations. Published by McGraw Hill Publishing Co., Aldwych, London, W.C.2. Price 30s.

So many text books on electron tubes have been written during the past few years that a con-considerable amount of overlapping is inevitable. Dr. Reich covers an extremely wide field and most of the applications of electron tubes which he discusses are dealt with in a clear and thorough manner. The first few chapters of his book are, however, a little disappointing, and a more accurate presentation of the fundamental principles could have been given without making the book any longer, if necessary by omitting some of the manufacturing details. The description of the action of the control grid, for example, on pages 30 and 40 is likely to leave the student with a false picture of the mechanism of the control of the space current. Valves of the hexode and heptode type have now been in extensive use for several years, and have already found applications outside the field of radio communication ; but, so far, no adequate analysis of their operation and characteristics has been given in any text book. Dr. Reich ignores them completely. Secondary emission is only briefly referred to, in spite of the author's statement that "the phenomenon of secondary emission is an important one in all types of electron tubes." A more serious omission is, however, the absence of any discussion or quantitative data on the important subject of "noise," either in tubes or in circuits. Chapter 4 deals with the analysis of vacuum tube circuits in a lucid manner which will be easily understood by the student approaching the subject for the first time and forms a sound foundation for the succeeding sections which deal very thoroughly with modulation and detection, amplifiers and oscillators. The chapter on electrical conduction in gases is included as an introduction to a description of Glow- and Arc-Discharge Tubes and their many applications which are dealt with in a manner which indicates a familiarity with the subject based on first-hand knowledge. The well condensed chapter on Light-Sensitive Tubes includes circuits for photometric measurements, and a brief description of the Zworykin type of secondary emission multiplier is given. Rather more than a mere reference might, however, have been made to the multipliers designed by Farnsworth and others. There is a useful chapter on Power Supplies, and the final chapter, which is devoted to Electron Tube Instruments, is an excellent summary of the various applications of electron tubes in this important field.

The subject matter of the book is well arranged (although the subject index would have been better without so many cross-references) and the book should be of considerable value not only to students, but also to a large number of engineers in whose fields of activity thermionic, photoelectric and gas-discharge tubes have become such important tools. The radio engineer, too, will find much useful information, although, as the author remarks, "the design of radio transmitters and receivers, which are adequately treated in books on radio engineering, has not been taken up." The bibliography contains a useful list of references on all the subjects covered ; but it is a pity that so many important papers published outside America have not been mentioned.

G. W. W.

Triode Oscillators for Ultra-short Wavelengths*

By M. R. Gavin, M.A., B.Sc.

(Communication from the Research Staff of the M.O. Valve Co., Ltd., at the G.E.C. Research Laboratories, Wembley, England)

SUMMARY.—The circuit and transit time limitations imposed on negative grid triode oscillators at ultra-short wavelengths are considered. The minimum wavelength permitted by the valve circuit can be determined from a knowledge of the valve capacitances together with the data given in Section 3. When the leads from the anode and grid form part of a transmission line, the advantage of low characteristic impedance is emphasised. A suitable method of achieving low minimum wavelength is to make the anode and grid integral parts of a concentric line.

The minimum wavelength permitted by transit time is calculated in Section 5 in terms of electrode clearances and applied voltages, and is found to agree well with experiment. It is shown that oscillation ceases when the total transit time from cathode to anode is about half the period of the oscillation.

An approximate theory of Class C oscillators, when transit time effects just begin to be appreciable, is given in Section 6. It is shown that, when the total transit time is about 1/12th of a period, the efficiency has dropped by 10 per cent. from the long wavelength value. A formula is given for the corresponding wavelength in terms of the electrode clearances and applied voltages.

Finally, from circuit and transit time considerations, it is shown that wavelengths of the order of 10 cm. are not beyond the possibility of achievement with negative grid triodes.

1. List of Symbols

L_a = inductance of the anode lead.
L_g = inductance of the grid lead.
C_{kg} = cathode-grid capacitance.
C_{ag} = anode-grid capacitance.
C_{ak} = anode-cathode capacitance.
E_a = steady anode voltage.
E_g = steady grid voltage.
E_e = effective voltage in the grid plane.
e_a = instantaneous value of the oscillatory anode voltage.
$\hat{e}_a$ = amplitude of the oscillatory anode voltage.
$e_{a\,min}$ = minimum value of the anode voltage.
$e_{g\,max}$ = maximum value of the grid voltage.
i_a = instantaneous value of the anode current.
I_a = mean value of the anode current.
P_0 = $E_a I_a$ = power input to the anode.
P_1 = power dissipation at the anode under long wave conditions.
η_1 = anode efficiency, corresponding to P_1.
P_2 = power dissipation at the anode when transit time effects are considered.
η_2 = anode efficiency corresponding to P_2.
λ = wavelength.
λ_m = minimum wavelength.
ω = angular frequency.
c = velocity of electromagnetic radiation.
T = period.
r_k = radius of the cathode.
r_g = radius of the grid.
r_a = radius of the anode.
d_{kg} = cathode-grid clearance.
d_{ga} = grid-anode clearance.
τ_{kg} = cathode-grid transit time.
τ_{ga} = grid-anode transit time.
τ = total transit time.
v_g = velocity of arrival of electrons at the grid.
μ = amplification factor.
e = charge of an electron.
m = mass of an electron.
Z_0 = characteristic impedance of a transmission line.

2. Introduction

THE power obtainable at very short wavelengths is limited mainly by two factors. These are (1) the inductances and capacitances associated with the electrodes and their connecting leads, which may be classed together as circuit limitations; and (2) electron transit time limitations. Large power requires large valves, and large electrodes; low inductances require small valves; low capacitances require small electrodes or large clearances between them; and lastly, short transit times require small electrode clearances or large voltages. Obviously these many conflicting requirements necessitate considerable compromise. This paper is concerned with some theoretical and experimental considerations of these requirements and it is hoped that it will provide some assistance in achieving the best compromise.

* MS. accepted by Editor, February, 1939.

Since the usual method of designing valves for shorter wavelengths has been to reduce the sizes and clearances of the electrodes, it is worth while, for completeness, to repeat the effects of making scale model valves, altering nothing but dimensions.

If all the linear dimensions of a valve are divided by a factor n and the operating voltages remain the same, then the valve constants μ, mutual conductance and internal resistance, and the electrode currents are unchanged. The valve capacitances and inductances, the electron transit times and the minimum wavelength are divided by n. The possible emission and permissible dissipation are divided by n^2; the current densities are multiplied by n^2, provided that the smaller valve does not saturate. At long wavelengths, the power output is divided by n^2, but at short wavelengths, when the efficiency is beginning to drop, the output is divided by a factor less than n^2.

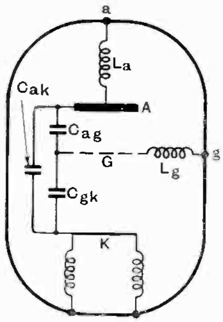

Fig. 1.—*The triode and its internal capacitances and inductances.*

These proportionalities are affected slightly by end effects, but they are sufficiently accurate for most design purposes.

3. Circuit Limitations

Fig. 1 shows the main inductances and capacitances inside the envelope of a triode. In an ultra short wave oscillator, the external circuit is usually connected between a and g, and the valve contributes to the main oscillatory circuit an inductance L, and a capacitance C, given by

$$L = L_a + L_g \qquad \ldots \quad \ldots \quad \ldots \quad (1)$$

$$\text{and } C = C_{ag} + \frac{C_{ak}C_{gk}}{C_{ak} + C_{gk}} \qquad \ldots \quad \ldots \quad (2)$$

The minimum wavelength obtainable is given by

$$\lambda_m = 60\pi\sqrt{LC} \text{ cm.} \qquad \ldots \quad \ldots \quad (3)$$

where L is in μH and C in $\mu\mu F$. Reduction in any one of L_a, L_g, C_{ag}, C_{ak} or C_{gk} will reduce λ_m.

When the connections to the internal electrodes are brought out by straight cylindrical conductors, the values of L_a and L_g can be approximately determined from the formula

$$L = 0.002l\left(\log_e \frac{4l}{d} - 1\right)\mu H \qquad \ldots \quad (4)$$

where l and d are respectively the length and the diameter of the wire in cm. In Fig. 2, curves are given of L against l for several values of d. It can be seen that L is almost proportional to l. Also, if a wire of a certain diameter is replaced by two wires of, say, half that diameter, L is reduced by a factor between 0.5 and 0.6, provided that the wires are sufficiently far apart. Thus, it is advantageous to use a number of thin wires in parallel in place of one single, thicker wire. Of course, when two or more wires are used, the effective inductance is increased on account of the mutual inductance between the wires, but, except for close spacings, the increase is negligible.

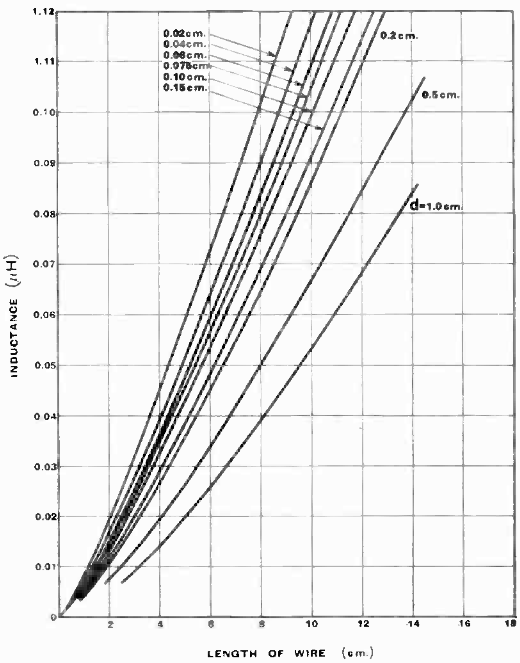

Fig. 2.—*Variation with length of the self inductance of a straight wire for different wire diameters.*

Now consider the external circuit which is connected to the valve. At ultra-short wavelengths, this usually consists of a transmission line circuit, as shown in Fig. 3, where a line of characteristic impedance Z_0 has one end connected between anode and grid and is bridged at the other end by a large condenser.

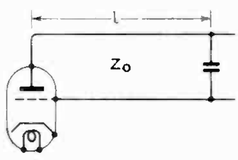

Fig. 3.—*Oscillatory circuit of a triode.*

The reactance of the external circuit is given by $Z_0 \tan \frac{2\pi l}{\lambda}$, and for resonance

$$\frac{1}{\omega C} = Z_0 \tan \frac{2\pi l}{\lambda}$$

where C is given by (2) and L_a and L_g are considered as integral parts of the external circuit.

$$\text{Since} \quad \omega = 2\pi f = \frac{6\pi \times 10^{10}}{\lambda}$$

$$\tan \frac{2\pi l}{\lambda} = \frac{\lambda}{6\pi \times 10^{10} C Z_0} \quad \ldots \quad \ldots \quad (5)$$

For a given λ, it is desirable to have as large an external circuit as possible. From (5), it can be seen that l can be increased by decreasing either C or Z_0. The exact relationship between λ, l, C and Z_0 can be determined from the double family of curves in Fig. 4, where $\frac{\lambda}{6\pi \times 10^{-2} C Z_0}$ and $\tan \frac{2\pi l}{\lambda}$ are plotted against λ; λ and l are in cm., C in $\mu\mu$F and Z_0 in ohms.

If $C = 4\ \mu\mu$F, $l = 7$ cm., and $Z_0 = 200\ \Omega$, we find from Fig. 4 that $\lambda = 85$ cm. With the same values of C and l, and $Z_0 = 60\ \Omega$, we find that $\lambda = 52$ cm. Thus Z_0 has a considerable bearing on the value of λ. If the connections to the anode and the grid are brought out by single parallel wires, then it is desirable to have these close together and of large diameter, in order to keep Z_0 small.

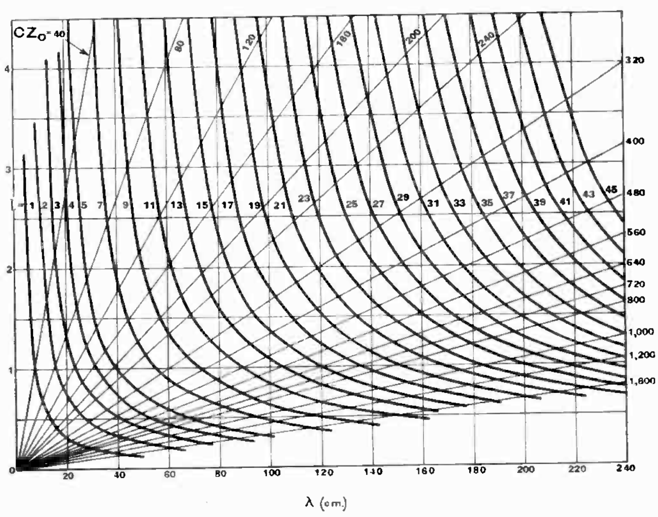

Fig. 4.—*Curves for determining the resonant wavelength, λcm, of a line circuit of length, lcm, loaded by capacitance CμμF, where Z_0 is the characteristic impedance of the line in ohms.*

The most convenient method of achieving low Z_0 is to make the circuit a concentric line with the anode and the grid forming integral parts of the line. Then C_{ag} has no longer a limiting effect on the length of the circuit, but there is still some capacitive loading on the line due to C_{gf} and C_{af} in series, with the result that the length of the line is always considerably less than a quarter wavelength.

This type of circuit, in which the anode and the grid form parts of a concentric line, has been described previously by Mouromtseff and Noble[1], who used a water-cooled valve for wavelengths down to 2.8m. In their theoretical considerations, they took no account of the loading capacitance due to C_{af} and C_{gf}. An open-ended line was used by them, which gives an additional quarter wavelength of circuit. The curves of Fig. 4 can be readily adapted to this type of circuit.

From Fig. 4 an estimate can be made of the absolute minimum wavelength which could be obtained with a valve in one of these concentric circuits. The loading capacitance could be reduced to 1 $\mu\mu$F or less. Allowing 2 cm. for the total length of circuit and $Z_0 = 40\ \Omega$, we get a wavelength of the order of 10 cm. (a frequency of 3,000 Mc/s). The power capabilities of such a valve would, of course, be small.

4. Transit Time Limitations

During the past few years, many theoretical papers have been written on the effects of finite electron transit times at ultra short wavelengths. A critical review of the state of present-day knowledge can be found in an article by Benham[2]. Most of these papers assume that the amplitudes of the alternating potentials are small, compared with the steady potentials and all of them are confined to valves working as Class A amplifiers. Hence, the results cannot be applied quantitatively to oscillators or amplifiers where the alternating potentials assume amplitudes of the same order as the steady potentials. The problems, in this case, are such as defy exact analytical treatment even at long wavelengths and it seems, at present, unlikely that the short wavelength cases, where the electron transit time becomes important, will prove amenable to mathematics. It is possible, however, that something may be done at the two ends of the transit time scale viz. :—(1) when transit time effects begin to become noticeable, and (2) when the limit of oscillation is reached. The former case approximates to a long wavelength problem, and the latter is a static problem. We shall examine these two cases in detail.

5. Limiting Wavelength set by Transit Time

(a) Theoretical

Consider a valve whose minimum wavelength depends only on the electron transit time, and not on any circuit limitation. At a wavelength slightly greater than λ_m, the valve oscillates weakly, and the alternating potentials on the grid and the anode are very small. Then the transit times from cathode to grid and from grid to anode are dependent on the steady potentials only. If E_g, the grid potential, is obtained by grid leak bias, then under the limiting conditions postulated, $E_g = 0$ and the only applied potential is E_a on the anode. The effective potential at the grid plane is then $\frac{E_a}{\mu}$, to a sufficient degree of accuracy except for very low values of μ.

In order to calculate the electron transit times, plane parallel electrodes are assumed. In most valves for ultra short waves, the electrodes are cylindrical. The transit times for such electrodes have been evaluated by McPetrie[3] and Fortescue[4], but their results are not in convenient form for analytical manipulation. Fortunately, the clearances in ultra short wave valves are small, and the ratios of the radii $\frac{r_g}{r_k}$ and $\frac{r_a}{r_g}$ are also relatively small, so that the cylindrical systems approximate to planar ones. By comparing the transit times for planar and cylindrical systems, it has been found that if $\frac{r_a}{r_g} < 3$ and $\frac{r_g}{r_k} < 2$, the values agree within 12 per cent. Since the clearances in the valves are not known to any greater accuracy than this, planar electrodes are assumed in order to simplify the calculations.

The electron transit time in the space charge limited region between cathode and grid for planar electrodes can be shown to be exactly three times the transit time that would occur if the electrons moved throughout with uniform velocity equal to the velocity of arrival at the grid.

$$\text{Therefore} \quad \tau_{kg} = \frac{3d_{kg}}{v_g}$$

$$\text{But} \quad v_g = \sqrt{\frac{2e}{m}}\, E_e,$$

$$\text{therefore} \quad \tau_{kg} = \frac{3d_{kg}}{5{\cdot}93 \times 10^7 \sqrt{\frac{E_a}{\mu}}}$$

where E_a is in volts.

Between the grid and the anode, space charge is neglected, and the potential at a point distant x from the grid is

$$\frac{E_a}{\mu} + \left(E_a - \frac{E_a}{\mu}\right)\frac{x}{d_{ga}}$$

The corresponding velocity is

$$5{\cdot}93 \times 10^7 \sqrt{E_a\left\{\frac{1}{\mu} + \left(1 - \frac{1}{\mu}\right)\frac{x}{d_{ga}}\right\}}$$

Hence the time of transit from grid to anode, τ_{ga}, is

$$\tau_{ga} = \int_0^{d_{ga}} \frac{dx}{5{\cdot}93 \times 10^7 \sqrt{E_a\left\{\frac{1}{\mu} + \left(1 - \frac{1}{\mu}\right)\frac{x}{d_{ga}}\right\}}}$$

$$= \frac{2d_{ga}}{5{\cdot}93 \times 10^7 \sqrt{E_a}} \times \frac{\sqrt{\mu}}{\sqrt{\mu} + 1}$$

The total transit time from cathode to anode is given by

$$\tau = \frac{1}{5{\cdot}93 \times 10^7} \times \frac{\sqrt{\mu}}{\sqrt{E_a}} \left\{ 3d_{kg} + \frac{2d_{ga}}{\sqrt{\mu} + 1} \right\} \quad \ldots \quad \ldots \quad (6)$$

If a valve ceases to oscillate when the total transit time becomes a certain fraction of the period, then

$$T = A\tau$$

where A is a constant.

Since $\lambda_m = cT$,

$$\lambda_m = cA\tau$$

so $$\lambda_m = k \frac{\sqrt{\mu}}{\sqrt{E_a}} \left\{ 3d_{kg} + \frac{2d_{ga}}{\sqrt{\mu} + 1} \right\} \quad \ldots \quad (7)$$

where k is a constant.

It will be shown in the next section that (7) agrees, to an accuracy of 10 per cent., with the experimentally determined minimum wavelengths for a series of five valves, and that the constant has a numerical value of approximately 1,000 when λ_m, d_{kg} and d_{ga} are in cm. and E_a is in volts.

Taking this value of k we find that the limit of oscillation is reached when the total transit time is equal to about half a period. Wagener[5] gives a curve showing that the limit of oscillation is reached when τ_{kg} is one-sixth of the period. The basis of the curve is not explained in his article, but it would seem from the present results that his estimate is too low. τ_{kg} is usually greater than τ_{ga} so that τ_{kg} at the limit of oscillation is more than a quarter of a period.

From equation (7), an estimate can be made of the absolute minimum wavelength set by transit time. Taking the clearances in the HA1 receiving acorn triode as the smallest that can be achieved, and assuming an anode voltage of 400 and a μ of 9, we get $\lambda_m = 6$ cm.

Thus it appears that neither circuit limitations nor transit time limitations preclude operation of negative grid triode oscillators at wavelengths of the order of 10 cm. (frequencies of 3,000 Mc/s). Samuel[6] has reported an output of one watt at 1,700 Mc/s using a triode with double parallel leads to anode and grid. The concentric system considered in the present article could probably be used to about twice this frequency and seems to be a simpler type of construction. So far, no attempt has been made to construct valves for frequencies greater than 1,200 Mc/s, but it is hoped to do this in the near future.

Since μ appears in formula (7), it is worth while finding the variation of λ with μ when the clearances and anode potential are kept fixed.

Equation (7) can be written

$$\lambda_m = \frac{3{,}000\, d_{kg}}{\sqrt{E_a}} \left\{ \sqrt{\mu} \left(1 + \frac{2d_{ga}/3d_{kg}}{\sqrt{\mu} + 1} \right) \right\}$$

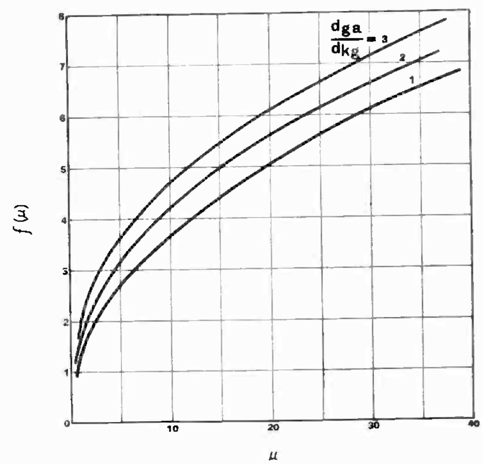

Fig. 5.—*Effect of μ on minimum wavelength (see text).*

The function, $f(\mu)$, in the double brackets is plotted against μ in Fig. 5 for a series of values of d_{ga}/d_{kg}. It can be seen that lower values of λ_m can be obtained by reducing μ. It should be remembered, however, that the considerations in this section apply only to the limiting wavelength, and higher values of μ may be preferable for operation at wavelengths other than λ_m.

(b) *Experimental confirmation*

Most of the triodes in use at present reach the circuit limitation before the transit time one. In order to test the validity of formula (7), a series of valves was made up in the concentric form considered in Section 3. Fig. 6 shows a photograph of one of the valves with a circuit for a wavelength of 90 cm. For comparison, a DET12 triode is shown with its 90 cm. circuit. The electrode capacitances and clearances are the same in both cases, and the advantage of the concentric circuit is obvious.

The lengths of the concentric circuits for a given wavelength were found to agree well with the values determined in Fig. 4.

The complete circuit diagram is shown in Fig. 7. In all the cases investigated, the minimum wavelengths were determined by extrapolation from efficiency-wavelength curves, and in no case did circuit limitation enter. The results are summarised in the accompanying table.

μ	d_{kg}	d_{ga}	λ_m	k
10.5	0.1	0.35	51	1060
15	0.15	0.525	85	995
15	0.1	0.525	63	1000
27	0.1	0.35	62	920
5	0.067	0.23	25app.	1000

k is found to be constant to an accuracy of 10 per cent., and has a mean value of 1,000.

6. Onset of Transit Time Effects

In a high efficiency self oscillator operating at long wavelengths, the electron current is in phase with the grid voltage and in antiphase with the anode voltage. When the electron transit time becomes an appreciable fraction of the period, then the above phase relationships still apply approximately to the electrons leaving the cathode but, owing to the finite time for transit, the electrons arrive at the anode when the anode voltage has passed through its minimum value, and the phase difference is now greater than π. As a result, there is increased power dissipation at the anode. Fig. 8 shows these effects in a simplified form. The full lines represent the anode voltage, anode current and anode dissipation at long wavelengths, and the broken lines represent the same quantities when the transit time becomes an appreciable fraction of the period.

The anode current is, for simplicity,

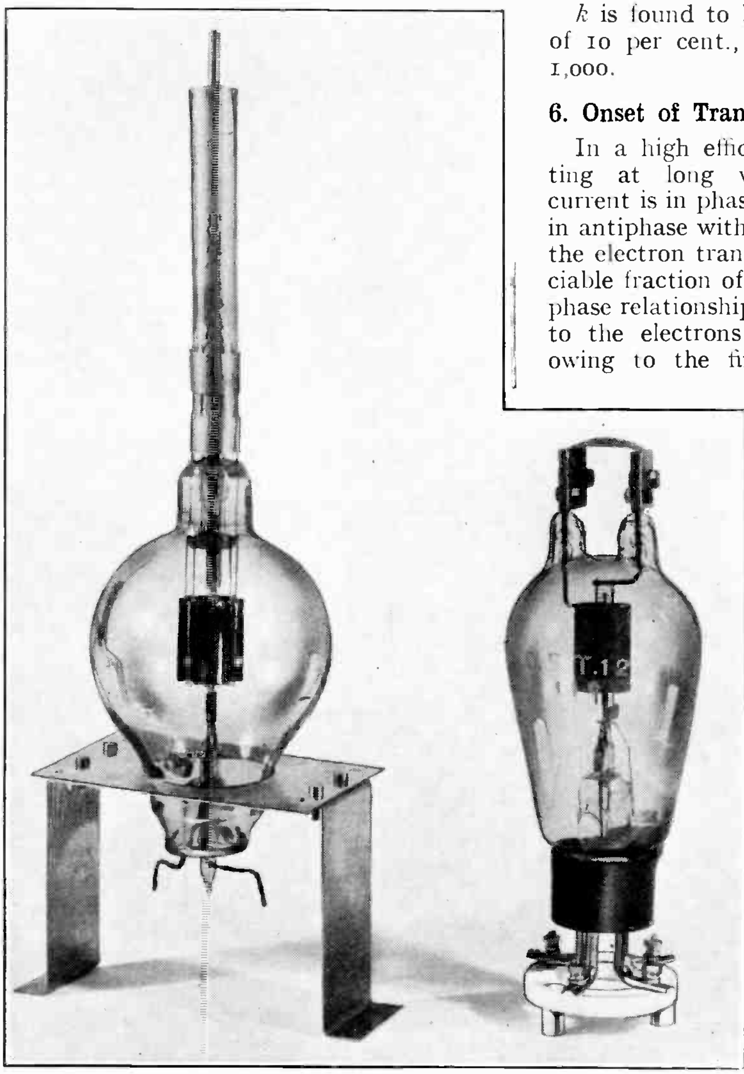

Fig. 6.—*On the left is a valve of the concentric type with the oscillatory circuit for a wavelength of 90 cm. For comparison a DET12, which has the same capacitances and clearances, is also shown with an oscillatory circuit for 90 cm. Between the anode and the external circuit, the outer of the concentric line consists of 8 wires.*

assumed to be in the form of a square pulse which flows during a quarter of the period. With these assumptions, an estimate can be made of the effect of the change in phase of the anode current on the efficiency of the oscillator.

For the long wave case, the instantaneous power loss at the anode is given by

$$e_a i_a = (E_a + \hat{e}_a \sin \omega t) i_a$$

and the mean power loss is

$$P_1 = \frac{1}{2\pi} \int_{\frac{5\pi}{4}}^{\frac{7\pi}{4}} (E_a + \hat{e}_a \sin \omega t) i_a d(\omega t)$$

$$= \frac{E_a i_a}{4} - \frac{\hat{e}_a i_a}{\pi\sqrt{2}}$$

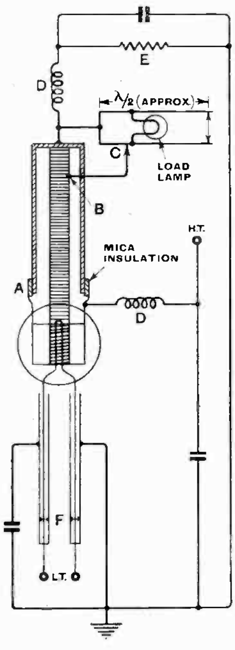

Fig. 7.—*This shows the circuit diagram of an oscillator using a valve with the anode and the grid as integral parts of a concentric line circuit, which is short circuited at the end remote from the valve. The lead from the control grid is a solid rod which is continued through the glass envelope and which forms the inner conductor of the concentric line. The leads from the anode come through the envelope in a circular seal of eight wires, which are connected to the outer conductor of the concentric line through a large condenser A, which is built round this conductor. The loading circuit consists of a parallel wire line, approximately* $\frac{\lambda}{2}$ *in length and short circuited at both ends. One of these ends is connected directly to the short circuited end of the concentric line. A further connection is taken from B on the inner of the concentric line through a slot in the outer to C on the parallel wire line. The output power is dissipated in a lamp connected across the parallel wire line. The degree of loading is controlled by varying the position of the lamp or of the tapping point C. The D.C. leads for the anode and the grid are made through chokes D, and the grid bias is obtained by means of the grid leak E. The two filament leads are fed through high impedance concentric line circuits, which are adjusted by means of the variable bridges at F.*

When the transit time becomes significant, the mean power loss is

$$P_2 = \frac{1}{2\pi} \int_{\frac{5\pi}{4}+\omega\tau}^{\frac{7\pi}{4}+\omega\tau} (E_a + \hat{e}_a \sin \omega t) i_a d(\omega t)$$

$$= \frac{E_a i_a}{4} - \frac{\hat{e}_a i_a}{\pi\sqrt{2}} \cos \omega\tau$$

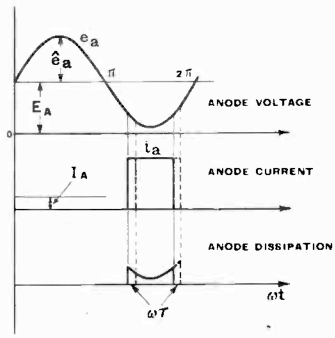

Fig. 8.—*Effect of transit time on the anode current and anode dissipation in a Class C oscillator. The full lines represent the conditions at long wavelengths and the dotted lines show the effect on the anode current and anode dissipation of finite electron transit time.*

Since $\omega\tau$ is assumed to be small,

$$P_2 = \frac{E_a i_a}{4} - \frac{\hat{e}_a i_a}{\pi\sqrt{2}} + \frac{\hat{e}_a i_a \omega^2 \tau^2}{2\pi\sqrt{2}}$$

The input power is the same in each case,

$$P_0 = E_a I_a$$

and the efficiencies are

$$\eta_1 = \frac{P_0 - P_1}{P_0}$$

and

$$\eta_2 = \frac{P_0 - P_2}{P_0}$$

Therefore

$$\eta_1 - \eta_2 = \frac{\hat{e}_a i_a \omega^2 \tau^2}{2\pi\sqrt{2}\, P_0}$$

But $\qquad I_a = \frac{i_a}{4}$

therefore

$$\eta_1 - \eta_2 = \frac{\sqrt{2}}{\pi} \frac{\hat{e}_a}{E_A} \omega^2 \tau^2 \quad \ldots \quad (8)$$

Thus, the decrease in efficiency is proportional to the square of the frequency, to the square of the transit time and to the ratio of the peak alternating voltage to the mean voltage of the anode.

It is well to consider the assumptions made in the derivation of (8).

(i) The anode current was assumed to form a square-topped pulse which lasted for a quarter of a period. Although this is a very rough representation of what occurs in reality, the error introduced may not be large, since the effect of transit time has been found by taking the difference of two results which both err to about the same extent and in the same way. A different form of anode current would give a similar equation to (8) with different constant terms.

(ii) The only transit time effect considered is the change of phase of the anode current. Actually, there must be decreased efficiency due to the increased damping of the input and output circuits arising directly from the finite electron transit time. The contribution from this source to the reduction of efficiency is very difficult to estimate, but it seems probable that it is small, compared with the reduction due to the change of phase of the anode current.

(iii) All the electrons have been assumed to have equal transit times. This assumption is probably not serious, since most of the electrons traverse the triode when the anode and grid voltages are near turning values and are changing slowly. In addition, when one of these voltages is increasing, the other is decreasing and this also tends to reduce the spread of transit time values.

(iv) Planar electrodes are assumed, but as already shown in Section 5 (a), this is justifiable for most valves used at very short wavelengths.

(v) The grid plane is assumed to be an equipotential surface and to have a potential equal to the grid voltage. This is only valid for high μ valves, but it is probable that this source of error is also negligible.

Thus it is probable that the proportionalities of equation (8) are reasonably accurate. Normally, in a Class C oscillator working at maximum efficiency,

$$\frac{\hat{e}_a}{E_A} \doteqdot 0.9 \quad \text{so that}$$

$$\eta_1 - \eta_2 \doteqdot 0.4\,\omega^2\tau^2 \quad \ldots \quad (9)$$

From (9), we and that the efficiency has dropped by 10 per cent. from the maximum value when the transit time is equal to about 1/12th of the period.

Equations (8) and (9) are not in a form suitable for design purposes. In order to get the frequency or wavelength at which the efficiency begins to decrease, in terms of the electrode clearances and voltages, it is necessary to make some further assumptions. In many Class C oscillators, the maximum grid voltage is approximately equal to the minimum anode voltage, i.e.,

$$e_{g\,\max} = e_{a\,\min} = \frac{E_a}{10} \quad \ldots \quad (10)$$

Hence the total transit time can be evaluated by considering the electrons moving with uniform velocity corresponding to a potential of $\frac{E_a}{10}$ volts for a distance equal to $3d_{kg} + d_{ga}$. Therefore

$$\tau = \frac{3d_{kg} + d_{ga}}{5.93 \times 10^7\sqrt{\frac{E_a}{10}}}$$

From (9), the wavelength at which the efficiency has dropped by 10 per cent. is given by

$$\lambda = \frac{2 \times 10^4(3d_{kg} + d_{ga})}{\sqrt{E_a}}\text{ cm.} \quad \ldots \quad (11)$$

The assumption (10) which was made in deriving (11), is one which is not always fulfilled in practice, and as a result, (11) may not give high accuracy. However, for want of anything better, it can be used to give a rough estimate of the wavelength at which transit time effects begin to become noticeable. The following table gives the calculated and observed wavelengths at which the efficiencies have dropped by 10 per cent. from the long wave values for four different valves.

	Observed Wavelength	Calculated Wavelength
DET 12	4.0 m.	3.7 m.
CAT 15 E770	4.3 m.	6.0 m.
ACT2	5.5 m.	5.6 m.
E773	4.0 m.	5.4 m.

The discrepancies in the values for CAT 15 and E773 are probably due to the fact that (10) is not fulfilled. By studying the characteristic curves of these valves, it can be seen that in order to obtain full output $e_{gmax} > \frac{E_a}{10}$ and the transit time between cathode and grid will in reality be smaller than that assumed in the calculation. However, even in these cases, the calculated values are of the correct order and (11) can be used as a rough guide for design purposes.

7. Conclusion

It has been shown that, on very simple theoretical grounds, some idea of the performance of triode oscillators at very short wavelengths can be determined by calculation to an accuracy which is in fair agreement with experiment.

The considerations have been directed towards self oscillators as distinct from amplifiers. However, experience shows that there is a close relationship between the short wave performances of the two types of operation.

In conclusion, the author desires to tender his acknowledgments to the General Electric Company, Ltd., and the Marconi Company, on whose behalf the work was done which has led to this publication.

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Electro-Acoustics

By Prof. Dr. Erwin Meyer. Pp. 117 and 84 diagrams and illustrations. Published by G. Bell & Sons Ltd., York House, Portugal Street, London, W.C.2. Price 10s.

This book is the outcome of a series of lectures delivered at the Institution of Electrical Engineers under the auspices of the University of London during the autumn of 1937.

In it the lesser known applications of electro-acoustic technique are dealt with at greater length than the selections of classical theory which have been included to give continuity. The result is an admirable corollary to standard works on the subject which will widen the outlook of the student and stimulate the thought of those engaged in original research.

It is for the ingenuity and variety of experimental methods employed by Dr. Meyer and his colleagues that this book is chiefly notable. The investigations of vibration in buildings, the use of supersonic sound in detecting cracks during the setting of cement and investigations into the qualities of musical instruments may be selected as typical examples.

Valuable contributions are also made to the understanding of transient phenomena in loud speakers, steel tape recording and the instantaneous analysis of noises of short duration.

The concluding chapter on architectural acoustics is unusually interesting and includes accounts of the measurement of the reverberation times of a hall using the orchestra as a source of sound during a concert performance, and of the absorption coefficients of materials in the Wasserschloss chamber of the hydro-electric power station at Walchensee, which has the phenomenal reverberation time at low frequencies of nearly 40 seconds.

F. L. D.

The Industry

SILVERING solutions for the production of stable films on the surface of ceramic and mica dielectrics are described in a pamphlet "Liquid Silver" issued by Melton Metallurgical Laboratories, Seymour Road, Slough, Bucks.

Erie Resistor, Ltd., Carlisle Road, The Hyde, London, N.W.9, have prepared a technical bulletin showing the advantages of the multiple ring type of resistance for high voltage ratings such as are met with in television receiver design.

A third edition of the descriptive pamphlet No. 11H gives full technical information relating to the many uses of Westinghouse metal rectifiers in telecommunications. Copies are obtainable from Westinghouse Brake & Signal Co., Ltd., 82, York Way, King's Cross, London, N.1.

A new publication giving details of the Types 4658 and 4659 interference suppressors has been prepared by Standard Telephones & Cables, Ltd., Connaught House, Aldwych, London, W.C.2.

Working instructions for the electro-deposition of tin from aqueous solutions and notes on the advantages and limitations of the various processes for different classes of work are given in Publication No. 92 of The International Tin Research and Development Council, Fraser Road, Greenford, Middlesex.

The British Standards Institution has issued a Specification relating to radio interference suppression for ignition systems which has been prepared as a result of co-operative effort on the part of the Society of Motor Manufacturers and Traders, the B.B.C., the E.R.A. and the G.P.O. Copies of the Specification, B.S. No. 833–1939, can be obtained from the British Standards Institution, 28, Victoria Street, London, S.W.1, price 2s. 2d. post free.

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

2244. On the Double Refraction of Electric Waves in Oak [Quantitative Investigation with 13.0 & 26.0 cm Waves].—K. F. Lindman. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 20, 1939, pp. 72–75.)

Using thermo-resonators as receivers. Interference measurements gave the refractive index as 1.87 and 1.58, when the direction of the fibres of the plate (which was cut parallel to the fibres) was parallel and perpendicular, respectively, to the electric force of the normally incident wave. These values were the same for the 26 cm wave as for the 13 cm, so that no dispersion was noticeable in this range of wavelengths: this confirms earlier observations of Slätis and of the writer, that solid bodies do not produce dispersion of Hertzian waves (footnotes 4 & 5). No signs of absorption in the oak (1.03 and 2.08 cm thick) could be found: this contradicts the conclusions of Righi and Mack from their qualitative results in the 1890's and supports the writer's previous results with birchwood and plate-glass plates (1272 of 1937). If the fibre direction was at an angle of 0° or 90° to the direction of the electric component of the normally incident waves, the emerging waves were plane polarised, but if it was at 45° the waves showed a weak elliptical polarisation, the directions of the principal axes agreeing well with the theoretical values. Footnote 7 gives a reference to a fuller paper on this work.

2245. Absorption and Reflection Measurements in the Centimetre-Wave Range [including Measurements of Electrical Constants of Soil of Various Degrees of Dampness].—Kebbel. (*See* 2444.)

2246. Experimental Proof of the Possibility of Long-Distance Communication on 16 cm Micro-Waves, *and* Paper on Long-Distance Communication on 50–60 cm Waves [including a Fading Effect].—S. Berline & H. Gutton: B. Michel & H. Gutton. (*See* 2568 & 2569.)

2247. Transmission Theory of Spherical [and Quasi-Spherical] Waves [yielding Physical Picture helping in Solution of Problems of Reflection, Refraction, Shielding, & Power Absorption].—S. A. Schelkunoff. (*Bell T. System Tech. Pub.*, Monograph B-1092, 14 pp.)

Definition of spherical & quasi-spherical waves: waves emitted by an electric current element: by an infinitely small electric current loop (metal shields are very much more effective for waves originated by condensers than for those originated by coils): transverse magnetic, electric, & electromagnetic spherical waves (the last cannot exist in free space, but may exist in the presence of two or more perfectly conducting conical wires emerging from a given point). As regards shielding, the present paper is complementary to the paper dealt with in 1740 of 1938.

2248. Some [Medium-Frequency] Ground-Wave Field-Intensity Measurements taken in New Zealand [Measuring Equipment (and the Necessary Distance from the Transporting Motor-Car): Effect of Obstacles in Wave-Path (Hills, Valleys, Overhead Wires, Belt of Trees, etc.): Electrical Constants of N.Z. Terrains: Field Intensities for Noise-Free Service: etc.].—G. Searle. (*New Zealand Journ. of Sci. & Technol.*, Nov. 1938 & Jan. 1939, Vol. 20, Nos. 3B & 4B, pp. 166–176B & 184–214B.)

2249. Further Note on the Propagation of Radio Waves over a Finitely Conducting Spherical Earth.—B. van der Pol & H. Bremmer. (*Phil. Mag.*, March 1939, Series 7, Vol. 27, No. 182, pp. 261–275.)

For previous papers *see* 3102 of 1938. Here, curves obtained in the second of these papers have been re-calculated with the Hankel approximation to Bessel functions used in the third; "in these new figures the curves could be given ranging from the immediate proximity of the emitter up to well into the shadow region, owing to the good fit existing in the transition region between the geometric optical formula and the residue formula."

2250. DIFFRACTION AND REFRACTION OF A HORIZONTALLY POLARISED ELECTROMAGNETIC WAVE [from a Vertical Magnetic Dipole] OVER A SPHERICAL EARTH.—Marion C. Gray. (*Phil. Mag.*, April 1939, Series 7, Vol. 27, No. 183, pp. 421–436.)

Author's abstract :—Formulas are derived [by Watson's method] for the electromagnetic field at a point on or above the surface of a spherical earth, due to the presence of a vertical magnetic dipole. It is shown that the resultant field resembles that due to a vertical electric dipole above a spherical earth of low conductivity, and that in the magnetic case the values of the earth constants are of much less importance than in the electric. Curves are included showing the variation of the field with distance and with height.

2251. THE PROPAGATION OF ELECTROMAGNETIC WAVES [Survey].—P. David. (*Rev. Gén. de l'Élec.*, 11th & 18th March 1939, Vol. 45, Nos. 10 & 11, pp. 303–316 & 333–350 : with bibliography of 159 items.)

2252. AN ANOMALY OF THE SOLAR PERIOD 1923–1933 [Period of Increase of Number of Sunspots longer than that of Decrease : This Exception to the General Rule occurs Once a Century : Possible Connection of Length of Sunspot Cycles with Intensity and Regularity of Weather].—H. Mémery. (*Comptes Rendus*, 6th March 1939, Vol. 208, No. 10, pp. 733–734.)

2253. THE EARTH'S MAGNETISM AND THE UPPER ATMOSPHERE.—K. R. Ramanathan. (*Sci. & Culture*, Calcutta, Feb. 1939, Vol. 4, No. 8, Supp. pp. 1–3.) Summary of a Sectional Presidential address to the Indian Science Congress.

2254. ORIGIN OF THE EARTH'S MAGNETIC FIELD [Theory based on Thermoelectric Currents in Metallic Core].—W. M. Elsasser. (*Nature*, 4th March 1939, Vol. 143, pp. 374–375 : preliminary letter.)

2255. THE PROPAGATION OF A SIGNAL IN A RAREFIED IONISED ATMOSPHERE [Integral of Maxwell's Equations : Possibility of Analysing Deformation of Signal : Group Velocity is Effective Velocity of Propagation].—L. Cagniard. (*Comptes Rendus*, 20th March 1939, Vol. 208, No. 12, pp. 918–920.)

2256. RESONANCE PHENOMENA IN IONISED GASES AND THEIR EFFECT ON THE PROPAGATION CHARACTERISTICS OF ELECTROMAGNETIC WAVES.—Y. Asami & M. Saito. (*Nippon Elec. Comm. Eng.*, Feb. 1939, No. 15, pp. 564–570.) A summary was dealt with in 892 of March.

2257. ORIGIN OF THE COLORATION OF THE AURORA BOREALIS TYPE B [Increase in Strength of Yellow-Red Bands : Observed Wavelengths and Relative Intensities].—R. Bernard. (*Comptes Rendus*, 13th March 1939, Vol. 208, No. 11, pp. 824–826.)

2258. POSSIBLE PRESENCE OF CYANOGEN BANDS IN THE SPECTRUM OF RED AURORAE OF TYPE B. —R. Bernard. (*Comptes Rendus*, 12th April 1939, Vol. 208, No. 15, pp. 1165–1167.)

2259. RED CYANOGEN BANDS IN THE SPECTRUM OF THE NIGHT SKY, *and* REMARKS ON THE VARIATIONS OF THE COLOUR OF THE NIGHT SKY.—G. Déjardin : R. Grandmontagne. (*Comptes Rendus*, 6th March 1939, Vol. 208, No. 10, pp. 751–753 : pp. 754–755.)

2260. EVALUATION OF THE BRILLIANCE OF THE NIGHT SKY, USING A CAESIUM PHOTOELECTRIC CELL.—R. Grandmontagne. (*Comptes Rendus*, 12th April 1939, Vol. 208, No. 15, pp. 1135–1137.)

2261. INVESTIGATIONS ON THE COMBINATION OF NITROGEN AND OXYGEN IN THE GLOW DISCHARGE.—W. Holtz & R. Müller. (*Ann. der Phys.*, Series 5, No. 6, Vol. 34, 1939, pp. 489–520.)

2262. H.F. TELEPHONY ALONG THREE-PHASE POWER LINES [General Equations : Propagation Constants : etc.], *and* H.F. TELECOMMUNICATIONS ALONG [Three-Phase] POWER LINES [Theory : Participation of All Three Phases in Propagation].—F. Carbenay. (*Comptes Rendus*, 6th March 1939, Vol. 208, No. 10, pp. 736–738 : 27th March 1939, No. 13, pp. 981–983.) For previous work *see* 1816 of May.

2263. COMBINATION TONES IN SOUND AND LIGHT [General Theory verified by Experiments].—W. Bragg. (*Nature*, 1st April 1939, Vol. 143, pp. 542–545.)

2264. COMBINATION OSCILLATIONS [and Their Significance in Various Fields].—H. Ruprecht. (*Funktech. Monatshefte*, March 1939, No. 3, pp. 65–69.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2265. THE FIELD-STRENGTHS OF THE ATMOSPHERIC PARASITES AT CALCUTTA ON WAVELENGTHS 10 TO 500 METRES.—S. P. Chakravarti. (*L'Onde Élec.*, March 1939, Vol. 18 [wrongly printed 20], No. 207, pp. 99–110.)

Using a method of measurement based on the theoretical work of Moullin in 1924. Among the results, the "importance" figures for interference (ratio of Indian intensities to European) vary from 704 (summer, wavelengths up to 100 m) to 10 (winter, wavelengths 200–545 m) : intensities vary with λ in the winter, but in summer and during the Rains the variation is complex—in April (a fairly typical summer month) an approximate relation is $S = A\lambda + B\lambda^2$ for wavelengths 50–300 m, but in other summer months and for other wave-ranges the variation follows other laws.

2266. ATMOSPHERIC DISTURBANCES [Survey of German Researches since 1926, particularly Those of Schindelhauer, Marcard (Niemegk : Spectral Distribution between 2×10^7 and 2×10^4 c/s, with Directional Observations), and Leithäuser & Menzel].—O. Morgenroth. (*Funktech. Monatshefte*, March 1939, No. 3, pp. 70–74.) *See* also 2267, below.

2267. THE INTENSITY AND SPECTRAL DISTRIBUTION OF ATMOSPHERIC DISTURBANCES, AND THEIR RELATIONS TO OTHER GEOPHYSICAL AND COSMIC PHENOMENA.—E. Marcard. (*Berlin Dissertation* 1936: discussed in Morgenroth's survey dealt with above—2266.)

2268. CHARGING PHENOMENA OF COMMUNICATION LINES BY "DUST WIND" IN MANCHUKUO.—Kano & others. (*Electrot. Journ.*, Tokyo, March 1939, Vol. 3, No. 3, pp. 63–66.)

2269. LIGHTNING TO THE EMPIRE STATE BUILDING [Investigation of Strokes occurring during Summers 1935/36/37].—K. B. McEachron. (*Journ. Franklin Inst.*, Feb. 1939, Vol. 227, No. 2, pp. 149–217.)

For previous work *see* 37 of 1937. In the present work, two experimental television aerials on top of the Empire State Building, New York, were used to get oscillograms and Boys-camera photographs of the same lightning stroke. The equipment is briefly described; many photographs of flashes and oscillograms are reproduced. Results discussed include the measurement of direct-current arcs (continuing strokes) between the cloud and the building; upward leaders developing into continuing strokes, with their related currents; branching (occurring in the direction of propagation of initial leader strokes); and the charges (which were much larger than hitherto believed probable). All strokes to the building began with the cloud negative; some changed to positive. "Downward stepped leaders to the building were observed in one case only . . . Leaders on all discharges after the first were always downward . . . Every stroke, but two, either struck the highest point on the building or outside a cone whose base radius at the ground level of the building was equal to the building height." The return-stroke velocities were also measured.

The deduced picture of the lightning stroke is described. "The front of the wave of current in a lightning discharge with initial downward leader to a transmission line is probably dependent upon the amount of charge available. . . . The downward leader stroke represents the type of stroke of greatest importance in the problem of protection of transmission lines and apparatus. . . . The matter of continuing strokes . . . may help to explain some of the failures of lightning arresters attributed to arcing grounds or other system disturbances." The directions of future work are indicated.

2270. INCREASE OF STRIKING DISTANCE BY RADIATION IMPACT, AND THE BRIGHTNESS OF "IMPACT" SPARKS [Measurements on Decrease of Striking Voltage due to Ultra-Violet Spark Radiation: Effect of Electrode Material: Brightness of Lightning Stroke].—M. Toepler. (*Physik. Zeitschr.*, 15th March 1939, Vol. 40, No. 6, pp. 206–216.) Extension of work referred to in 915 of March.

2271. DROP IN STRIKING VOLTAGE OF ELECTRICAL DISCHARGE DUE TO IONISATION BY AN EXTERNAL SOURCE, *and* DROP IN STRIKING VOLTAGE IN AIR AT ATMOSPHERIC PRESSURE [Measurements using Spark Illumination as External Ionising Agent].—Brinkmann. (*Arch. f. Elektrot.*, 15th Feb. 1939, Vol. 33, No. 2, pp. 121–130: *Zeitschr. f. Phys.*, No. 11/12, Vol. 111, 1939, pp. 737–746.)

2272. DISCUSSION ON "THE MECHANISM OF THE LONG SPARK."—T. E. Allibone. (*Journ. I.E.E.*, April 1939, Vol. 84, No. 508, pp. 483–494.) *See* 2680 of 1938.

2273. THE MARCONI SPLIT-GAP HORN ARRESTER [for Protection of Transmitter Installations, etc., against Lightning: Defect of Ordinary Horn Arrester largely if not completely Overcome].—N. Wells. (*Marconi Review*, April/June 1939, No. 73, pp. 25–26.)

2274. REMARKS ON A PAPER BY TOHMFOR & VOLMER: NUCLEUS FORMATION [for Water Drops] UNDER THE INFLUENCE OF ELECTRICAL CHARGES [Unnecessary to assume Diminished Dielectric Constant of Liquid in Form of Drops].—T. Glosios. (*Ann. der Phys.*, Series 5, No. 5, Vol. 34, 1939, pp. 446–448.) *See* 919 of March.

2275. DIURNAL VARIATION OF THE ELECTRICAL CONDUCTIVITY OF THE AIR AND THE NUMBERS OF IONS AND CONDENSATION NUCLEI AT THE OBSERVATORY OF CHAMBON-LE-FORÊT.—O. Thellier. (*Comptes Rendus*, 12th April 1939, Vol. 208, No. 15, pp. 1167–1170.)

2276. THE DETERMINATION OF THE MOBILITIES OF GASEOUS IONS [Theory of Method to Decide whether Ions of One Sign have Unique Mobility or Grouped Values].—E. Montel. (*Comptes Rendus*, 12th April 1939, Vol. 208, No. 15, pp. 1141–1144.)

2277. A PRECISION RADIO INSTRUMENT FOR TRANSMITTING MEASUREMENTS OF ULTRA-VIOLET INTENSITIES FROM UNMANNED BALLOONS TO A GROUND STATION [Combination of Photocell, Balanced D.C. Amplifier, Relaxation Oscillator, & Ultra-Short-Wave Transmitter].—R. Stair. (*Journ. of Res. of Nat. Bur. of Stds.*, March 1939, Vol. 22, No. 3, pp. 295–300.) The calibration is automatically determined and broadcast each time an altitude signal is given.

2278. AN IMPROVED RADIOBAROGRAPH [on Olland Principle].—Johnson & Korff. (*Review Scient. Instr.*, March 1939, Vol. 10, No. 3, pp. 82–85.)

PROPERTIES OF CIRCUITS

2279. NEW TYPES OF "CONTROL-" AND "FILTER"-QUARTZES.—Rohde. (*See* 2456.)

2280. ON THE THEORY OF FILTERS COMPOSED OF "X" CIRCUITS [Bridge Filters].—R. Feldtkeller. (*T.F.T.*, Jan. 1939, Vol. 28, No. 1, pp. 27–32.)

Author's summary :—The theory of the Zobel *m*-section is extended to *X*-circuits. It is shown how *X*-circuit filters can be calculated with the same characteristic impedance but different transmission losses. As an example, a "current purifier" is calculated for a note-frequency signal generator, which suppresses the harmonics of the generator voltage and the unwanted components from the mains, and gives the signal generator a pure sinusoidal output voltage.

2281. ON THE EFFECT OF LOSSES IN BAND FILTERS.—E. Labin. (*L'Onde Élec.*, March 1939, Vol. 18 [wrongly printed 20], No. 207, pp. 120–148.)

Using the method of treatment originated by Mayer [the Mayer "frequency transformation" rule, where ω^2 is replaced throughout by $\omega^2 - j\epsilon\omega$: see *E.N.T.* of 1925] and appearing again in the theories of Jaumann and of Cauer. Practical applications which are described are (1) to the checking of a filter already constructed, and (2) to the predetermination of the tolerable angle of loss and of the diminution of band width.

2282. AMPLITUDE FILTERS AND THEIR USE IN TELEPHONE INSTALLATIONS [AEG Circuits using Full-Wave Valve Rectifiers: Suppresser for Small Amplitudes, Limiter for Large].—W. Benz. (*T.F.T.*, Feb. 1939, Vol. 28, No. 2, pp. 63–68.)

2283. DESIGN OF R.F. OUTPUT NETWORKS FOR BROADCASTING TRANSMITTER.—Koike. (*See* 2305.)

2284. "TENSOR ANALYSIS OF NETWORKS" [Book Review].—G. Kron. (*Electrician*, 31st March 1939, Vol. 122, p. 413.) ". . . this remarkable book which, we foresee, will have a profound influence in both educational and practising spheres of electrical engineering."

2285. AN IMPROVED PHASE SHIFTER OF THE BRIDGE TYPE.—T. Sakamoto. (*Nippon Elec. Comm. Eng.*, Feb. 1939, No. 15, pp. 540–545.)

2286. AMPLI-EQUALISER OF BRIDGED-FEEDBACK TYPE [with Any Desired Gain/Frequency Characteristics to suit Attenuation Characteristic of Cable].—K. Kobayashi. (*Electrot. Journ.*, April 1939, Vol. 3, No. 4, p. 96.)

2287. THE TRANSIENT PHENOMENA IN THE RECTIFIED-FEEDBACK AMPLIFIER [as used as Expander or Compresser.]—M. Simada & Y. Aono. (*Nippon Elec. Comm. Eng.*, Feb. 1939, No. 15, pp. 573–575 : summary only.)

2288. THE CALCULATION OF THE COUPLING LINKS IN NEGATIVE-FEEDBACK CIRCUITS.—O. Schmid. (*Funktech. Monatshefte*, Feb. 1939, No. 2, pp. 61–62.)

2289. HIGH-FREQUENCY RESISTANCE [Mechanism involved in the Increase of Resistance with Frequency].—F. R. W. Strafford. (*Wireless World*, 20th April 1939, Vol. 44, pp. 369–370.)

2290. THE CALCULATION OF THE ENERGY IN AN OSCILLATING SYSTEM BY THE OPERATIONAL CALCULUS.—A. V. Rimski-Korsakov. (*Journ. of Tech. Phys.* [in Russian], No. 20, Vol. 8, 1938, pp. 1836–1838.)

In solving a technical problem by the operational calculus the results of calculations are usually expressed by a function of time and space representing the motion of the system under consideration. To obtain an expression for the energy of the system it is necessary to carry out an additional integration with respect to time. In the present paper, starting from the general formula for the energy of the system $E = \int_{-\infty}^{+\infty} f(t)\phi(t)dt$ and using Rayleigh's theorem (*Phil. Mag.*, 1889, Vol. 27, p. 466), a formula (6) is derived, which permits the calculation of E by integrating in the complex plane without the use of functions $f(t)$ and $\phi(t)$. The discussion is applied to the case of a battery discharging into a circuit consisting of resistances and capacities (Fig. 1).

2291. TWO SYSTEMS OF ELECTRO-MECHANICAL ANALOGIES FROM THE POINT OF VIEW OF THE LAGRANGE EQUATION.—K. Teodorchik. (*Journ. of Tech. Phys.* [in Russian], No. 18, Vol. 8, 1938, pp. 1652–1658.)

2292. SIMILITUDE OF CRITICAL CONDITIONS IN FERRORESONANT CIRCUITS [Predetermination of Critical Stable Conditions for a Reactor from Knowledge of Those Conditions for Any Other Reactor using Same Grade of Iron].—W. T. Thomson. (*Elec. Engineering*, March 1939, Vol. 58, No. 3, Transactions pp. 127–130.)

TRANSMISSION

2293. THE FORMATION OF NEGATIVE RESISTANCE IN A SPLIT-ANODE MAGNETRON.—V. Lukoshkov & V. Iljinski. (*Journ. of Tech. Phys.* [in Russian], No. 22/23, Vol. 8, 1938, pp. 1996–2011.)

A critical survey is given of various theories of the operation of a split-anode magnetron, and a study is presented of electron movements in the magnetron. A graphic-analytical method was employed for this investigation, and it was necessary to plot a large number of electron trajectories. This task was considerably simplified by (a) preliminary preparation of electric field charts with the aid of an electrolytic bath, and (b) a specially developed apparatus (to be described in a later paper) for calculating the radii of curvature and for plotting the trajectories. A number of charts thus obtained for various operating conditions are shown and discussed in detail. The conclusions reached are compared with those of other authors.

2294. THE EFFECT OF INTERELECTRODE CAPACITIES AND THE ACTIVE RESISTANCES OF THE LEADS ON THE LENGTH OF THE WAVE GENERATED BY A TRIODE.—Yu. A. Katzman. (*Journ. of Tech. Phys.* [in Russian], No. 19, Vol. 8, 1938, pp. 1736–1746.)

Special triodes of small dimensions suitable for generating decimetre waves are considered, and it is assumed that the duration of electron travel in these triodes is sufficiently small and that the minimum wavelength is limited only by the interelectrode capacities and by the active resistances of the leads. The operation of such triodes is discussed and the necessary conditions for self-excitation are established. The effect of the above-mentioned factors on these conditions is then considered separately for oscillating circuits with (a) capacitive coupling (Fig. 1a and 2a) and (b) capacitive and inductive coupling (Fig. 1b and 2b). On the basis of this investigation a number of suggestions are made on the construction of the triodes.

2295. ON RESONATORS SUITABLE FOR KLYSTRON OSCILLATORS [Description of Various "Hohlraum" Resonators: Definition of Shunt Impedance: Calculation of Properties using Various Mathematical Techniques].—W. W. Hansen & R. D. Richtmeyer. (*Journ. of Applied Phys.*, March 1939, Vol. 10, No. 3, pp. 189–199.) For the "klystron" oscillator *see* 1848 of May.

2296. A PRACTICAL NEGATIVE-RESISTANCE OSCILLATOR ["Transitron" Oscillator].—C. Brunetti. (*Review Scient. Instr.*, March 1939, Vol. 10, No. 3, pp. 85–88.) *See* also 1851 of May. The present paper represents the salient points less technically, to make clearer the many applications outside the field of radio communications.

2297. FUNDAMENTAL CONSIDERATIONS ON FOUR-PHASE OSCILLATION CIRCUITS [and the Practicability of Four-Phase Generation by coupling Two Valve Circuits instead of Four], *and* A POLAR VARIABLE-PHASE OSCILLATOR.—I. Takao. (*Memoirs of Ryojun Coll. of Eng.*, Dec. 1938, Vol. 11, No. 9, Supp. pp. 7–8: March 1939, Vol. 12, No. 1, Supp. p. 1: summaries only, in English.) The first paper is given in full in *Electrot. Journ.*, Tokyo, April 1939, Vol. 3, No. 4, pp. 75–79 (in English).

2298. MEASUREMENTS OF THE FREQUENCY STABILITY AND THE OVERTONE CONTENT OF VALVE OSCILLATORS.—G. Nüsslein. (*Hochf:tech. u. Elek:akus.*, March 1939, Vol. 53, No. 3, pp. 89–97.)

The two circuits here investigated were dealt with in 1932 Abstracts, pp. 163–164 (Llewellyn) and 164 & 222 (Dow). They contain special devices for frequency stabilisation. The theory of frequency variations due to voltage fluctuations of the current sources is dealt with in § II; eqn. 1 gives the relation between the harmonic content and the deviation of the frequency from its true value, eqn. 2 the effect of the current distribution; § II.3 discusses the effect of the valve capacities. § III describes the measurements; Fig. 1 shows the principle of the frequency measurement, in which the frequency under investigation is compared with that from a quartz oscillator. The two frequencies are mixed; their difference is compared with that of an audio-frequency beat oscillator by producing an ellipse on the screen of a cathode-ray tube. The measurement of harmonic content (§ III.2; Fig. 2) employs an exploring-note method in which the frequency under investigation and one from a receiver-test generator are mixed in a hexode. The mixing circuit is shown in Fig. 3.

Experimental results are described in § IV and shown in the form of curves. With Llewellyn's circuit "a considerable degree of independence of frequency as regards anode voltage was attained, though not at the highest frequency used (4.24 Mc/s). Stabilisation of frequency as regards heating-voltage fluctuations was only found in one case. Simultaneous independence of frequency as regards anode and heating voltage never occurred. It seems probable from measurements of the harmonic content that the strength and form of the overtones also have a bearing on frequency stabilisation." Dow's electron-coupled oscillator gave stabilisation as regards anode voltage for all frequencies from 1.69 to 4.24 Mc/s. "For this it was necessary to tune the anode circuit to the fundamental of the oscillations produced in the grid circuit and to adjust the screen-grid voltage to a definite fraction of the anode voltage. No compensation effects are produced if the anode circuit is tuned to an overtone; the frequency then becomes chiefly dependent on the screen-grid voltage. The variation of frequency with the heating voltage was small, with the oscillating valve used."

2299. ON THE COMPENSATION OF TEMPERATURE COEFFICIENT OF TUNING CIRCUIT [Theoretical and Experimental Investigation: Capacitance Compensation by Bimetallic Construction: Inductance Compensation by Micalex-Bars/Bakelite-Cylinder Bobbin: Coefficient reduced to 5×10^{-6}].—S. Uemura. (*Nippon Elec. Comm. Eng.*, Feb. 1939, No. 15, pp. 575–576: summary only.)

2300. 250-WATT CRYSTAL OSCILLATOR [Proof of Authors' Contention that Improvement in Valve Design is of First Importance if Increased Power Output of Crystal Oscillator is desired: More than 250 W obtained easily with MD-546-C Pentode (Nisio & Ikezawa) at 5 Mc/s].—I. Koga, W. Yamamoto, & others. (*Electrot. Journ.*, Tokyo, April 1939, Vol. 3, No. 4, pp. 92–94.)

2301. NEW TYPES OF "CONTROL-" AND "FILTER"-QUARTZES.—Rhode. (*See* 2456.)

2302. A FREQUENCY-CHECKING SUPERHET: UTILISING BROADCAST STATIONS FOR AMATEUR TRANSMITTER FREQUENCY CONTROL.—D. A. Griffin. (*QST*, April 1939, Vol. 23, No. 4, pp. 38–41 and 88.)

2303. MODULATION [Systematic Examination of Definitions and Fundamental Principles].—H. Ruprecht. (*E.N.T.*, Feb. 1939, Vol. 16, No. 2, pp. 43–47.)

From the author's summary:—The term "modulation" is a specific name for a physical process dominated by the idea of the variation of a parameter in the expression for an oscillation, not by a Fourier analysis (sideband representation), . . . which is the analysis of the form produced by modulation and represents a special form of frequency transformation *as the result* of modulation. The term " modulation " should only be used in the range of degrees of modulation greater than zero and up to and including unity. Higher degrees of modulation belong to the region of " overmodulation," which is only of theoretical interest. A modulated oscillation is characterised as a *fluctuating* oscillation (in which one parameter fluctuates round a fixed positive value), in contrast to the *oscillating* oscillation with a parameter oscillating about zero (complete beats). The modulation is amplitude or phase-angle modulation, according to whether the otherwise constant factor (amplitude A) or the argument (the phase angle $\omega t + \phi$) is the fluctuating parameter. These two principal types have among many other possible sub-types the important ones of amplitude and phase-angle modulation respectively, with the modulating frequency in the denominator of the modulating function. The latter is known as frequency modulation, while the former has no special name. The word " phase modulation," that is, modulation of the zero phase angle ϕ, ought to disappear, for several reasons . . . there is no real physical basis for a modulation of the zero phase angle, which would look correct in the formula, in an oscillation varying with time.

2304. MODULATION METHODS FOR THE ATTAINMENT OF A HIGH EFFICIENCY : PART I [Condemnation of Chireix System : Full Analysis and Discussion of Doherty System, with Calculation of Its Efficiency : Variations (Telefunken Patents) of Doherty System, avoiding Defects of Latter].—R. Hofer. (*Telefunken Hausmitteilungen*, March 1939, Vol. 20, No. 80, pp. 85–100.)

" In the practical use of a transmitter with the Doherty connection there is the complication that the grid a.c. ratio p requires in general a very accurate adjustment in order that the resulting working characteristic may have as linear a form as possible to give good modulation-quality. With weak modulation a distorting curvature of the resulting characteristic can only be reduced sufficiently by the artifice of negative feedback (*e.g.* over a linearly working rectifier) if a serious deterioration of the energy balance is not to be suffered. Moreover, it has already been pointed out that with modulation of comparatively wide band-width the external impedance of the carrier valve may be markedly complex, causing an increase of the form distortion for high modulation tones. These objectionable phenomena can be improved if the carrier valve is allowed to work, during modulation, in a permanently over-voltaged condition and the sideband frequencies are controlled in both l.f. half-periods by valves which are connected at the other end of a [coaxial-tube] transmission line. There are two ways of doing this, which are described below " [(1) arrangement of a separate valve group for the sideband amplification, and (better) (2) arrangement of a separate push-pull modulator for the sideband amplification].

2305. DESIGN OF RADIO-FREQUENCY OUTPUT NETWORKS FOR BROADCASTING TRANSMITTERS [Analysis of Sideband Cut-Off due to Resonance Characteristic, Filtering Action on Higher Harmonics, and Modulation Distortion due to Phase Rotation of Sidebands : Equations and Charts : Pi-Type Circuit treated as Two L-Type Circuits].—Y. Koike. (*Nippon Elec. Comm. Eng.*, Feb. 1939, No. 15, pp. 546–553.)

2306. A NON-LINEAR DIFFERENTIAL-FEEDBACK OSCILLATOR.—G. Hakata & M. Abe. (*Nippon Elec. Comm. Eng.*, Feb. 1939, No. 15, pp. 526–536.) A summary was dealt with in 955 of March.

2307. AUTOMATIC VOLUME COMPRESSION.—Pawley. (*See* 2576.)

2308. A PEAK-LIMITING AMPLIFIER FOR AMATEUR USE : INCREASING COMMUNICATION EFFICIENCY AND PREVENTING OVER-MODULATION, BY SPEECH-COMPRESSION.—R. Macfarland. (*QST*, April 1939, Vol. 23, No. 4, pp. 36–37 and 114.)

2309. RECENT DEVELOPMENTS IN RADIO TRANSMITTERS [Broadcasting, Short-Wave Broadcasting, & General Purpose Transmitters, Ultra-Short-Wave Police & Broadcast-Pick-Up Equipment].—J. B. Coleman & V. E. Trouant. (*RCA Review*, Jan. 1939, Vol. 3, No. 3, pp. 316–334.)

2310. A TELEFUNKEN WHALING TRANSMITTER [Very Small Automatic Transmitter, with 6 Mile D.F. Range, for tracing Killed and Floating Whales].—(*Telefunken Hausmitteilungen*, March 1939, Vol. 20, No. 80, p. 121.)

2311. SAFETY DEVICES FOR AMATEUR TRANSMITTERS.—G. Grammer. (*QST*, April 1939, Vol. 23, No. 4, pp. 42–44.)

2312. RELATION BETWEEN THE POWER RADIATED BY A SHIP STATION AND THE NUMBER OF " METRE-AMPERES."—Marique. (*See* 2586.)

RECEPTION

2313. A SUPERHET CONVERTER FOR 5- AND 10-METRE RECEPTION [using U.H.F. Valves : Comparative Merits of Types 1231, 954, 1852, & 1853].—F. Lester. (*QST*, April 1939, Vol. 23, No. 4, pp. 30–34 and 106.)

2314. ON THE COMPENSATION OF TEMPERATURE COEFFICIENT OF TUNING CIRCUIT.—Uemura. (*See* 2299.)

2315. VARIABLE-FREQUENCY QUARTZ CRYSTALS FOR SUPERHETERODYNE RECEPTION, ETC.—Uda & Honda. (*See* 2457.)

2316. THE REDUCTION OF DIODE-DETECTOR DISTORTION BY POSITIVE BIAS.—(*Marconi Review*, April/June 1939, No. 73, pp. 10–12.)

A comparison of eqns. 1 & 2 for the max. modulation percentage acceptable without distortion (due to the amplifier grid leak, when a resistance-capacity coupling transfers the a.f. voltages from the detector to the grid of the first a.f. amplifier) shows that this percentage can be increased by positive bias to the diode. For satisfactory operation (avoidance of increased damping) the bias should be controlled by the signal input, and a method of achieving such control is described.

2317. THE RECEIVERS OF TO-DAY FOR TRANS-OCEANIC COMMUNICATIONS.—P. Kotowski. (*Telefunken Hausmitteilungen*, March 1939, Vol. 20, No. 80, pp. 30–52.)

2318. A STUDY OF WIRELESS PRINTING TELEGRAPH SYSTEM, *and* FADING AND STATIC INTERFERENCE IN WIRELESS PRINTING TELEGRAPH [Dairen/Hsinking (Manchukuo) Experiments: Desirability of Step-by-Step Printer, but Necessity for Static Elimination (Success of "*MTT*" Anti-Static Apparatus using Condenser-Resistance Time-Constant Circuit and Thyratron): etc.].—Sugiyama, Yamamoto, Nakata. (*Nippon Elec. Comm. Eng.*, Feb. 1939, No. 15, p. 571: p. 573: summaries only.)

2319. PARASITIC RECTIFICATION [by Imperfect Contacts: Some Instances].—"Log-Roller." (*World-Radio*, 21st April 1939, Vol. 28, p. 10.)

2320. THE ACTION *via* THE MAINS OF H.F. INTERFERENCE VOLTAGES ON BROADCAST MAINS RECEIVERS.—A. Dennhardt & O. Stauss. (*Hochf:tech. u. Elek:akus.*, Feb. 1939, Vol. 53, No. 2, pp. 45–50.)

The fundamental circuit used in this investigation of the penetration *via* the mains of h.f. disturbances into a broadcast receiver is shown in Fig. 1; an "artificial disturbance" is superposed on the normal h.f. input voltage, and differs from it by a frequency of the order of 1000 c/s. The measurement of the loudness of the interference tone, the adjustment of the normal working condition of the receiver, and the introduction through the mains of the disturbing h.f. voltage are described. Results are described in § IV (Figs. 3–6). The "anti-noise rigidity" (Störfestigkeit) of a receiver is defined by eqn. 1 as the percentage ratio of the permissible h.f. voltage entering by the mains to the useful input voltage: it is the reciprocal of the "sensitivity to noise." The question of its magnitude is discussed in § V.1; Fig. 9 shows how it varies with the input voltage required by the receiver. The effect of introducing a h.f. rejector circuit (Fig. 10) and the influence of aerial and earth resistances (input circuits for determining this influence, Fig. 11; influence on "anti-noise rigidity," Figs. 12a & b) are discussed in § VI: the decrease of "rigidity" with increase in earth resistance is serious. Fig. 12c shows the effect of various capacities of a counterpoise earth, for a simple single-circuit receiver: the "rigidity" is improved by the counterpoise, and a max. value is indicated for a capacity around 500 picofarads.

2321. A CAUSE OF SCATTERING [of Results] IN THE MEASUREMENT OF RADIOPHONIC INTERFERING VOLTAGES [by CISPR Technique: Theory (and Experimental Confirmation) of the Limits of Precision for Superheterodyne Receivers].—G. Goffin. (*L'Onde Élec.*, Feb. 1939, Vol. 18 [wrongly printed 19], No. 206, pp. 57–69.)

The author's conclusions are as follows:—In the case of isolated pulses of interference, the peak value read on the indicating instrument of the interference-measuring equipment lies between two symmetrical limits on either side of the true value. When such pulses (*e.g.* those due to the working of a tramcar controller) are measured, there is an uncertainty which depends on the qualities of the receiver employed and which, with the receivers tested, amounted to about 4 db whenever it was impossible to repeat the measurement so many times that an average value could be calculated. In the case of periodically repeated interference, even when the pulses are strictly identical, the needle of the indicating instrument shows continual oscillations about a mean value: the amplitude of these oscillations depends on the periodic frequency of the pulses and on the receiver qualities.

Equation 15 shows that to reduce as much as possible the dispersion between the measured values two possible courses may be taken: (1) the intermediate-frequency selection-factor λ may be reduced as much as possible: λ is defined (pp. 62–63) as the ratio of the sinusoidal voltage at the intermediate frequency f_m to that voltage (at the pre-selector resonance frequency f_o) which produces the same deflection in the indicator of the peak voltmeter when similarly applied to the input of the measuring receiver. The reduction of λ means that the pre-selecting circuits must have very little damping, and should contain a wave-trap circuit tuned to the intermediate frequency. The selectivity of the pre-selecting circuits cannot, however, be increased beyond certain limits, the CISPR type receiver having to have a h.f. pass band of 9 kc/s at all frequencies. Course (2) is to increase the intermediate frequency: in practice, however, this can hardly exceed 500 kc/s.

2322. POSSIBILITIES OF INTERFERENCE ELIMINATION IN BROADCAST RECEIVERS [Survey].—G. St. Dallos. (*Funktech. Monatshefte*, Feb. 1939, No. 2, pp. 33–41.)

"Cut-out" (interruption) methods and the advantage of homodyne ("zero-beat") reception—difficulties "great but not insurmountable": the writer's commutator machine for the quantitative investigation of "cut-outs" with variable duration and frequency of make and break: interruptions shorter than 1.4 msec. are hardly noticeable if their frequency does not exceed 20–30 per sec. (provided that building-up and decay processes, and hysteresis effects, are avoided): interruption circuits (Figs. 7 & 12). Amplitude limitation, static and dynamic: the General Electric dynamic limiting circuits, with series diode (Fig. 9, for weak signals) and parallel diode (Fig. 10, for strong signals), and an advantageous combination of the two (Fig. 11). For a correction see *ibid.*, March 1939, No. 3, p. 74.

2323. SUPPRESSION AND CAR PERFORMANCE [Test Experience of Effect of "Resistance" Suppression (of Interference) on Road Performance of Car: "Entirely Negligible"].—C. Attwood. (*Wireless World*, 13th April 1939, Vol. 44, pp. 345–346.)

2324. PUSH-BUTTON TUNING IN A NEW LIGHT [P-B Receivers may be Much More Efficient and Flexible than Ordinary Type, where Many Variables must be set permanently in Compromise Positions].—(*Wireless World*, 30th March 1939, Vol. 44, pp. 293–294.)

2325. CALCULATION OF TONE CONTROLS AND CORRECTING CIRCUITS [for Broadcast Receivers and Gramophones].—H. Pitsch. (*Funktech. Monatshefte*, March 1939, No. 3, pp. 75–79.) Continuing the work dealt with in 1395 of 1938 and back reference.

2326. THE *Wireless World* STAND-BY THREE [Low Tension from Dry Cells: an Emergency Receiver].—(*Wireless World*, 30th March & 6th April 1939, Vol. 44, pp. 290–293 & 314–317.)

2327. A HURRICANE EMERGENCY RECEIVER: A SIMPLE BATTERY JOB FOR GENERAL USE WHEN POWER FAILS [Wave-Range 2–2000 m].—G. M. Smith. (*QST*, April 1939, Vol. 23, No. 4, pp. 48–51 and 106.)

2328. THE GERMAN 1938 "SMALL RECEIVER" [" DKE," to give Same Performance as the "People's Receiver" at about Half the Price—say RM 35].—(*Lorenz Berichte*, Dec. 1938, No. 3/4, pp. 78–80.)

2329. ON THE APPLICATION POSSIBILITIES OF THE "UNIVERSAL" OUTPUT TRANSFORMER [with Tapped Primary and Secondary: for Matching to Output Valve and to Loudspeaker: as Mains Transformer: in Modulated Signal Generator].—M. Wünsch. (*Funktech. Monatshefte*, March 1939, No. 3, pp. 80–84.)

2330. TRANSFORMER LAMINATIONS WITHOUT WASTE OF MATERIAL [Advantages of the "E & I" Core Form, and Its Derivative the "Pure E" Core with All Dimensions as Multiples of "Window" Width: Type Classification System: Table of Dimensions for Types from "E 8" to "E 20"].—Käser. (*Funktech. Monatshefte*, March 1939, No. 3, pp. 87–89.)

AERIALS AND AERIAL SYSTEMS

2331. TELEVISION STATION HAS RADICALLY DESIGNED ANTENNA ["Cubic-Shaped" (Eight Copper Tubes) 4.5 m-Wave Aerial for Helderberg (Schenectady) Station].—General Electric Company. (*Sci. News Letter*, 11th March 1939, Vol. 35, No. 10, p. 159.) *See* also *World-Radio*, 5th May 1939, p. 13. For previous information on this station *see* 1987 of May.

2332. RADIATION RESISTANCE OF A HORIZONTAL DIPOLE ABOVE EARTH [Completion of McPherson's Analysis, and Derivation of Expression in Form suitable for Practical Use].—L. Lewin. (*Marconi Review*, April/June 1939, No. 73, pp. 13–24.) For McPherson's work *see* 3591 of 1938 and back ref. The year of publication there given ("1938") is correct; not "1937" as quoted in the present paper.

2333. THE CALCULATION OF THE ENERGY RADIATION OF AERIAL SYSTEMS [consisting of *n* Parallel Straight Radiators of Finite Length, the Position of the Radiators, the Current Distribution, and the Phase Displacements between the Individual Currents being Known: Explanation of Pistolkors' Method of Direct Integration, illustrated by Its Application to a Two-Radiator System].—F. Oberhettinger: Pistolkors. (*Lorenz Berichte*, Dec. 1938, No. 3/4, pp. 67–77.) For Pistolkors' method *see* also 1929 Abstracts, p. 329.

2334. MODEL MEASUREMENTS ON FIXED AIRCRAFT AERIALS FOR DETERMINING THE RADIATION CHARACTERISTICS IN THE SHORT-WAVE RANGE.—E. Harmening & W. Pfister. (*Hochf:tech. u. Elek:akus.*, Feb. 1939, Vol. 53, No. 2, pp. 41–45.)

These measurements on the wavelength range 80–120 m for a full-sized aeroplane were made on a model of a "Ju 52" (Fig. 1) diminished in the ratio 1 : 18. The wavelength actually used was 5 m, corresponding to 90 m on the full-sized machine. The model, containing a small transmitter, was fastened into a wooden frame (Fig. 2) so that it could be rotated about its three principal axes. The transmitting and receiving posts were 50 m apart, each on a wooden tower 50 m high so that neither the wave reflected from the earth, nor cables or iron in the neighbourhood, affected the results. Relative measurements of field-strength were made; the results for various positions and lengths of transmitting aerial are shown in Figs. 3–10. It was found that an equivalent dipole could be found for every radiation characteristic. "The horizontal diagram (round the principal axis) is, for the ordinary aerial dispositions, almost circular; a rod used as an aerial has marked directional effect, depending on its position. Vertical polarisation of the radiation can be attained by symmetrical arrangement; this prevents the equivalent dipole being inclined obliquely to one of the sides. Oblique inclination in the forward or backward direction can however occur; this depends on frequency and can be got rid of by choosing a corresponding position for the aerial."

2335. "KURZWELLEN-ANTENNEN" [Short-Wave Transmitting & Receiving Aerials in Theory & Practice: Book Review].—R. Kollak & H. Wehde. (*Zeitschr. V.D.I.*, 1st April 1939, Vol. 83, No. 13, p. 396.)

2336. MEASUREMENT OF EFFECTIVE HEIGHT OF AUTOMOBILE ANTENNAS [including a Special Apparatus for the Purpose, and Its Calibration & Use].—D. E. Foster & G. Mountjoy. (*RCA Review*, Jan. 1939, Vol. 3, No. 3, pp. 369–381.)

2337. MEASUREMENT OF BROADCAST COVERAGE AND ANTENNA PERFORMANCE: PART II—THE MEASUREMENT OF THE EFFICIENCY OF THE ANTENNA SYSTEM.—W. A. Fitch & W. S. Duttera. (*RCA Review*, Jan. 1939, Vol. 3, No. 3, pp. 340–354.) For Part I see 2910 of 1938.

2338. THE [Anti-Fading] AERIAL OF THE TELEFUNKEN BROADCASTING STATION AT HÖRBY [Square-Sectioned 130 m Insulated Tower with " Eight-Rayed Star " Top-Capacity for Small Variations of Natural Wavelength: Measurements of Anti-Fading Results with Varying Number of Top-Capacity " Rays ": etc.].—H. Larsson. (*Telefunken Hausmitteilungen*, March 1939, Vol. 20, No. 80, pp. 101–109.)

2339. CALCULATION OF ATTENUATION FOR TRANSMITTING AERIALS.—W. Wiechowski. (*Hochf: tech. u. Elek:akus.*, Feb. 1939, Vol. 53, No. 2, pp. 50–54.)

The current and voltage distribution along the aerial is assumed to be similar to that along a line with attenuation. The differential equations of the equivalent line are solved; the energy equation (energy supplied = energy radiated) leads to an equation for determining the attenuation constant which is solved numerically (Figs. 2 & 3) for the case of an unloaded homogeneous aerial excited at the base. The current and voltage distribution and the power and field of the aerial are calculated. Fig. 2 shows also (broken lines) that the approximate method of obtaining αh from R_s/Z (Siegel & Labus, 2155 of 1937) gives slightly different values, which are, however, useful for rough estimations.

2340. CERTAIN PROPERTIES OF DISSYMMETRICAL T PURE REACTANCE NETWORKS: PART I [Ambiguities in Calculation of Voltage & Current at Input Terminals of Aerial coupled to Feeder by Such a Network, liable to lead to Serious Errors].—(*Marconi Review*, April/June 1939, No. 73, pp. 27–35.)

2341. A COUPLING SYSTEM FOR THE CLOSE-SPACED ANTENNA-DIRECTOR [Half-Wave, with One-Tenth-Wave Element Spacing: Link Coupling, to simplify Matching Problems].—M. P. Mobley: Stavrou. (*QST*, April 1939, Vol. 23, No. 4, pp. 16-17.) For use with the aerial described by Stavrou (2762 of 1938), which has proved extremely successful.

2342. LONG FEEDERS FOR TRANSMITTING WIDE SIDEBANDS, WITH REFERENCE TO THE ALEXANDRA PALACE AERIAL-FEEDER SYSTEM [Reflection Phenomena: Nature of Impedance Irregularities (Effect of Insulator Spacing, etc.), and Effect on Received Image: Matching the Aerial to the Feeder: Impedance-Measuring Technique: the Final Design].—E. C. Cork & J. L. Pawsey. (*Journ. I.E.E.*, April 1939, Vol. 84, No. 508, pp. 448–467: Discussion pp. 475–480.)

2343. HIGH-FREQUENCY FEEDERS [Open-Wire Feeders (including Test at Daventry on Four-Wire Type): Concentric Feeders: Matching: Harmonic Suppression: Dissipative Feeders (for Transmitter Testing)].—F. C. McLean. (*World-Radio*, 14th April 1939, Vol. 28, pp. 11–12 and 13.)

2344. AERIAL-FEEDING EQUIPMENTS IN GERMAN SHORT-WAVE STATIONS.—Buschbeck. (In paper dealt with in 2580, below).

2345. CHARTS FOR TRANSMISSION-LINE MEASUREMENTS AND COMPUTATIONS [for Rapid Determination, from Simple Measurements, of Load Impedance at Any Desired Position along Line, or of Current and Voltage Distributions, etc.].—P. S. Carter. (*RCA Review*, Jan. 1939, Vol. 3, No. 3, pp. 355–368.)

2346. A " DOUBLE-BARRELLED " ANTENNA SYSTEM: SIMPLIFIED FLAT-LINE FEEDING FOR A TWO-BAND [14 & 28 Mc/s] ANTENNA.—L. M. Swift. (*QST*, April 1939, Vol. 23, No. 4, pp. 22–23 and 102.)

2347. CORONA VOLTAGE AND CORONA LOSS OF DOUBLE-CONDUCTOR TRANSMISSION LINE [of H.T. POWER SYSTEM].—Satoh & others. (*Electrot. Journ.*, Tokyo, March 1939, Vol. 3, No. 3, pp. 66–69.)

2348. STEEL AERIAL MAST [Triangulated Mast of Steel Conduit Tube as used for Electric Light Wiring].—(*Wireless World*, 6th April 1939, Vol. 44, pp. 317–318.)

2349. EARTHING [Methods of Reducing the Resistance of Earth Connections].—H. G. Taylor. (*Wireless World*, 27th April 1939, Vol. 44, pp. 394–396.)

VALVES AND THERMIONICS

2350. THEORY AND MEASUREMENT OF ULTRA-SHORT-WAVE VALVES.—H. Zuhrt. (*T.F.T.*, Feb. 1939, Vol. 28, No. 2, pp. 37–44.)

" In earlier works of the writer [2775 of 1938 and back ref.] the behaviour of a triode at ultra-high frequencies was calculated, taking into account the electron path times . . . It was shown that the conceptions valid at low frequencies as to the passage of the electrons are no longer adequate for ultra-high frequencies, and that here the whole displacement current connected with the electron motion must be considered: this ' displacement ' current, to distinguish it from previous currents under that name, will in what follows be called, from its cause, the ' influence ' current. Since these conceptions apply to all valve processes at ultra-high frequencies, it is desirable to develop further the explanations thus begun and to represent them in a uniform manner. In the following pages, therefore, the whole behaviour of a triode at ultra-high frequencies will be explained accurately on a physical basis, theoretical calculation being avoided: the significance of the ' influence ' current will emerge particularly clearly. Further, in the last section some new measurements [on the Telefunken SD1] are given." The nature of the " influence " current is first described, starting from the elementary experiments with an electroscope and charged bodies. Its importance in the action of magnetrons and B-K oscillators is mentioned only in passing. Its effect on the decrease and phase displacement of the transconductance of a triode is then discussed in detail: the next sections deal with its action in diminishing the input resistance, and with the practical significance of these effects in the amplification and generation of ultra-short waves.

2351.—COMPARISON OF ULTRA-HIGH-FREQUENCY VALVES [Types 1231, 954, etc.].—Lester. (*See* 2313.)

2352. RELATION BETWEEN VIRTUAL CATHODE AND POTENTIAL DISTRIBUTION IN MAGNETRON [Virtual-Cathode Radius calculated as 80% of Anode Radius, from Anode-Voltage/Anode-Current Characteristic: as 60% from Voltage-Distribution Considerations, agreeing Better with Experimental Results].—G. Hara. (*Electrot. Journ.*, Tokyo, March 1939, Vol. 3, No. 3, p. 72.)

2353. HIGH-FREQUENCY, FREQUENCY-CHANGING, AND DETECTOR STAGES OF TELEVISION RECEIVERS.—Strutt. (*See* 2428.)

2354. THE NEW SECONDARY-EMISSION VALVE: SOME APPLICATIONS OF THE ELECTRON-MULTIPLIER PRINCIPLE [Use as Frequency Changer: as Vision-Frequency Amplifier, yielding Two Outputs in Opposite Phase, each with Stage Gain around 40].—E. S. Viller. (*Wireless World*, 30th March 1939, Vol. 44, pp. 303–304.)

2355. ON THE DEPENDENCE OF THE COEFFICIENT OF SECONDARY EMISSION ON THE ANGLE OF INCIDENCE OF THE PRIMARY BEAM [Application of Lukjanov & Bernatovich's Formula (in First Approximation, $\log_e \sigma = \log_e B - 2/3 \cdot \gamma \cos \phi$) to Müller's Results: Good Agreement].—S. J. Lukjanov [Luk'yanov]: Müller. (*Physik. Zeitschr. der Sowjetunion*, No. 1, Vol. 13, 1938, pp. 123–126: in English.) *See* Müller, 2180 of 1937.

2356. ON THE THEORY OF CONDUCTIVITY OF THERMIONIC VALVES.—Yu. A. Katzman. (*Journ. of Tech. Phys.* [in Russian], No. 20, Vol. 8, 1938, pp. 1824–1835.)

The results obtained by Benham (1928 Abstracts, p. 288) and Llewellyn (1934 Abstracts, pp. 89–90) in their investigation of varying currents in a thermionic valve are "too complicated," and the author has therefore attempted to derive a simpler solution of the fundamental equations and to develop a theory of conductivity of a diode sufficiently simple for technical purposes. To achieve this result equation (9), showing the relationship between the electron velocity and the current density, is derived from the fundamental equations (1–3) determining the movement of electrons *in vacuo* between two electrodes. A solution of this equation is found (31) and from this the distribution of potential between the electrodes is determined. Equations (51) and (52) are then derived determining respectively the active and reactive conductivities of the space between the electrodes per unit surface of the electrodes. A detailed physical interpretation of the results obtained is given.

2357. INCONSTANCY OF "DURCHGRIFF" [Reciprocal of Amplification Factor] AND CUBICAL DISTORTIONS IN SINGLE-GRID VALVES.—H. Holzwarth. (*E.N.T.*, Jan. 1939, Vol. 16, No. 1, pp. 27–36.)

This work is based on the assumption of a linear variation of the "durchgriff" with the working point on the characteristic (*see* Harnisch & Raudorf, 2790 of 1938). The second- and third-order distortions are calculated, using the three-dimensional representation of characteristic surface and working surface shown in Fig. 1; the formulae arrived at are given in eqns. 17, 18. From these the "klirr" factors and coefficients are deduced and shown in Figs. 3–7. It is found that "for one definite external resistance the cubical distortion vanishes, *i.e.* internal compensation of the 'klirr' factor occurs. This resistance is determined by the working point and the internal resistance of the valve and can thus be arbitrarily varied by varying these quantities." The calculations were sufficiently confirmed by experiment (circuit Fig. 8) for valves with linear "durchgriff" variation, but other valves gave completely different results. It is found necessary to determine the dynamic variation of the "durchgriff" if the distortions are to be successfully predicted.

2358. A VALVE TESTING PANEL FOR MEASURING "DURCHGRIFF," SLOPE, AND INTERNAL RESISTANCE BY MEANS OF ALTERNATING CURRENT.—E. W. Helmholz. (*Physik. Zeitschr.*, 15th March 1939, Vol. 40, No. 6, pp. 201–205.)

The panel is composed of bridge circuits working at audio frequencies. Their principles are given in § II (Fig. 1, measurement of "durchgriff," the reciprocal of the amplification factor; Fig. 2, measurement of slope; Fig. 3, measurement of internal resistance). The arrangement of the panel is shown in Fig. 4. The errors of the simple circuits, and their removal, are discussed in § IV; their final form is described in § V (Figs. 5–7 corresponding to Figs. 1–3). The time taken to reach stationary conditions, the sensitivity of the bridge, and the relative and absolute degree of accuracy attainable, are dealt with in § VI and compared with Barkhausen's valve formula; § VII compares this accuracy with the scattering which occurs among valve data.

2359. FREQUENCY-CHANGER VALVES [Undesirable Effects in Short-Wave Reception, and Valve Makers' Recent Counter-Measures].—E. G. James. (*Wireless World*, 30th March 1939, Vol. 44, pp. 295–296.)

2360. CORRECTION TO DATE IN "A NEW CONVERTER TUBE FOR ALL-WAVE RECEIVERS."—Herold & others. (*RCA Review*, Jan. 1939, Vol. 3, No. 3, p. 381.) *See* 3951 of 1938.

2361. PROGRESS IN THE FIELD OF REGULATING [AVC] VALVES [with "Sliding" Screen-Grid Voltage: the EBF 11, EFM 11, ECH 11, EF 11, etc.].—H. Pitsch. (*Funktech. Monatshefte*, Feb. 1939, No. 2, pp. 45–50.)

2362. RECENT PROGRESS IN VALVES.—B. Decaux. (*Rev. Gén. de l'Élec.*, 4th March 1939, Vol. 45, No. 9, pp. 263–273.)

2363. A MODERN LOW-POWER TRANSMITTING PENTODE: THE PENTODE S.F.R. P.16 [Peak Output 15–30 Watts on Broadcasting Frequencies, with Low Control Energy and Low Screen-Grid Dissipation: Suitable also for Short & Ultra-Short Waves (down to 3.8 m without Neutrodyning)].—Bustarret & others.—(*Bull. de la Soc. franç. Radioélec.*, Supp. Number, 1938, Vol. 12, No. 5, pp. 132–145.)

2364. AMPLITUDE-LIMITER OF ANODE-SATURATION TYPE [using Beam Power Valve].—Osawa. (*See* 2433.)

2365. THE QUESTION OF THE OXIDE-COATED CATHODE [and Its Mechanism : Short Survey of Recent Researches].—(*Funktech. Monatshefte*, March 1939, No. 3, Supp. pp. 22–23.)

Of the six references given, the work of Heinze & Wagener was dealt with in 4382 of 1938 and 998 of March ; of Mie, in 152 of January ; of Suhrmann & Frühling, in 1893 of 1938 ; and of Benjamin, Huck, & Jenkins, in 2801 of 1938. The sixth reference is Herrmann's Berlin Dissertation of 1938.

2366. EMISSION OF NEGATIVE IONS FROM OXIDE CATHODES [Beam of Negative Ions in Cathode-Ray Tube shown by Darkening Effect on Fluorescent Screen : Identification of Component Ions : Measurement of Negative-Ion Current : Formation Processes and Origins of Ions].—L. F. Broadway & A. F. Pearce. (*Proc. Phys. Soc.*, 1st March 1939, Vol. 51, Part 2, No. 284, pp. 335–348.)

2367. THE ADSORPTION OF OXYGEN AND HYDROGEN ON PLATINUM AND THE REMOVAL OF THESE GASES BY POSITIVE-ION BOMBARDMENT.—C. W. Oatley. (*Proc. Phys. Soc.*, 1st March 1939, Vol. 51, Part 2, No. 284, pp. 318–328.)

" . . . Results of measurements of the contact potential difference between a tungsten filament and a platinum anode after the latter has been subjected to various treatments . . . a clean platinum surface can be obtained by successive bombardments of the anode with positive ions of oxygen and of argon. The work function of a surface so prepared is found to be in good agreement with the most recent values obtained by thermionic measurements on clean platinum. Values are obtained also for the work functions of oxygen on platinum, hydrogen on platinum, and mixed layers of oxygen and hydrogen on platinum. The bearing of these results on the structure of the mixed layers is discussed."

2368. FORMATION OF NEGATIVE IONS BY NEGATIVE-ION BOMBARDMENT OF SURFACES : A NEW PROCESS.—Sloane & Cathcart. (*See* 2493.)

2369. A COMBINATION OF THE HYDRODYNAMIC THEORY OF HEAT TRANSFERENCE WITH THE LANGMUIR THEORY : II.—W. Elenbaas. (*Physica*, April 1939, Vol. 6, No. 4, pp. 380–381 : in German.) Supplementary to the paper dealt with in 153 of 1938.

DIRECTIONAL WIRELESS

2370. A NEW AUTOMATIC RADIOGONIOMETER WITH VISUAL INDICATION : THE "RADIOGONIOSCOPE" [Loop (or Goniometer Coil) revolving at about 6 r.p.s : Synchronously Rotating Neon-Tube Indicator resembling an Enlarged "Thermometer" Tuning Indicator].—J. Marique. (*L'Onde Élec.*, March 1939, Vol. 18 [wrongly printed 20], No. 207, pp. 111–119.)

The basic idea is the desirability that the operator should have before his eyes a sufficiently accurate representation of how the signal intensity varies in the neighbourhood of the minima : this not only helps him to make his reading but also enables him to judge the degree of accuracy of the reading and to distinguish easily between the true minima and the false ones due to the spaces in telegraphic signalling. It is arranged that the length of the luminous column is a maximum when the signals are at a minimum : the amplifier is such that at signal maxima the voltage to the indicator is about 10 volts above the ionising voltage of 180, giving a luminous length of 1–2 cm only (compared with some 20 cm at the minima) ; the voltage never falls below this value, so that the indicator is always ionised and there is no "hysteresis."

2371. APPARATUS FOR DIRECTION FINDING IN AIRCRAFT [particularly the Telefunken Target-Flight Equipment and the R.C.A. Radio-Compass AVR-8].—O. J. Koch. (*Funktech. Monatshefte*, Feb. 1939, No. 2, pp. 50–56.)

2372. THE MARCONITRACK AIRCRAFT RADIO BEACON SYSTEM [with Ultra-Short-Wave Equi-Signal Path from Two Marconi-Franklin Series Phase Arrays : Causes & Effects of Horizontally Polarised Component : the Curing of This Trouble : Use of Central Reflecting Screen to reflect back Side Radiations leading to False Courses : etc.].—J. M. Furnival. (*Marconi Review*, April/June 1939, No. 73, pp. 1–9.)

2373. THE METCALF BLIND LANDING SYSTEM FOR AIRPLANES [17-Inch Micro-Waves giving Straight Glide Path formed by Four Overlapping Beams : "Three Lighted Dots in Cathode-Ray-Tube Instrument," Centre Dot controlled by the Beams, Outer Dots by Bank & Climb Gyroscopes].—I. R. Metcalf & others. (*Science*, 10th March 1939, Vol. 89, Supp. pp. 8–9.)

2374. POSSIBLE APPLICATION OF THE RADIO-ECHO ALTIMETER TO AERIAL MAP MAKING.—Espenschied & Newhouse. (*Science*, 31st March 1939, Vol. 89, Supp. p. 9 : paragraph only.) The altimeter dealt with in 1931 of May is stated to be capable, theoretically, of showing height changes as small as 10 feet.

2375. ACCURACY OF DIRECTION FINDERS [Calibration : Errors : Optimum Procedure].—R. L. Smith-Rose & others : W. Ross. (*Nature*, 11th March 1939, Vol. 143, p. 440 : short note on recent I.E.E. Symposium.) *See* also 1933 of May.

2376. SPECIAL DIRECTION-INDICATING DEVICES OF LUMINOUS TYPE FOR USE WITH INDUCTOR COMPASSES FOR AERIAL NAVIGATION [Vibrating-Reed, C-R-Tube, and RCA 6E5 Electron-Ray Tube Types].—G. Giulietti. (*L'Elettrotec.*, 10th Jan. 1939, Vol. 26, No. 1, pp. 10–11.)

ACOUSTICS AND AUDIO-FREQUENCIES

2377. MAGNETIC SCREENING BY PLANE METAL SHEETS AT AUDIO FREQUENCIES.—F. Moeller. (*E.N.T.*, Feb. 1939, Vol. 16, No. 2, pp. 48–52.)

Measurements are described of the magnetic field produced by a given coil behind plane metal sheets of various sizes, thicknesses, and non-magnetic materials, for different distances of the screen from the coil and audio frequencies up to 10 kc/s. The arrangement of exciting coil, screen, and test coil is shown in Fig. 1; the field strength along the axis of the exciting coil was measured by moving the test coil along the axis and altering the current in the exciting coil until the same field was obtained in the test coil. Experimental results for square screens are shown in Figs. 2–10 for various conditions; general deductions about the dimensions of screen required in various cases are made. An approximate formula (eqns. 7a, b) is deduced which is valid over a limited range.

2378. AMPLIFICATION OF WIDE-BAND MODULATED WAVES AT TRANSMITTER AND RECEIVER: THE HEFOD SYSTEM.—Hayasi. (*See* 2424.)

2379. PAPERS ON H.F. TELEPHONY ALONG THREE-PHASE POWER LINES.—Carbenay. (*See* 2262.)

2380. THE NEW BROADCASTING HOUSE AT BRUSSELS [with Description of the "Alpha-Lambda" Switching].—C. H. Colborn. (*World-Radio*, 31st March 1939, Vol. 28, pp. 12–13.)

2381. THE PRODUCTION PANEL [or Dramatic Control Unit].—W. J. Stentiford. (*World-Radio*, 21st April 1939, Vol. 28, pp. 14–15.)

2382. A DISTRIBUTOR-AMPLIFIER FOR THREE SEPARATE CHANNELS [Type V 36, for Association with Main Microphone Amplifier].—G. Schadwinkel. (*Telefunken Hausmitteilungen*, March 1939, Vol. 20, No. 80, pp. 110–112.)

2383. THE CALCULATION OF *RC* CIRCUITS FOR BASS ACCENTUATION IN AUDIO-FREQUENCY AMPLIFIERS [Simple Graphical Method].—C. H. Sturm. (*Funktech. Monatshefte*, March 1939, No. 3, pp. 89–90.)

2384. THE ABSOLUTE CALIBRATION OF MICROPHONES [Calibration of Same Condenser Microphone by Rayleigh-Disc, Pressure-Chamber, Electrostatic (Grutzmacher & Meyer) and Electrodynamic (Gerlach) Methods in Succession: Comparison of Accuracy (Greatest with Pressure-Chamber Method)].—W. Ernsthausen. (*Akust. Zeitschr.*, Jan. 1939, Vol. 4, No. 1, pp. 13–19.) The calculated value of the transmission equivalent at 100 c/s was 1.94 mv/μb, while the pressure-chamber method gave 1.8 mv/μb.

2385. CALIBRATION OF MICROPHONES AND TESTING OF LOUDSPEAKERS: STANDARDISATION OF MEASURING METHODS: ISA 43, UK 3a.—German Acoustics Committee. (*Akust. Zeitschr.*, Jan. 1939, Vol. 4, No. 1, pp. 62–65 and 65–67.)

2386. INHOMOGENEITY OF THE MAGNETIC FIELDS OF DYNAMIC LOUDSPEAKERS [as a Source of Non-Linear Distortion: Mathematical Treatment and Experimental Plotting of Flux Density Distribution in Air Gap].—W. Reinhard. (*Akust. Zeitschr.*, March 1939, Vol. 4, No. 2, pp. 137–141.)

"The curves [Fig. 5] show that for amplitudes up to about 2 mm the smallest distortions are obtained with coils which are thin [short axial length] compared with the magnetic field. However, the difference between such a thin coil and a very thick coil [long axially] is only slight, and the thick coil is superior at large amplitudes. It has the additional advantage that on account of the smaller number of lines of force required the magnetic field demands considerably less energy. By far the worst behaviour is shown by the coil of the same breadth [as the magnetic field]. With this, for a movement of (for example) 2 mm, a note in the neighbourhood of the natural frequency of the diaphragm causes a weakening of up to 20% in the sound pressure of higher notes present at the same time. A modulation of the higher notes is thus produced, and higher harmonics occur in the reproduction of low notes."

2387. ON THE "INVERSION" OF SOUND WAVES OF LARGE AMPLITUDE [Hypothesis explaining Phenomenon of Increase of Non-Linear Distortion during Propagation: Experiments].—L. L. Mjasnikov [Miasnikov]. (*Tech. Phys. of USSR*, No. 12, Vol. 5, 1938, pp. 932–943, in English: *Journ. of Tech. Phys.* [in Russian], No. 21, Vol. 8, 1938, pp. 1896–1907.)

If a source of sound radiates a flat wave of large amplitude, for example when a loudspeaker unit is connected to an "infinite" tube of constant cross-section, the wave will gradually be transformed into a "shock" wave, *i.e.* the slope of the curve $U = f(x)$, where U is the oscillating velocity of the wave, will gradually increase until a moment is reached when dU/dt becomes infinity. This break of continuity in the curve is called the "inversion" of the wave.

In the present paper the suggestion of Stokes & Rayleigh, that the "inversion" of a wave is accompanied by the appearance of waves travelling in the opposite direction, is discussed theoretically, and an account is given of experiments which have confirmed this suggestion. In these experiments the coefficient of reflection of the wave was determined by observing the variation of sound pressure along a section of an "infinite" tube. The relationship between the coefficient of reflection and sound intensity at a constant frequency was also investigated. The transformation of a harmonic wave into a "shock" wave has also been confirmed experimentally by analysing the wave at various points along the tube for different intensities of sound.

2388. COMBINATION TONES IN SOUND AND LIGHT [General Theory verified by Experiments].—W. Bragg. (*Nature*, 1st April 1939, Vol. 143, pp. 542–545.)

2389. THE NEW KÖRTING HIGH-NOTE AUXILIARY LOUDSPEAKER UNIT FOR ALL-ROUND RADIATION [embodying Three Loudspeakers].—Körting. (*E.T.Z.*, 9th March 1939, Vol. 60, No. 10, pp. 320–321.)

2390. THE "CRYSTAL LOW-SPEAKER" FOR HOSPITALS, ETC.—Grawor Company. (Mentioned in article on Leipzig Fair, 2623, below.)

2391. DISCUSSION ON ELECTROACOUSTICS [including Frequency Response of Loudspeakers, Architectural Acoustics, Noise Measurements, etc.].—C. V. Drysdale & others. (*Proc. Phys. Soc.*, 1st March 1939, Vol. 51, Part 2, No. 284, pp. 359–375.)

2392. INDICIAL IMPEDANCE OF CERTAIN INFINITE HORNS.—A. A. Kharkevich. (*Journ. of Tech. Phys.* [in Russian], No. 20, Vol. 8, 1938, pp. 1839–1849.)

Using Webster's equation (*Proc. Nat. Acad. Sci.*, 1919, Vol. 5, pp. 275–282) representing the propagation of a sound wave in a horn, a general expression is derived determining the indicial impedance z of an infinite horn whose section varies in accordance with the law $S = ax^b$, where $b = 2n + 1$. From this expression formulae are derived determining indicial impedances for the following particular cases:—§ 2: $b = 2$ (conical horn); § 3: $b = 4$; § 4: $b = 6$; and § 5: exponential horn ($S = S_0e^{mx}$). The results obtained are summarised in a table (the case of a cylindrical horn is also included) and a discussion is added in which a comparison is made between the different types of horn.

2393. THE PROBLEMS OF THE WORKS PUBLIC ADDRESS EQUIPMENT IN A MODERN ENTERPRISE.—I. Kirstaedter. (*E.T.Z.*, 9th March 1939, Vol. 60, No. 10, pp. 295–299.)

2394. RATING OF PUBLIC ADDRESS EQUIPMENT [Recommendations of Institute of P.A. Engineers].—D. Robinson. (*Wireless World*, 27th April 1939, Vol. 44, p. 396.)

2395. THE THEOREM OF RECIPROCITY AND SCHOTTKY'S LAW AS APPLIED TO NON-STATIONARY PROCESSES.—A. A. Kharkevitch. (*Journ. of Tech. Phys.* [in Russian], No. 21, Vol. 8, 1938, pp. 1889–1895.)

The Schottky law of the reception of low frequencies, stating that if a sound radiator is used for reception its efficiency at low frequencies is higher than that when it is used as a radiator, has been formulated for stabilised sinusoidal operation only. In the present paper non-stationary processes are considered, and starting with a simpler and at the same time more general proof of the theorem of reciprocity, a new formulation of the law with a wider meaning is obtained. The discussion is illustrated by two examples in which the sound radiator takes the form of (a) a pulsating sphere, and (b) an infinite plane oscillating along a perpendicular axis.

2396. FUNDAMENTALS IN THE TESTING OF SOUND-RECORDING EQUIPMENTS OF ALL TYPES [from Dictaphones to Sound Films].—German Acoustics Committee. (*Akust. Zeitschr.*, Jan. 1939, Vol. 4, No. 1, pp. 68–73.)

2397. A TONE-FLUCTUATION METER [for Measurement of Distortions (in Sound-Film Work, etc.) in the Form of Amplitude or Frequency Modulations from Various Causes: Capable of measuring Amplitude Modulations of 0.03–10% and Frequency Modulations of 0.01–3%].—K. H. R. Weber. (*Akust. Zeitschr.*, Jan. 1939, Vol. 4, No. 1, pp. 33–42.)

2398. ELECTRIC ORGANS [Letters on the Working Principles of the Compton "Electrone," Midgley-Walker Organ, etc.].—(*Electrician*, 31st March 1939, Vol. 122, pp. 401–402.) *See* also *ibid.*, 14th April 1939, p. 478.

2399. A NOTE ON THE EFFECT OF FINITE BREADTH OF THE HAMMER STRIKING A PIANOFORTE STRING.—D. Basu. (*Current Science*, Bangalore, March 1939, Vol. 8, No. 3, pp. 109–110.)

2400. ACOUSTIC PROPERTIES OF VIOLINS OF OUTSTANDING TONE QUALITY.—H. Meinel. (*Akust. Zeitschr.*, March 1939, Vol. 4, No. 2, pp. 89–112.) A fuller version of the Baden-Baden paper dealt with in 1525 of April.

2401. INTERNATIONAL FIXING OF THE STANDARD PITCH NOTE [Support for Adoption of 440 c/s].—German Acoustics Committee. (*Akust. Zeitschr.*, Jan. 1939, Vol. 4, No. 1, pp. 67–68.)

2402. ACOUSTIC SPECTRA OBTAINED BY THE DIFFRACTION OF LIGHT FROM SOUND FILMS [including Probable Value as Additional Method of Sound Analysis].—D. Brown. (*Proc. Phys. Soc.*, 1st March 1939, Vol. 51, Part 2, No. 284, pp. 244–255.)

From the author's abstract:—"The theory of diffraction is applied to a generalised form of diffraction grating such as that provided by a variable-density sound film. The results indicate that under certain conditions the different frequency components in the original sound will be uniquely represented by spectral lines in the diffraction pattern, producing an acoustic spectrum. The theory of the method is shown to be of great generality, permitting an analysis of transient as well as of sustained sounds . . ."

2403. FREQUENCY ANALYSER OF DIRECTLY VIEWING TYPE [for Wave Forms varying and attenuating Rapidly, as in Sound Phenomena: C-R-Oscillograph Apparatus using Magnetostrictive Resonators].—T. Hayashi & K. Koseki. (*Electrot. Journ.*, Tokyo, April 1939, Vol. 3, No. 4, p. 96.)

The higher the selectivity, the lower the analysing speed, so bar-type magnetostrictive resonators could not be used: tubes, with a proper amount of a suitable substance inserted in them to lower the selectivity, were therefore employed.

2404. THE CALCULATION OF THE VARIABLE CONDENSERS OF A HOWLING-TONE HETERODYNE GENERATOR [Main (Note-Selecting) Condenser and the Rotating Auxiliary Condenser].—K. Tamberg. (*Funktech. Monatshefte*, Feb. 1939, No. 2, pp. 57–61.)

2405. THE "TRANSITRON" OSCILLATOR [applicable to Audiometers, Supersonic-Wave Generators, etc.].—Brunetti. (*See* 2296.)

2406. SURVEY OF LEGAL MEASURES FOR THE RESTRICTION OF NOISE.—German Acoustics Committee. (*Akust. Zeitschr.*, Jan. 1939, Vol. 4, No. 1, pp. 73–80.)

2407. THE CALCULATION OF THE SOUND FIELD OF AN AIR-SCREW.—W. Ernsthausen & W. Willms. (*Akust. Zeitschr.*, Jan. 1939, Vol. 4, No. 1, pp. 20–28.)

2408. ON THE REDUCTION OF NOISE IN VENTILATION CHANNELS OF INDUSTRIAL AND CIVIL BUILDINGS.—J. I. Schneider. (*Journ. of Tech. Phys.* [in Russian], No. 18, Vol. 8, 1938, pp. 1671–1674.)

2409. SOUND TRANSMISSION LOSSES IN TUBES AND HOSES, *and* THEORETICAL REMARKS ON THE MEASUREMENT OF SUCH LOSSES.—E. Waetzmann, W. Wenke. (*Akust. Zeitschr.*, Jan. 1939, Vol. 4, No. 1, pp. 1–9: pp. 10–12.)

Measurements on rigid tubes confirmed previous observations on the validity of Kirchhoff's theory. Roughness doubled or trebled the attenuation (contrary to Tischner's result of a 20-fold increase, 1930 Abstracts, pp. 575 & 634). With elastic hoses the wall movement was the predominant factor: several rubber tubes showed marked resonance points. The sound velocity in tubes was found to be only a little less than in free space: anomalous dispersion occurred at the resonance points in elastic tubes.

2410. ACOUSTIC FILTERS AND THEIR POSSIBLE APPLICATION IN CERTAIN CASES FOR THE ELIMINATION OF NOISE [from Motors, etc.].—S. Rama. (*L'Elettrotec.*, 10th Jan. 1939, Vol. 26, No. 1, pp. 19–20: summary only.)

2411. ON THE ABSORPTION OF SOUND WITH THE HELP OF DAMPED RESONATORS [Analysis and Experimental Investigation].—W. Willms. (*Akust. Zeitschr.*, Jan. 1939, Vol. 4, No. 1, pp. 29–32.) Primarily in connection with the sound-proofing of aeroplane cabins.

2412. COMPARATIVE MEASUREMENTS OF ABSORPTION PERCENTAGE [Investigation of Discrepancies between Values obtained for Same Material in Different Laboratories].—E. Meyer & A. Schoch. (*Akust. Zeitschr.*, Jan. 1939, Vol. 4, No. 1, pp. 51–61.)

2413. MEASUREMENT OF ACOUSTIC IMPEDANCES [Absorption Coefficient of Sound-Absorbing Materials].—W. Wisotzky. (*Hochf:tech. u. Elek:akus.*, March 1939, Vol. 53, No. 3, pp. 97–104.)

This "electro-acoustic bridge" is "an apparatus in which the acoustic pressure and velocity are measured at the input of a Kundt's tube. They are transformed into alternating voltage and current respectively and then introduced into a Larsen compensator. The adjustment of this compensator is then . . . directly proportional to the acoustic impedance of the Kundt's tube." The scheme of the apparatus is shown in Fig. 1; the source of sound is an externally-excited dynamic loudspeaker which has a special coil system delivering an alternating voltage proportional to the velocity of the membrane, and which is placed at the input of the Kundt's tube. This voltage is amplified and led into the Larsen compensator. A crystal microphone, used as a pressure meter, is hung inside the Kundt's tube close to the loudspeaker membrane; the voltage produced in it is compensated by the output voltage of the Larsen compensator. The theory of the method is given in § II.2; it is found that, "when the tube attenuation is neglected, the absorption coefficient at the beginning of the tube is equal to the absorption coefficient of the material at the end of the tube, whatever the tube length," which is of great practical importance at low frequencies. The apparatus is described in § II.3; Fig. 2 shows the loudspeaker with a piston membrane. The calibration (§ II.4) uses the properties of the input impedance of a Kundt's tube, with circles of constant absorption coefficient (Fig. 3). § III describes measurements on the materials used in the construction of sound damped rooms in the laboratory (Fig. 4); Fig. 5 shows absorption coefficients of cotton-wool, Fig. 6 the best frequency/absorption curve attained. § III.2 describes measurement of resistance of absorbing materials to the motion of air currents through them (apparatus Fig. 7, results for cotton-wool Fig. 8), § III.3 measurements to test the known theory of porous absorbing materials (*see* Cremer, 620 [also 1068] of 1936). A list of literature references is appended.

2414. OHM'S ACOUSTICAL LAW.—F. Trendelenburg. (*Akust. Zeitschr.*, March 1939, Vol. 4, No. 2, 2 pp.)

2415. ON THE DEPENDENCE OF THE LOUDNESS OF THE SUBJECTIVE DIFFERENCE TONE ON THE FREQUENCY OF THE PRIMARY TONE [Amplitude independent of Primary-Tone Frequency to over 10 000 c/s, but Loudness increases with Frequency up to Maximum at 6000 c/s, then decreases: etc.].—W. Kuhl. (*Akust. Zeitschr.*, Jan. 1939, Vol. 4, No. 1, pp. 43–50.)

2416. THE MONAURAL THRESHOLD: THE EFFECT OF SUBLIMINAL AND AUDIBLE CONTRALATERAL AND IPSILATERAL STIMULI.—J. W. Hughes. (*Proc. Roy. Soc.*, Series A, 7th March 1939, Vol. 169, No. 939, p. S 20: abstract only.)

2417. ON THE PIEZOELECTRIC MEASUREMENT OF THE ABSOLUTE THRESHOLD OF AUDIBILITY IN BONE CONDUCTION.—G. von Békésy. (*Akust. Zeitschr.*, March 1939, Vol. 4, No. 2, pp. 113–125.)

2418. ON A DIAPHRAGM OF A VIBROMETER FOR SUBMARINE ACOUSTICAL MEASUREMENT [Analysis of Transmission Characteristic of Clamped Circular Diaphragm in Hole in Infinite Rigid Wall with Water on One Side].—T. Hayasaka. (*Nippon Elec. Comm. Eng.*, Feb. 1939, No. 15, p. 572: summary only.)

2419. THE EXPERIMENTAL FOUNDATIONS OF THE DEVELOPMENT OF THE ACOUSTIC AIR-JET GENERATOR [Frequencies 5000 c/s (640 W Radiation) to 100 000 c/s (1.6 W Radiation)].—J. Hartmann & E. von Mathes. (*Akust. Zeitschr.*, March 1939, Vol. 4, No. 2, pp. 126–136.)

2420. THE ABSORPTION OF SUPERSONIC WAVES IN HUMAN TISSUE AND ITS DEPENDENCE ON FREQUENCY.—R. Pohlman. (*Physik. Zeitschr.*, 1st March 1939, Vol. 40, No. 5, pp. 159–161.)

2421. SUPERSONIC WAVES IN THE SERVICE OF MEDICINE [Short Survey].—Fehr. (*Funktech. Monatshefte*, March 1939, No. 3, pp. 93–94.)

2422. DETERMINATION OF THE ADIABATIC PIEZO-OPTIC COEFFICIENT OF LIQUIDS [Work bearing on Diffraction of Light in Supersonic Fields].—V. Raman & K. S. Venkataraman. (*Proc. Roy. Soc.*, Series A, 7th March 1939, Vol. 169, No. 939, p. S 14: abstract only.)

PHOTOTELEGRAPHY AND TELEVISION

2423. NARROW-BAND TRANSMISSION SYSTEM FOR ANIMATED LINE IMAGES [C-R-Tube Reception of Line Image of Woman's Head transmitted on Total Band Width of 2600 c/s, or Animated Cartoon Figure on 10 000 c/s: Various Applications, including Maps].—A. M. Skellett. (*Elec. Engineering*, March 1939, Vol. 58, No. 3, Transactions pp. 124–126.) The total band widths mentioned are made up of two equal bands for the potentials to the two sets of deflecting plates. The spot traces out the line image 20 or more times a second.

2424. AMPLIFICATION OF WIDE-BAND MODULATED WAVES: THE HEFOD [High-Efficiency Frequency-Operated Device: with Application to Television and Under-Water Supersonic Communication].—T. Hayasi. (*Electrot. Journ.*, Tokyo, April 1939, Vol. 3, No. 4, p. 95.)

At the transmitter, the microphone currents are filtered into the high-frequency (H) and low-frequency (L) components: these are reunited before application to the modulating stage, but H, in the meantime, is made to provide a control voltage (by a special rectifier whose output is independent of the input amplification but increases with the input frequency) which regulates the damping of the tuning circuits and radiating system: as the damping increases the supply voltage is increased to maintain the otherwise diminished output. Thus the band widths are kept adjusted to the requirements of the instant, and high-efficiency transmission is obtained. A similar process occurs at the receiver.

2425. PROBLEMS INVOLVED IN THE TRANSMISSION OF WIDE FREQUENCY BANDS OVER LINES AND CABLES [Recent Developments enable Frequency Bands of more than 2 Mc/s to be transmitted over Hundreds of Kilometres].—A. Köpping. (*Funktech. Monatshefte*, Feb. 1939, No. 2, Supp. pp. 9–12.)

2426. THE CHARACTERISTICS OF CABLES FOR HIGH-FREQUENCY CURRENTS [for Television, etc.].—G. Wuckel. (*Rev. Gén. de l'Élec.*, 4th March 1939, Vol. 45, No. 9, pp. 278–280.) Long summary of the German paper referred to in 2902 of 1938.

2427. TELEVISION TRANSMISSION TECHNIQUE: V—THE TRANSMISSION OF THE LOW-FREQUENCY IMAGE SIGNALS [and the Question of the D.C. Component].—F. Ring. (*Funktech. Monatshefte*, Feb. 1939, No. 2, Supp. pp. 12–15.)

2428. HIGH-FREQUENCY, FREQUENCY-CHANGING, AND DETECTOR STAGES OF TELEVISION RECEIVERS.—M. J. O. Strutt. (*L'Onde Élec.*, Feb. 1939, Vol. 18 [wrongly printed 19] No. 206, pp. 83–91.) Conclusion of the Zurich Conference paper referred to in 1591 of April; a correction to the first instalment is given at the bottom of p. 82. For a *Wireless Engineer* version *see* 1909 of May.

2429. TELEVISION STATION HAS RADICALLY DESIGNED ANTENNA [" Cubic-Shaped " Aeria for Schenectady Station].—General Electric Company. (*See* 2331.)

2430. E.M.I. CATHODE-RAY TELEVISION TRANSMISSION TUBES [Emitron & Super-Emitron—Mechanism, Construction, and Comparative Performance: the Signal/Noise Ratio and Its Limitation by the Spurious " Tilt " Signal: " Streaking " and Other Distortions: Other (Experimental) Tubes, including the Use of a " Double-Sided " Mosaic: etc.].—J. D. McGee & H. G. Lubszynski. (*Journ. I.E.E.*, April 1939, Vol. 84, No. 508, pp. 468–475: Discussion pp. 475–482.)

2431. THE GENERATION OF SAW-TOOTH CURRENTS FOR MAGNETIC DEFLECTION IN TELEVISION TUBES.—J. Günther. (*Funktech. Monatshefte*, March 1939, No. 3, Supp. pp. 17–22.)

Advantages of magnetic over electrostatic deflection: control of generator output-valve by saw-tooth voltage (calculation of amplifier; calculation of time constant; capacity-free deflecting coils; deflecting coils with capacity; utilisation of fly-back energy): control by square-wave impulses: self-oscillating generators, particularly the "current-transformer" type (Fig. 8, with iron-cored deflecting coil; Fig. 9, with air-cored coil; both generating their own control pulses): advantages of these over the separately controlled type. " Finally, it may be said that of the various types of saw-tooth generators the most advantageous are those in which the deflecting circuit can carry out as undamped as possible a half-oscillation during the fly-back, since these allow the use of the greatest possible ' deflecting activity ' (winding turns) and function most efficiently by a recovery of the coil energy."

2432. LIGHT-STORAGE IN TELEVISION: ITS APPLICATION TO CATHODE-RAY RECEPTION.—M. von Ardenne. (*Wireless World*, 30th March 1939, Vol. 44, pp. 297–298.) Based on the full German paper dealt with in 1063 of March.

2433. Amplitude-Limiter of Anode-Saturation Type [Beam Power Valve (RCA-6L6) has Almost Ideal Saturation Characteristic when loaded with only 3 Kilohms (compared with 100 Kilohms for Pentode UZ-77): Advantages for Amplitude-Filter for separating Synchronising from Picture Signals].—J. Osawa. (*Electrot. Journ.*, Tokyo, March 1939, Vol. 3, No. 3, p. 71.)

2434. Light Filter for Television Studio Illumination [Use of "Palatine Black A" Solution to prevent Dazzling and Heating without decreasing Sensitivity of Iconoscope].—T. Seki & others. (*Electrot. Journ.*, Tokyo, March 1939, Vol. 3, No. 3, pp. 71–72.)

2435. Penetration of Low-Speed Electrons through Thin Mica Film [Experiment with Bearing on Güntherschulze "Spritz" Discharge, Malter Effect, and Secondary-Emission Image Amplification].—N. Kato & S. Takada. (*Electrot. Journ.*, Tokyo, Feb. 1939, Vol. 3, No. 2, p. 48.)

2436. On the Dependence of the Coefficient of Secondary Emission on the Angle of Incidence of the Primary Beam.—Lukjanov. (*See* 2355.)

2437. The Spectral Sensitivity of Selenium Rectifier Photoelectric Cells [Factors determining Course of Sensitivity/Output Curve and Temperature Coefficient of Sensitivity].—G. P. Barnard. (*Proc. Phys. Soc.*, 1st March 1939, Vol. 51, Part 2, No. 284, pp. 222–236.)

2438. The Sensitisation of Reversible Photovoltaic Cells [Zinc and Copper Electrodes in Their Respective Sulphates].—S. Schlivitch. (*Comptes Rendus*, 13th March 1939, Vol. 208, No. 11, pp. 803–805.)

2439. Photoactivation of Solids and Its Effect on Adsorption.—J. A. Hedvall & G. Cohn. (*Nature*, 25th Feb. 1939, Vol. 143, pp. 330–331.)

2440. The Spectral Variation of the Photosensitivity of Visual Purple.—E. E. Schneider, C. F. Goodeve, & R. J. Lythgoe. (*Proc. Roy. Soc.*, Series A, 16th March 1939, Vol. 170, No. 940, pp. 102–112.)

2441. High-Efficiency Mercury and Sodium Vapour Lamps, *and* The Basis for High Efficiency in Fluorescent Lamps.—Buttolph: Thayer & Barnes. (*Journ. Opt. Soc. Am.*, March 1939, Vol. 29, No. 3, pp. 124–130: pp. 131–134.)

MEASUREMENTS AND STANDARDS

2442. Measurement of Complex Electrical Resistances at Ultra-High Frequencies.—E. Djakov. (*Hochf:tech. u. Elek:akus.*, Feb. 1939, Vol. 53, No. 2, pp. 54–60.)

The purpose of this paper is the determination of the limits to the use of a quasi-stationary oscillating circuit for impedance measurements by the width of the resonance curve, and a theoretical and experimental investigation of the resonance curve of a Lecher-wire system of variable length, used for impedance measurements. § II gives the theory of impedance measurements with a quasi-stationary oscillating circuit, and describes experimental investigations (valve voltmeter circuit Fig. 2, using an acorn triode as anode-bend rectifier); the lower limit of wavelengths to which the method could be applied was found to be about 100 cm. The parallel-wire system, terminated with the unknown impedance, is investigated in § III, which includes the theory of the resonance curve for variable length, without and with natural damping in the system; some special cases are considered. The measuring system used is shown in Fig. 4; Fig. 5 gives the connection of the valve voltmeter to the Lecher-wire system, Fig. 8 a measuring system for small impedances. The resonance curves obtained are shown in Figs. 6, 7. It was found that the accuracy and range of the Lecher-wire method were considerably greater than those of the oscillating-circuit method; the Lecher-wire method seemed to be particularly suited to measurements of impedance and capacity of valves at very high frequencies.

2443. Impedance Measurements in the Decimetre-Wave Range.—H. Kaufmann. (*Hochf:tech. u. Elek:akus.*, Feb. 1939, Vol. 53, No. 2, pp. 61–67.)

The method of measurement here described is based on a variable measuring circuit in the form of a Lecher-wire system of adjustable length with the object to be measured in parallel to its input (Fig. 1). The theoretical basis of the method is discussed (§ I) for a system without and with attenuation in the Lecher wires. A voltage indicator with high input impedance is described in § II (principle, Fig. 5; apparatus, Fig. 6); it consists of a diode combined with a Lecher-wire system. The whole measuring arrangement is shown in Fig. 7; the precautions to be taken in its use are enumerated. The attainable accuracy and some results are discussed in § IV.

2444. Absorption and Reflection Measurements in the Centimetre-Wave Range [1.65–7.2 cm].—W. Kebbel. (*Hochf:tech. u. Elek:akus.*, March 1939, Vol. 53, No. 3, pp. 81–89.)

The purpose of this work is defined as "the elimination of the difficulties still inherent in the general optical methods [applied to centimetre waves] and the measurement of the dielectric constants and the loss factor or the h.f. conductivity of technical insulating materials, biological substances [fat and muscle tissue], dipole liquids, and earth of various degrees of dampness." § II describes the method used; the theory of transmission and reflection of plane electric waves through a plane-parallel plate of absorbing dielectric as a function of its thickness is given (§ II b); the scheme of the apparatus used (§ II c) is shown in Fig. 4 (*see* also, for example, Seeberger, 1933 Abstracts, p. 207). The improvement introduced (§ II d) is "the introduction of frequency modulation and thus the extinction of the interferences between emitter and receiver and of the dependence on position of the results of the transmission measurements." Results are given in § III in the form of tables and curves (Figs. 6–11) for the materials mentioned above. Table 5 gives the measured electrical constants of river sand containing various amounts of water; the increase of conductivity and dielectric constant with frequency is found to be greater than at lower frequencies. § III d2 describes the selective absorption of low-loss ceramic insulating materials of high dielectric constant, which are found to retain their favourable properties at these high frequencies.

2445. A Laboratory Method for Measuring the Energy Absorbed by a Living Organism in an Ultra-High-Frequency Field.—L. V. Fridman. (*Journ. of Tech. Phys.* [in Russian], No. 19, Vol. 8, 1938, pp. 1728–1735.)

When using u.h.f. currents for experimental and medical purposes it is necessary, in order to compare the results obtained, to refer these to some quantitative basis such as the voltage across the condenser, the current at the end of the feeder, the field intensity, or the energy absorbed by the living organism. The suitability of these factors for serving as a basis for comparison, and various methods for their determination, are discussed, and a new method is proposed for determining the energy absorbed by the living organism. The method is based on the theory of long lines and it is shown that the required value can be obtained by measuring the voltage and current at a point of the feeder at which these quantities pass through a minimum and a maximum respectively. Specially developed meters for measuring voltages and currents are described.

2446. A New Method of measuring High Resistance at High [and Ultra-High] Frequencies.—M. Saito. (*Electrot. Journ.*, Tokyo, Feb. 1939, Vol. 3, No. 2, pp. 45–46.)

An oscillatory circuit containing a variable condenser C is coupled to a h.f. power source and (loosely) to a thermojunction/galvanometer circuit. C is adjusted to give max. current, and this process is repeated with C shunted in succession by a standard h.f. resistance and by the unknown resistance, whose value is then obtained from eqn. 4 involving only the standard resistance and the three galvanometer deflections. The best result is obtained when the two resistances are equal.

2447. Corrections to "A Survey of Ultra-High-Frequency Measurements."—L. S. Nergaard. (*RCA Review*, Jan. 1939, Vol. 3, No. 3, p. 381.) *See* 1620 of April.

2448. Remarks on the Paper by Levitskaja, Frankfurt, & Cherpakov: "The Determination of the Inertia of Thermocouples."—K. Vulfson. (*Journ. of Tech. Phys.* [in Russian], No. 18, Vol. 8, 1938, pp. 1681–1682.) *See* 272 of 1938.

2449. The Use of the Lissajous Ellipse for Some Measurements with the Cathode-Ray Oscillograph.—G. A. Ouzounoff. (*L'Onde Élec.*, Feb. 1939, Vol. 18 [wrongly printed 19], No. 206, pp. 70–82.)

"Although the methods of measurement do not give very accurate results, they have the advantage of being simple and applicable over a very wide range of frequencies." The cases considered are: (1) Measurement of the impedance and phase displacement of a dipole. If $A = B$ (*i.e.* if the ellipse is inclined at 45°) the phase displacement is obtained directly by doubling the angle α (Fig. 1): such equality of A and B can be assured by regulating the amplitude A by rheostats free from inductance and capacity, or by regulating the amplification of the two deflecting-plate amplifiers if (as is usual) the oscillograph is equipped with these. If A and B cannot be equalised, the phase displacement can be calculated from eqns. 2 & 3. Refinements of the method are described in pp. 78–81. (2) Determination of the conditions of the maximum transmission of energy, *e.g.* in the connection of a number of quadripoles. If the conditions are satisfied, the c-r oscillograph connected as in Fig. 11 will show a straight line inclined at 135° or 45°; if one of the two conditions is unsatisfied, an ellipse inclined at the same angle will appear; if the other condition is unsatisfied, a straight line will be obtained but not inclined at 135° or 45°; if both conditions are unsatisfied, an ellipse will be seen at some "wrong" angle. Thus the elements of the dipoles can be adjusted to give the optimum conditions, or on the other hand the losses due to the maladjustment of the impedances can be calculated.

2450. Applications of the Cathode-Ray Oscillograph to Measuring Purposes.—M. Demontvignier. (*Rev. Gén. de l'Élec.*, 8th & 15th April 1939, Vol. 45, Nos. 14 & 15, pp. 419–432 & 454–458.)

2451. A New Apparatus for the Measurement of Impulse Times [Relay and C-R-Tube Combination: primarily for Pulses of Automatic Telephone Systems].—Breitenbruch & Fülling. (*T.F.T.*, Feb. 1939, Vol. 28, No. 2, pp. 51–54.)

2452. The Amplifier in Electrical Measuring Technique [Survey].—M. Schleicher & W. Thal. (*E.T.Z.*, 2nd March 1939, Vol. 60, No. 9, pp. 257–260.)

2453. The Vector-Potential Field of Toroids carrying Currents [Theory: Toroids with Circular and Square Cross-Sections: Infinitely Thin Toroid].—G. Schenkel. (*Ann. der Phys.*, Series 5, No. 6, Vol. 34, 1939, pp. 541–560.)

2454. Measurements of the Frequency Stability and Harmonic Content of Valve Oscillators.—Nüsslein. (*See* 2298.)

2455. The Development of a Small Variable Air Condenser compensated for Rapid Changes of Temperature [Weight 5¾ oz: Capacity Range 17–68 μμF: Temperature Coefficient of Capacity adjustable between Zero and − 120 Parts in Million per Degree Centigrade].—H. A. Thomas. (*Journ I.E.E.*, April 1939, Vol. 84, No. 508, pp. 495–498.) For previous work *see* 3641 of 1937.

2456. New Types of Quartz Oscillators and Resonators for Frequency-Control and Filtering Purposes ["Control"- and "Filter"-Quartzes].—L. Rohde. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 20, 1939, pp. 75–80.)

The chief causes of frequency-variation in control quartz oscillators are: (1) change of position between the electrodes, (2) effect of change of pressure of the fixing arrangements, (3) varying dispersion of sound energy, (4) alteration of the parallel capacity, and (5) influence of temperature. These effects are specially marked with longitudinal oscillators, and it is with the new treatment of these, to fulfil the increasingly stringent requirements of constancy, that the writer deals. Causes 1, 3, & 4 are avoided by making the quartz itself carry the electrodes, by depositing on it metallic coats to which soldered connections can be made. Cause 2 is eliminated by elastic fixings at oscillation nodes (Fig. 1): the wires soldered at these nodes (1, 2, 3), and carried by the brackets 5 & 6, act both as leads and as supports. The equivalent circuit for such a quartz plate is seen in Fig. 3, which compares with the ordinary quartz holder of Fig. 2. The only remaining cause (5) is dealt with by a special thermostat, which (owing to the small mass of the deposited electrodes) can be designed to weigh, altogether, less than 15 gm; a very robust thermometer ("12" in Fig. 4) with a small amount of mercury is employed, and the whole oscillator in its metal screen only measures 60 mm in height. The frequency constancy is better than $\pm 3 \times 10^{-6}$ in the face of severe shaking and external temperature variation. The frequency range of such oscillators is 90–250 kc/s: a specially convenient frequency for wavemeters, standard generators, and calibrating purposes is found to be 100 kc/s. The design is also suitable for oscillators of the highest precision, such as those used for quartz clocks.

It is also suitable for quartz filters, but for these an even better design has been evolved. The use of any two-electrode quartz as a filter in its fundamental mode of oscillation is always hampered by its unavoidable transverse capacity (C_{12} in the equivalent circuit of Fig. 6) which forms a permanent "pass" path. This can be compensated, by special circuits, in the neighbourhood of transverse resonance but not in general, except by a design which is different in principle. Such a design is the four-electrode ("three-pole") quartz of Fig. 7a & b (longitudinal type) and 7c (transverse type), with one electrode on one side and three (1, 0, and 2) on the other. The coating 1 serves for the excitation of the quartz: the middle coating 0 acts as a screen between 1 and 2, and the coating 2 delivers the output voltage. A voltage applied to 1 cannot (except at resonance) arrive at 2, since the whole plate acts as a screened condenser (Fig. 7d): if the electrodes are properly dimensioned the electrode 0 gives almost perfect screening. Only when resonance produces mechanical vibration of the quartz can a voltage on 1 be reproduced at 2: so that, outside resonance, a complete blocking effect is obtained, the "penetration" capacity from 1 to 2 (C_{12} of the ordinary equivalent circuit) being in practice lower than 0.05 picofarad. Thus the arrangement actually forms a filter and justifies its name of "filter quartz": it has, incidentally, the property of producing a phase change of about 180° between electrodes 1 and 2. The special equivalent circuit of such a "filter-quartz" is seen in Fig. 9, while Fig. 10 shows its transmission characteristic (broken line) compared with those of a two-electrode quartz (also broken line) and of the latter with an oscillatory circuit compensated by inductance (full-line curve).

A final section describes how the phase-rotation property of a "filter-quartz" enables it to be used in an oscillator connection without any oscillatory circuit to produce a reversal of phase. Thus in the simple connection of Fig. 11 the anode and grid circuits contain only ohmic resistances: such an arrangement is extraordinarily independent of valve properties and of variation in filament and anode voltages.

2457. Variable-Frequency Quartz Crystals [with "Partial" Vibrations, using Movable Upper Electrode].—S. Uda & S. Honda. (*Electrot. Journ.*, Tokyo, Feb. 1939, Vol. 3, No. 2, p. 47.)

Further observations on the crystals dealt with in 1097 of March. Beat-method tests show the continuous variation of the frequency (starting at 9.1 Mc/s) with the entire range of movement of the electrode, except for local "jump" and hysteresis phenomena "if the surface of the crystal is not uniform in its inclination owing to poor grinding." Suggested applications are to local oscillators for frequency analysis or superheterodyne or heterodyne reception, and to standard oscillators for frequency-stability measurement. *Cf.* 2458, below.

2458. Anomalies of Thickness Vibration of Quartz Plates due to Non-Uniform Thickness.—I. Koga & M. Tatibana. (*Electrot. Journ.*, April 1939, Vol. 3, No. 4, pp. 81–85.)

An investigation evidently prompted by the work dealt with above (2457). "The range within which the frequency can be adjusted seems, as shown by experiment 2, to be of the order of less than one thousandth [but *cf.* 1097 of March]. And, to tell the truth, if this is all the adjustment required, why not just finish the faces in parallel for the best oscillating condition and then make such adjustment by changing the gaps between the plate and the electrodes? The latter [plan] seems to be much more convenient and dependable."

2459. 250-Watt Crystal Oscillator.—Koga, Yamamoto, & others. (*See* 2300.)

2460. Internal Friction in Quartz Crystals.—R. Günther. (*E.N.T.*, Feb. 1939, Vol. 16, No. 2, pp. 53–62.)

The internal friction in quartz crystals is here determined from the equivalent impedance of a crystal bar oscillating piezoelectrically, with the equivalent circuit of Fig. 1. The three-dimensional theory is given for infinitely thin bars oscillating longitudinally, for any direction of cut of the crystal. Fig. 3 shows a model of the three-dimensional elasticity modulus of quartz, Fig. 6 models of its piezoelectric moduli. Measurements were made with the bar placed between the electrodes as shown in Fig. 7; the effect of the air space between crystal and electrodes was considered, using the extended equivalent circuit of Fig. 8. The equivalent impedance was measured by Pauli's method (circuit Fig. 9) by switching known impedances into the circuit. A special holder (Figs. 10, 11) was designed for the crystal, to avoid the effect of external damping influences. The experimental results are given in detail; Fig. 13 shows the equivalent impedance as a function of the air pressure, Figs. 14, 15 as a function of the width of the air space. The degree of uncertainty of the measurements is discussed in § IV. It was found that "the internal friction of quartz varies from crystal to crystal, fluctuating round a mean value. This is probably due to statistical distribution of flaws in crystal structure. The friction is also subject to temporal fluctuations up to $\pm$ 30%, probably caused by thermal movement. . . . The internal friction in oscillating bars does not arise uniformly in the whole of the space they occupy, but depends on the amount of surface. The present measurements showed no variation of the internal friction with the velocity of deformation (that is, with the frequency)."

2461. Laue Photograph of Quartz and Its Application [to Accurate Determination of Orientation of Faces: Experimental Investigation].—I. Koga & M. Tatibana. (*Electrot. Journ.*, Tokyo, Feb. 1939, Vol. 3, No. 2, pp. 38–39.)

2462. The Stress Distribution in an Aeolotropic Circular Disc [with Calculations for Thin Quartz Plate].—H. Okubo. (*Phil. Mag.*, April 1939, Series 7, Vol. 27, No. 183, pp. 508–512.)

2463. On the Theory of Plastic Deformation and Twinning ["Caterpillar"-Motion Theory].—J. Frenkel & T. Kontorawa. (*Physik. Zeitschr. der Sowjetunion*, No. 1, Vol. 13, 1938, pp. 1–10: in English.)

2464. Performance of Crystal Clock observed during 6 Months [Clock without Any Temperature-Regulating Device, using Special Low-Temperature-Coefficient 1 Mc/s Plate].—I. Koga, M. Tatibana, & H. Torizawa. (*Elektrot. Journ.*, Tokyo, March 1939, Vol. 3, No. 3, p. 70.) Working out to a frequency/temperature coefficient of -0.80×10^{-6} per degree Centigrade. If the ambient temperature were controlled to within $\pm 0.1°$ C, the clock could probably be kept accurate to 0.01 sec. per day.

2465. On the Maintenance of the Motion of a Pendulum by an Alternating Current of Frequency High in Comparison with the Natural Frequency of the Pendulum [and the Bethenod-Soulier Pendulum Clock driven by Mains Current without Contacts].—A. Soulier: Bethenod. (*Rev. Gén. de l'Élec.*, 4th March 1939, Vol. 45, No. 9, pp. 275–277.) Reproducing and supplementing the paper by Bethenod giving the theory (676 of February).

2466. A New Method of Frequency Measurement [Writer's "Photographic Coincidence" Method (originally for Gravity Measurements) adapted to Continuous Checking of Mains Frequencies with Accuracy within 0.01%].—H. Martin. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 20, 1939, pp. 104–108.) For previous work (in connection with relay times) *see* 342 of 1935.

2467. Emission of Standard Frequencies from the Physikalisch-Technische Reichsanstalt on the Deutschlandsender [Particulars of Emission of Standard 1000 and 440 c/s].—A. Scheibe & U. Adelsberger. (*Physik. Zeitschr.*, 15th March 1939, Vol. 40, No. 6, p. 216.)

2468. Measurement of Broadcast Coverage and Antenna Performance: Part II.—Fitch & Duttera. (*See* 2337.)

2469. Some Ground-Wave Field-Intensity Measurements taken in New Zealand.—Searle. (*See* 2248.)

2470. A New Method of Stabilisation of an Electrometer Valve [Circuit].—J. Gillod. (*Comptes Rendus*, 3rd April 1939, Vol. 208, No. 14, pp. 1080–1081.) *Cf.* Rogozinski, 2057 of May.

2471. An Apparatus for Charging an Electrometer.—Walch. (*See* 2561.)

2472. Instrument Current Transformers: the Self Determination of Errors [without Reference to Resistance or Other Standards].—A. Glynne. (*Electrician*, 17th March 1939, Vol. 122, pp. 341 and 340.)

2473. Researches on the Inertial Latency [Preliminary Time Lag, as distinct from Other Inertia Effects during the Movement] of Magnetomotive Electrograph [String Galvanometers, etc: Recording Equipment for Accurate Measurement, and Some Results].—A. Tschermak-Seysenegg. (*E.T.Z.*, 23rd March 1939, Vol. 60, No. 12, pp. 370–371: long summary.)

2474. A Valve Testing Panel for measuring "Durchgriff," Slope, and Internal Resistance by means of Alternating Current.—Helmholz. (*See* 2358.)

2475. A Direct-Reading Modulation Meter [Cross-Coil Electrodynamometer Type].—Tomituka. (In paper dealt with in 2622, below.)

2476. A Null Detector for A.C. Bridge Measurements [with Almost Constant Sensitivity in Range 25–70 000 c/s: Rugged and Stable].—J. E. Binns & H. W. Webb. (*Review Scient. Instr.*, March 1939, Vol. 10, No. 3, pp. 89–90.)

2477. A 6H6 A.C.-D.C. VOLTMETER [using Two Diode Rectifiers to avoid Certain Defects of Dry-Plate Rectifiers].—C. W. Carter. (*QST*, April 1939, Vol. 23, No. 4, pp. 45–46.)

2478. A NEW INDUCTION MAGNETOMETER FOR ABSOLUTE MEASUREMENT.—G. Filippini. (*L'Elettrotec.*, 10th Feb. 1939, Vol. 26, No. 3, pp. 72–80.)

SUBSIDIARY APPARATUS AND MATERIALS

2479. FOUR-BEAM ELECTRON [Cathode-Ray] TUBE WITH HIGH RECORDING VELOCITY [with Step-by-Step Increase of Anode Voltage].—A. Bigalke. (*Arch. f. Elektrot.*, 15th Feb. 1939, Vol. 33, No. 2, pp. 108–118.)

For preliminary experiments *see* 1949 of 1937. The electron-optical system is common to all the beams. The principal lens is investigated with the tube shown in Fig. 1; its magnification and voltage ratio are given in Fig. 2. High recording power is developed by a step-by-step increase of anode voltage. The optimum dimensions of the lens are given. Pre-concentration (Fig. 6) and deflecting system (Fig. 7; Fig. 8, potential fields for various methods of connecting the plates) are also described. The four-beam tube developed for 100 kv total voltage is shown in cross-section in Fig. 10; relevant data are given. The maximum velocity which could be recorded photographically was in the neighbourhood of 1000 km/s.

2480. THE OVER-CONTROL SPECTRUM OF A CATHODE-RAY TUBE.—Hollmann. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 20, 1939, pp. 80–82.)

Author's summary:—"With the previously described 'inversion spectrograph' [274 of January: this uses a 'white' electron ray, produced by 'wobbling' the anode voltage by, for example, superposing a suitably transformed a.c. voltage from the mains on a somewhat higher d.c. voltage. This 'white' ray passes first between deflecting plates supplied with alternating voltage of whatever frequency is being investigated (in the present work an ultra-high frequency is used) and then through a magnetic dispersing lens. If the deflecting frequency has a period long compared with the passage time of the electrons through the deflecting field, a stationary deflection spectrum appears as a standing image on the screen, uniformly broadening towards the lower ray velocities in accordance with the sensitivity law; when the frequency is ultra-high, however, the spectrum shows dilatations and compressions due to the 'inversion' properties of the c-r tube] over-control produces in the deflection spectrum the appearance of dark zones which, when the over-controlling deflecting voltage is high enough, divide the spectrum into two interlaced helical strips [one representing the outward deflection, the other the return]. This phenomenon is explained with the help of electron paths calculated for various different path-time angles." The clue to the explanation of this interlaced double spectrum lies in its appearance only when the ray motion is over-controlled, *i.e.* when the ray is extinguished during each half period by striking one of the two deflecting plates (*see* also 705 of February.)

2481. A NEW SMALL OSCILLOGRAPH WITH HIGH-VACUUM CATHODE-RAY TUBE [Reasons for Rejecting the Advantages (for Small Portable Equipments) of the Gas-Focused Tube: the Electrostatically-Focused AEG High-Vacuum Tube HR 1/60/0.5 with 60 mm Screen and Over-All Length of 160 mm: Complete Equipment, capable of dealing with a 1 Mc/s Oscillation].—Bigalke & Pieplow. (*E.T.Z.*, 23rd March 1939, Vol. 60, No. 12, pp. 357–359.)

2482. A COSSOR DOUBLE-BEAM CATHODE-RAY TUBE.—Scroggie. (*Wireless World*, 27th April 1939, Vol. 44, pp. 389–390.)

2483. THE INVESTIGATION OF ELECTRON LENSES.—Klemperer & Wright. (*Proc. Phys. Soc.*, 1st March 1939, Vol. 51, Part 2, No. 284, pp. 296–317: Discussion pp. 376–377.)

Two new methods, analogous to optical methods, are here described. "In the first of these, the trigonometrical ray-tracing method is employed. From a series of equipotentials as measured in the electrolytic trough, the path of the ray is traced by application of the law of refraction at successive equipotential surfaces. The other new method . . is closely analogous to the well-known Hartmann test [in optics]. A number of fine electron pencils emerging through a pepper-pot-like diaphragm is traced through the actual electron lens by means of a sliding fluorescent target, and the path of the beam is measured up with a calibrated microscope." Spherical aberration, Petzval curvature, measurements of principal points with divergent beams, etc., are discussed.

2484. APPLICATIONS OF THE CATHODE-RAY OSCILLOGRAPH TO MEASURING PURPOSES.—Demontvignier. (*Rev. Gén. de l'Élec.*, 8th & 15th April 1939, Vol. 45, Nos. 14 & 15, pp. 419–432 & 454–458.)

2485. THE USE OF THE LISSAJOUS ELLIPSE FOR SOME MEASUREMENTS WITH THE CATHODE-RAY OSCILLOGRAPH.—Ouzounoff. (*See* 2449.)

2486. APPLICATION OF THE CATHODE-RAY TUBE TO THE ELECTRICAL SOLUTION OF DIFFERENTIAL EQUATIONS.—Kleinwächter. (*See* 2594.)

2487. THE PRODUCTION OF X-RAYS DURING THE WORKING OF CATHODE-RAY TUBES WITH HIGH ANODE VOLTAGES [as used for Projection Television or Oscillography and for Oscillographic Recording at Very High Speeds: Dependence on Ray Current & Voltage and on Screen Material: Directional Characteristic: Necessary Thickness of Lead to reduce to Tolerable Dose: etc.].—Bode & Glöde. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 20, 1939, pp. 117–124.)

2488. MULTIPHASE VECTOR RECORDING [with Triograph & Quadrugraph].—Hollmann. (*See* 2611.)

2489. A SEPARATELY EXCITED CURRENT TRANSFORMER [with Ring Core of High Permeability] AS UNIVERSAL TRANSFORMER FOR THE OSCILLOGRAPHY OF A.C. CURRENTS WITH D.C. COMPONENTS.—Krämer. (*E.T.Z.*, 30th March 1939, Vol. 60, No. 13; pp. 393–395.)
Further development of the " d.c. measuring transformer " dealt with in 1141 of 1938.

2490. DISCHARGE CHARACTERISTICS OF SWITCH-GAPS [as used for Starting of Oscillographs, etc.].—Mochizuki & Miyoshi. (*Electrot. Journ.*, Tokyo, April 1939, Vol. 3, No. 4, pp. 86–89.)

2491. PENETRATION OF LOW-SPEED ELECTRONS THROUGH THIN MICA FILM.—Kato & Takada. (*See* 2435.)

2492. EMISSION OF NEGATIVE IONS FROM OXIDE CATHODES [Beam of Negative Ions in Cathode-Ray Tube].—Broadway & Pearce. (*See* 2366.)

2493. FORMATION OF NEGATIVE IONS BY NEGATIVE-ION BOMBARDMENT OF SURFACES: A NEW PROCESS [Emission from Wire Gauze between Oxide-Coated Cathode and First Slit of Mass Spectrograph].—Sloane & Cathcart. (*Nature*, 18th March 1939, Vol. 143, pp. 474–475.)
" A similar . . . emission is to be expected from some of the grids of commercial multi-electrode thermionic valves with oxide-coated cathodes."

2494. ELECTRON BOMBARDMENT OF BIOLOGICAL MATERIALS: I—AN ELECTRON TUBE FOR THE PRODUCTION OF HOMOGENEOUS BEAMS OF CATHODE RAYS FROM ONE TO FIFTEEN KILOVOLTS.—Cooper, Buchwald, & others. (*Review Scient. Instr.*, March 1939, Vol. 10, No. 3, pp. 73–77.)

2495. GENERATORS FOR VERY HIGH D.C. VOLTAGES [for Atomic Physics Research: Survey], *and* PRODUCTION OF HIGH ENERGY PARTICLES [Review of Recent Progress in Development of Extremely High Voltages].—Klein: Wells. (*Bull. Assoc. suisse des Élec.*, No. 16, Vol. 29, 1938, pp. 436–440, in German: *Journ. of Applied Phys.*, Nov. 1938, Vol. 9, No. 11, pp. 677–689.)

2496. RECENT DEVELOPMENTS IN CYCLOTRON TECHNIQUE; *also* PRESENT-DAY DESIGN AND TECHNIQUE OF THE CYCLOTRON; *also* THE CYCLOTRON AND ITS APPLICATIONS; *and* THE CYCLOTRON OF THE STATE RADIUM INSTITUTE, AND THE PRODUCTION OF THE FIRST PROTON AND H_2^+ BEAMS.—Mann: Kurie: Cockcroft: Rukavischnikov & Alkhazov. (*Nature*, 8th April 1938, Vol. 143, pp. 583–585: *Journ of Applied Phys.*, Nov. 1938, Vol. 9, No. 11, pp. 691–701: *Journ. Scient. Instr.*, Feb. 1939, Vol. 16, No. 2, pp. 37–44: *Tech. Phys. of USSR*, No. 10, Vol. 5, 1938, pp. 778–788—in German.)

2497. THEORY OF COLLECTOR CURRENTS IN A PLASMA DISTURBED BY A MAGNETIC FIELD [Cycloidal Electron Motion which distorts the Collector Characteristics].—Spiwak & Reichrudel. (*Tech. Phys. of USSR*, No. 9, Vol. 5, 1938, pp. 715–724: in English.)

2498. VARIATION OF THE FOCAL DISTANCE IN AN ELECTRON X-RAY TUBE, AND THE SECURING OF A REGULAR DISTRIBUTION OF THE ELECTRONS.—Solovjev. (*Journ. of Tech. Phys.* [in Russian], No. 18, Vol. 8, 1938, pp. 1642–1651.)

2499. THE FLUORESCENCE OF COMPOUNDS CONTAINING MANGANESE [Emission at Low Temperatures: Data of Spectra for Pure Manganese Halides and Solids containing only Manganese as Impurity: Classification].—Randall. (*Proc. Roy. Soc.*, Series A, 21st March 1939, Vol. 170, No. 941, pp. 273–293.)

2500. INFLUENCE OF THE ELECTRIC FIELD ON THE FORM OF THE EMISSION BANDS IN ELECTRO-PHOTOLUMINESCENCE [Measurements on Zinc-Sulphide Combinations].—Destriau & Loudette. (*Comptes Rendus*, 20th March 1939, Vol. 208, No. 12, pp. 891–893.)

2501. LUMINESCENCE AND ABSORPTION OF ZnS-MnS MIXED CRYSTALS [including the Dependence of Luminescent Intensity on Temperature and on Amount of Manganese Activator].—Kröger. (*Physica*, April 1939, Vol. 6, No. 4, pp. 369–379: in English.)

2502. THE SENSITISED FLUORESCENCE OF POTASSIUM [from Tube containing Mixture of Potassium and Mercury Vapours: Absorption of Potassium Lines by Mercury: Increase in Intensity of Potassium Fluorescence on Introduction of Hot Filament].—Krause. (*Phys. Review*, 15th Jan. 1939, Series 2, Vol. 55, No. 2, pp. 164–169.)

2503. FLUORESCENCE AND ABSORPTION OF DIACETYL, *and* FLUORESCENCE, ABSORPTION, AND DISCHARGE IN A MERCURY-THALLIUM MIXTURE.—Almy & others: Winans & others. (*Phys. Review*, 15th Jan. 1939, Series 2, Vol. 55, No. 2, pp. 238–239: p. 242: abstracts only.)

2504. SOME METHODS IN VACUUM TECHNIQUE.—Sinel'nikov, Walter, Gumenyuk, & Taranov. (*Journ. of Tech. Phys.* [in Russian], No. 21, Vol. 8, 1938, pp. 1908–1922.)
A survey of various improvements adopted during recent years in the H.T. Laboratory of the Physico-Technical Institute in Kharkov. There has been a tendency to avoid the use of glass and to employ all-metal vacuum apparatus. Details of such apparatus are described, together with alarm systems and methods for localising and stopping leakages in vacuum systems.

2505. USES FOR SYNTHETIC RUBBER-LIKE COMPOUNDS [particularly " Koroseal "] IN VACUUM TECHNIQUE, *and* A NEW CONSTRUCTION FOR LEAD GASKET SEALS [for High-Voltage Vacuum Tubes].—Strong: Pockman. (*Review Scient. Instr.*, March 1939, Vol. 10, No. 3, pp. 104–105: p. 105.)

2506. A SIMPLE GLASS-MEMBRANE MANOMETER FOR LOW PRESSURES [0.1–20 mm Hg, with Accuracy to 2–3%].—Grigorovici. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 20, 1939, pp. 102–104.)

2507. On a Macleod Manometer with Oil Filling.—Kosljakovskaja. (*Journ. of Tech. Phys.* [in Russian], No. 20, Vol. 8, 1938, pp. 1850–1851.)

2508. Surface Structures of Possibly Atomic Dimensions using Autelectronic or 'Field' Emission from Fine Metal Points [Patterns obtained from Clean Tungsten correspond to Main Planes in Crystal Lattice: Technical Method for Study of Metal Surfaces and Their Contamination].—Benjamin & Jenkins. (*Nature*, 8th April 1939, Vol. 143, p. 599.)

2509. Investigations on the Combination of Nitrogen and Oxygen in the Glow Discharge.—Holtz & Müller. (*Ann. der Phys.*, Series 5, No. 6, Vol. 34, 1939, pp. 489–520.)

2510. Temperature Measurements in a Glow Discharge [using Stretched Bolometer Wire: Variation with Position, Current Density, Gas Pressure, Kind of Gas: Errors: Deduction of Heat communicated to Gas by Discharge].—Rudolph. (*Zeitschr. f. Phys.*, No. 7/8, Vol. 111, 1939, pp. 523–534.)

2511. A Simple Polarity Indicator for Breakdown Discharges.—Debus & Hueter. (*E.T.Z.*, 16th Feb. 1939, Vol. 60, No. 7, p. 195.)

2512. Photoionisation by the Electrical Spark [Electrometer Measurements of Electrons emitted from Metallic Electrode: Results for Various Conditions of Voltage, Pressure, Distance of Light Source from Electrode: Absorption by Air, Quartz Glass].—Brinkmann. (*Arch. f. Elektrot.*, 16th Jan. 1939, Vol. 33, No. 1, pp. 1–22.)

2513. Papers on the Striking Voltage and Striking Distance of Discharges in Air.—Toepler: Brinkmann. (*See* 2270 & 2271.)

2514. Primary Ions of the Spark Discharge [and the Question of the Mechanism of Their Production].—Fujitaka & Kobayasi. (*Electrot. Journ.*, Tokyo, April 1939, Vol. 3, No. 4, pp. 90–92.)

2515. The Initial Characteristic of the Townsend Discharge in Noble Gases [Measurements: Explanation based on Schade's Extension of Townsend's Theory].—Büttner. (*Zeitschr. f. Phys.*, No. 11/12, Vol. 111, 1939, pp. 750–769.) *See* Schade, 2219 of 1938.

2516. Sparking Potentials at Low Pressures [Measurements on Air and Other Gases].—Quinn. (*Phys. Review*, 15th Jan. 1939, Series 2, Vol. 55, No. 2, p. 240: abstract only.)

2517. A New Method of Extinguishing a Mercury-Vapour Arc [Ion Current necessary for Extinction greatly reduced by Special Connection of Two Grids].—Watanabe & Kasahara. (*Electrot. Journ.*, Tokyo, March 1939, Vol. 3, No. 3, pp. 51–55.)

2518. A New Form of Band Igniter for Mercury Pool Tubes [Ignition Voltage reduced by Use of Thin Dielectric Layers between Starter and Mercury Cathode].—Germeshausen. (*Phys. Review*, 15th Jan. 1939, Series 2, Vol. 55, No. 2, p. 228.)

2519. On the Quantitative Theory of the Excitation of Atoms in a Gaseous Discharge.—Fabrikant. (*Tech. Phys. of USSR*, No. 11, Vol. 5, 1938, pp. 864–888: in English.)

2520. A Conference on the Question of Electric Discharge in Gases and Its Applications.—Sena. (*Journ. of Tech. Phys.* [in Russian], No. 12, Vol. 8, 1938, pp. 1184–1187.)

2521. The Charging of Dielectric Surfaces by Surge Potentials: Charge Measurements on Lichtenberg Figures.—Conradt. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 20, 1939, pp. 109–116.)

"The interest in the process of surface charging, which has arisen from the revival of activity in the field of electrostatic machines, has prompted the following new observations on the charging by surges." Measurements of charges on glass, Calit, and Condensa, showing their variation with the thickness, nature of surface, etc., are described.

2522. Absorption of 1.65–7.2 cm Waves [including Measurements on Ceramic Insulators].—Kebbel. (*See* 2444.)

2523. Strength Investigations on "Organic Glasses": I [Tensile Strength of Polystyrol and Plexiglass; with Deductions as to Their Structure].—Rexer. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 20, 1939, pp. 97–102.)

2524. On Low-Temperature Dielectric Losses in Glass containing Metallic Ions.—Lysenko. (*Journ. of Tech. Phys.* [in Russian], No. 18, Vol. 8, 1938, pp. 1637–1641.)

It is well known that dielectric losses in glass containing oxides of alkali metals (especially in the case of Na_2O) are much higher than those in pure glass. To explain this phenomenon it has been suggested by Frenkel (*Comptes Rendus de l'Ac. des Sci. de l'URSS*, 1937, p. 287) that a metallic ion contained in glass can be regarded as a form of sound radiator which when set oscillating by the electric field transfers the energy of oscillations to the glass particles and thus dissipates the energy of the field. On the basis of this theory the author has derived formulae (2) and (3) determining tan δ for the following two extreme cases: (a) a cubic crystal, and (b) an isotropic continuum. These formulae do not agree with experimental results, which leads to the conclusion that Frenkel's theory is not correct.

2525. The Influence of Medium and of Adsorbing Substances on the Mechanical Properties of Mica: I.—Logginov. (*Journ. of Tech. Phys.* [in Russian], No. 21, Vol. 8, 1938, pp. 1857–1871.)

2526. Plastic Materials: Injection as applied to Thermo-Setting Plastics.—(*Electrician*, 14th April 1939, Vol. 122, p. 469.)

2527. ON THE ELECTRICAL CONDUCTIVITY OF PAPER AND CELLULOSE.—Shorygin & Shorygin. (*Journ. of Tech. Phys.* [in Russian], No. 22/23, Vol. 8, 1938, pp. 1992–1995.)

Many attempts have been made to increase the conductivity of cellulose materials to prevent the accumulation of electrical charges when these materials are passed through paper-making or printing machines. In the present paper the theory of conductivity as determined by the amount of moisture present in the material is discussed, and a formula is derived for calculating the specific resistance of the material.

2528. "THE ELECTROCHEMISTRY OF GASES AND OTHER DIELECTRICS" [Book Review].—Glockler & Lind. (*Electrician*, 14th April 1939, Vol. 122, p. 476.)

2529. ELECTRIC BREAKDOWN OF ALCOHOL SOLUTION [and the Spectra of the Coloured Streamers (White, for "Chopped" Waves) produced in Needle-Gap Discharge].—Toriyama & others. (*Electrot. Journ.*, Tokyo, Feb. 1939, Vol. 3, No. 2, pp. 47–48.)

2530. THE DIELECTRIC CONSTANT OF AMMONIUM SULPHATE IN THE NEIGHBOURHOOD OF THE TRANSITION POINT [Simultaneous Maximum of Dielectric Constant and Absorption Coefficient for Wavelength 2700 m].—Guillien. (*Comptes Rendus*, 27th March 1939, Vol. 208, No. 13, pp. 980–981.)

2531. THE THERMAL STABILITY OF A CYLINDRICAL STRATIFIED DIELECTRIC [Theory: Comparison with Flat Dielectric: Application to Condensers].—Whitehead. (*Phil. Mag.*, March 1939, Series 7, Vol. 27, No. 182, pp. 276–285.)

2532. THE DEVELOPMENT OF A SMALL VARIABLE AIR CONDENSER COMPENSATED FOR RAPID CHANGES OF TEMPERATURE.—Thomas. (*See* 2455.)

2533. STUDY OF VERY THIN FILMS OF PLATINUM [Optical Parameters differ from Those of Massive Metal].—Rouard. (*Comptes Rendus*, 12th April 1939, Vol. 208, No. 15, pp. 1146–1148.)

2534. PAPERS ON THE ELECTRICAL CONDUCTIVITY, LIGHT TRANSMISSION, AND STRUCTURE OF THIN GOLD FILMS.—Was. (*Physica*, April 1939, Vol. 6, No. 4, pp. 382–389 : 390–392 : in English.)

2535. THE CONDUCTIVITY OF THIN FILMS OF THALLIUM ON A PYREX GLASS SURFACE.—Bristow. (*Proc. Phys. Soc.*, 1st March 1939, Vol. 51, Part 2, No. 284, pp. 349–354.)

2536. THE THERMAL EVOLUTION OF THE CONDUCTIVITY OF THIN NICKEL FILMS.—Colombani. (*Comptes Rendus*, 13th March 1939, Vol. 208, No. 11, pp. 795–797.)

2537. PRODUCTION AND STRUCTURE OF ELECTROLYTIC ALUMINIUM-OXIDE FILMS.—Baumann. (*Zeitschr. f. Phys.*, No. 11/12, Vol. 111, 1939, pp. 708–736.)

2538. SPONTANEOUS ELECTRON EMISSION OCCURRING AT THE ELECTRODES AS THE AFTER-EFFECT OF GASEOUS DISCHARGES, AND THE FIELD ELECTRON EMISSION AT THIN INSULATING FILMS [with Application to Self-Excitation of Counters].—Paetow. (*Zeitschr. f. Phys.*, No. 11/12, Vol. 111, 1939, pp. 770–790.)

The first emission is found to originate in surface deposits on the electrodes and to be excited by the short-wave photons of the discharge. It can be transformed into the second emission by suitable preparation of the electrodes. This shows that self-excitation of counters is a field emission at the remaining insulating surface deposits. The field emission at the cathode of the so-called "spray" discharge (Guntherschulze's "Spritzentladung"—a glow discharge without cathode drop and without Hittorf dark space, occurring at semiconducting cathodes) is found to be excited by photons, not ions.

2539. MAGNETIC SCREENING BY PLANE METAL SHEETS AT AUDIO FREQUENCIES.—Moeller. (*See* 2377.)

2540. MECHANISM OF MAGNETISATION [Experiments on Reduction of Magnetic Field inside Iron Tubes indicate Magnetisation initiated at Surface and proceeding inwards by "Chain Effect."]—Wall. (*Nature*, 25th Feb. 1939, Vol. 143, pp. 331–332.)

2541. MAGNETIC NICKEL ALLOYS: THEIR USES IN RADIO EQUIPMENT.—Everest. (*Wireless World*, 13th April 1939, Vol. 44, pp. 347–348.) From the Mond Nickel Company.

2542. ON THE MAGNETIC PERMEABILITY OF IRON IN HIGH [and Ultra-High-] FREQUENCY FIELDS.—Mash & Enushkov. (*Journ. of Tech. Phys.* [in Russian], No. 22/23, Vol. 8, 1938, pp. 1986–1991.)

Experiments in which the rise of temperature was observed in a small iron ball (with a radius of a few mm) when this was placed in a h.f. magnetic field. The tests were conducted on waves from 4.1 to 20 m and with field intensities varying from 0.7 to 7 gauss. The main conclusions reached are as follows: (1) μ does not depend on the radius of the ball and increases linearly with the wavelength from 175 at 4 m to 260 at 20 m ($H = 5$ gauss); (2) μ rises sharply at approximately 1 gauss and then falls gradually with a further increase in the field intensity. This is in contradiction to the results published by Schwarz and Kreielsheimer, who found that μ steadily increased with increase in the field intensity (1932 Abstracts, pp. 471–472: *Ann. der Physik*, No. 3, Vol. 17, 1933).

2543. ALTERNATING HYSTERESIS LOSS IN ELECTRICAL SHEET STEELS [with Direct Method of Measuring].—Brailsford. (*Journ. I.E.E.*, March 1939, Vol. 84, No. 507, pp. 399–407.)

2544. ON MAGNETIC TESTS OF ELECTROTECHNICAL STEEL IN SHEETS: I & II.—Janus & others. (*Journ. of Tech. Phys.* [in Russian], No. 19, Vol. 8, 1938, pp. 1703–1712 & 1713–1722.)

2545. The Determination of the Saturation Magnetisation and the Saturation Field of Ferromagnetic Plates by the Method of applying Direct and Alternating Fields.—Grabovskij. (*Journ. of Tech. Phys.* [in Russian], No. 13/14, Vol. 8, 1938, pp. 1206–1211.)

2546. " Ferromagnetism " [Book Review].—Ashworth. (*Electrician*, 23rd Dec. 1938, Vol. 121, p. 756.)

2547. Shape of the Domains in Ferromagnetics [Theory].—Kennard. (*Phys. Review*, 1st Feb. 1939, Series 2, Vol. 55, No. 3, pp. 312–314.)

2548. Collective Electron Ferromagnetism: II—Energy and Specific Heat.—Stoner. (*Proc. Roy. Soc.*, Series A, 7th Feb. 1939, Vol. 169, No. 938, pp. 339–371.)

2549. The Magnetic Anisotropy of Iron, Nickel, and Cobalt [Calculations based on New Model of Ferromagnetic Material].—Honda & Hirone. (*Zeitschr. f. Phys.*, No. 7/8, Vol. 111, 1939, pp. 477–483.)

2550. Magnetic Studies in the Ternary System Fe-Ni-Al.—Snoek. (*Physica*, April 1939, Vol. 6, No. 4, pp. 321–331 : in English.)

2551. On the Theory of the Technical Magnetisation Curve of Ferromagnetic Monocrystals: I, *and* Hysteresis Anisotropy in Ferromagnetic Monocrystals: II.—Vonsovskij : Shur. (*Journ. of Tech. Phys.* [in Russian], No. 20, Vol. 8, 1938, pp. 1805–1816 : pp. 1817–1823.)

2552. The Measurement of Magnetic Saturation Intensities at Different Temperatures [New Method].—Sucksmith. (*Proc. Roy. Soc.*, Series A, 7th Feb. 1939, Vol. 169, No. 938, pp. 52–53 : abstract only.)

2553. Papers on Transformers.—Wünsch : Käser. (*See* 2329 & 2330.)

2554. Transformer Windings with Graduated Conductor Widths [Calculations giving Dimensions for Minimum Impedance].—Scharstein. (*Arch. f. Elektrot.*, 15th Feb. 1939, Vol. 33, No. 2, pp. 139–142.)

2555. Devices for the Filtering of Alternating Currents of Any Wave Form [yielding Sinusoidal Waves suitable for Electro-acoustical Purposes, Magnetic Loss Measurements, etc.].—Giulietti. (*L'Elettrotec.*, 10th Nov. 1938, Vol. 25, No. 21, pp. 771–774.)

2556. An Automatic Stabiliser Circuit [for Magnetic Fields, etc : Modification of Wynn-Williams Circuit].—Rogers. (*Review Scient. Instr.*, March 1939, Vol. 10, No. 3, p. 104.)

2557. Thyratron Counter for Measurement of Radiation [Calibration constant within 2% over Six Weeks].—Rymer. (*Journ. Scient. Instr.*, March 1939, Vol. 16, No. 3, pp. 84–87.)

2558. Smoothing Equipments for Low-Power Rectifiers [and Their Calculation].—Böhm. (*E.T.Z.*, 23rd March 1939, Vol. 60, No. 12, pp. 359–362.)

Author's summary :—" While the size of smoothing condensers can be calculated easily, the design-calculation of smoothing chokes presents considerable difficulty owing to the marked dependence of the inductance on the d.c. component. For constant current density and number of ampere turns, and for a given harmonic content, the inductance varies inversely as the fourth power of the wire diameter. Measured curves of inductance as a function of wire diameter are given for the most important cases, and a method of measuring the harmonics is described, in which a current-transformer is used to cut out the d.c. component." A comparison is made (Table 1) between the arrangement of given components in a simple and in a double (choke-condenser-choke-condenser) network.

2559. Primary Batteries according to Recent Patents.—Jumau. (*Rev. Gén. de l'Élec.*, 1st April 1939, Vol. 45, No. 13, pp. 397–403.)

2560. The Method of Increasing the Voltage of Direct Current with the Help of Condensers [New Method using System of Auxiliary Condensers as Link between Rectifiers and the Series Condensers].—Likhoff & Pavloff. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 2/3, Vol. 20, 1938, pp. 121–124 : in French.)

2561. An Apparatus for Charging an Electrometer [using Voltage-Multiplication from, say, 10 Volts (Torch Batteries) to 600 Volts or more, by Motion of Plunger causing Enormous Change in Capacity of Two-Plate Condenser].—Walch. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 20, 1939, pp. 82–83.)

2562. The Exponential Characteristic of Copper-Oxide Rectifiers.—Tamm & Bath. (Referred to in Pawley's paper dealt with in 2576, below.)

2563. The Theory of Crystal Rectifiers [Nature of Potential Barrier between Semiconductor and Metal : Electrons, Thermally Excited, go *over* Barrier, not *through* It].—Mott. (*Proc. Roy. Soc.*, Series A, 7th March 1939, Vol. 169, No. 939, p. S 18 : abstract only.)

2564. Investigations of the Electrical Conductivity and Thermoelectric Properties of Semiconductors.—Hochberg & Sominski. (*Physik. Zeitschr. der Sowjetunion*, No. 2, Vol. 13, 1938, pp. 198–223 : in German.)

2565. A Periodic Wave Analyser [for Point-by-Point Delineation : All Moving Parts and Contacts of Joubert Disc replaced by Electronic Means].—Klemperer. (*Review Scient. Instr.*, March 1939, Vol. 10, No. 3, pp. 69–73.)

2566. THE REQUIREMENTS FOR THE PRODUCTION OF A STROBOSCOPIC IMAGE [Theory: Transparency or Reflecting Power of Moving Body and Time Variation of Illumination must have Components of Same Frequency: Calculation of Form and Contrast of Stroboscopic Image: Experiments].—Strobl. (*Arch. f. Elektrot.*, 15th Feb. 1939, Vol. 33, No. 2, pp. 100–107.)

2567. CHARACTERISTICS OF TUNGSTEN FUSES.—Utiyama & Arai. (*Electrot. Journ.*, Tokyo, Jan. 1939, Vol. 3, No. 1, pp. 10–13.)

STATIONS, DESIGN AND OPERATION

2568. EXPERIMENTAL PROOF OF THE POSSIBILITY OF LONG-DISTANCE COMMUNICATION ON 16 cm WAVES [up to 152 km from Transmitter on Puy-de-Dôme Observatory] AND OBSERVATIONS MADE IN THE COURSE OF THE EXPERIMENTS.—Berline & Gutton. (*Bull. de la Soc. franç. Radioélec.*, Supp. Number, 1938, Vol. 12, No. 5, pp. 120–125.)

A *Comptes Rendus* Note was dealt with in 3831 of 1938. The apparatus is here described: it embodies (at the transmitter) an 8-segment magnetron S.F.R. M.16 [giving a peak modulated output of 10 w: anode modulation was employed] in a Ni-Al permanent-magnet field of 500 gauss reducible by a magnetic shunt, and (at the receiver) a retarding-field super-regenerative detector S.F.R. U.C.16 with tuned grid and internal quarter-wave aerial placed on the focal line of a cylindro-parabolic mirror. The transmitting quarter-wave vertical doublet had a mirror of paraboloid of revolution form, and was at a height of 1465 m above sea level. The receiver was always within "optical" range, but the Puy-de-Dôme was perpetually hidden by mist, and the weather conditions were especially bad for the 152 km test.

When the ground in front of the receiver was flat, a system of horizontal interference fringes was found when the mirror was raised above the ground: the spacing was of the order of one metre. The fringes did not occur if the ground sloped sharply in front of the receiver. Their formation is discussed on p. 124. "The interference fringe at the ground is 'black' on account of the phase change at reflection: this explains the difficulty of reception on a slope opposed to the transmitter." The tests have shown "that the propagation of decimetric waves shows no anomalies on condition that the receiver is kept 'in sight' of the transmitter and is situated on ground inclined towards the latter. In these conditions it is not necessary to raise the receiver more than a metre above the ground." The direction of the transmitter could be found, by orienting the receiving mirror, to within about one degree.

2569. PORTABLE ULTRA-SHORT-WAVE [50–60 cm Micro-Wave] TRANSMITTER-RECEIVER TYPE D.E.R.X. 1/0.01.—Michel & Gutton. (*Bull. de la Soc. franç. Radioélec.*, Supp. Number, 1938, Vol. 12, No. 5, pp. 126–131.)

The transmitter embodies an oscillator triode in a special patented circuit consisting of two U-shaped strips of copper, one inside the other. One end of (say) the outer strip is connected to the valve plate, the opposite (far) end of the inner strip to the grid. The return of the grid to the cathode is through a resistance connected to the inner strip near this end. The plate voltage is applied at the mid-point of the outer strip. "The efficiency is better than that of ordinary oscillators and the wavelength is short compared with the length of the circuits." For covering the range of 50–60 cm a high-Q adjustable Lecher system is connected to the ends of the outer (plate) strip. Anode modulation is used, with a pentode as speech-amplifier. The receiver is super-regenerative: the main oscillatory circuit is identical with that of the transmitter and, thanks to the high-Q property of the circuit, is highly selective: the quench-frequency is about 150 kc/s. A common aerial system is used for transmission and reception: it is of the S.F.R. Chireix-Mesny saw-tooth type with a similar reflector, and in spite of the aerial power being only about 1/10th of a watt, telegraphic and telephonic communication was obtained at 75 km when conditions were very favourable. Over flat or slightly undulating country communication was excellent within a radius of 20–30 km. From the Puy-de-Dôme, ranges of 50 and 80 km were obtained. In one test only, between two mountains 112 km apart, severe fading was encountered, apparently produced by the arrival of two or more rays by different paths owing to reflections from lower hills lying between the two stations.

2570. EQUIPMENTS FOR MULTIPLEX CARRIER TELEPHONY ON ULTRA-SHORT WAVES [Frequencies 72–78 Mc/s, Carrier Output 35–50 Watts].—Matsumae & Yonezawa. (*Nippon Elec. Comm. Eng.*, Feb. 1939, No. 15, pp. 554–563.)

2571. WIRED WIRELESS BROADCASTING: THE POST OFFICE REDIFFUSION SCHEME.—(*Wireless World*, 6th April 1939, Vol. 44, p. 323.) Based largely on Wiessner's paper (3408 of 1938) on the Lorenz system.

2572. THE DISTRIBUTION OF POWERS IN THE AMPLIFIER STATION FOR WIRE BROADCASTING.—Klein. (*T.F.T.*, Jan. 1939, Vol. 28, No. 1, pp. 33–35.) From the German State Post Office.

2573. THE WIRE BROADCASTING GROUP CONNECTION ["Sammelschaltung."].—Klein. (*T.F.T.*, Feb. 1939, Vol. 28, No. 2, pp. 69–72.)

Of the two existing networks possible for wire broadcasting, the electric light system is more widely distributed than the telephone system but is less suitable technically. The telephone system on the other hand has, in Germany, only about 2 million subscriber's main stations (the extension stations cannot in general be counted on for wire broadcasting, since they are mostly in offices) compared with the 10 million broadcast receiving stations. An average of 5 wire broadcasting points would therefore require to be based on each subscriber's line; in many cases as many as 20 or more points are needed in such a "group" system. The economic planning and construction of such systems is discussed in the present paper.

2574. AN APPARATUS FOR THE HIGH-FREQUENCY CONTROL OF THE TRANSMITTERS FOR COMMON-WAVE WIRE BROADCASTING [Equipment for Preliminary Investigations, on Cable Lengths up to 12 km: Importance of Symmetry with respect of Earth: Practical Circuits].—Bender. (*Funktech. Monatshefte*, Feb. 1939, No. 2, pp. 41–44.)

2575. SINGLE-SIDEBAND MODULATION, TRANSMISSION AND RECEPTION [Short Survey of Advantages and Disadvantages].—Peschke. (*Funktech. Monatshefte*, March 1939, No. 3, pp. 84–86.)

The writer concludes that single-sideband working will not come into use in broadcasting, except perhaps for television. For ordinary broadcasting the further development of common-wave systems is the solution to the lack of channels.

2576. AUTOMATIC VOLUME COMPRESSION [and a Simple and Satisfactory Compresser using Copper-Oxide Rectifiers (with Exponential Characteristic): Noise Reduction: etc.].—Pawley. (*World-Radio*, 7th April 1939, Vol. 28, pp. 12–13.)

2577. MEASUREMENT OF BROADCAST COVERAGE AND ANTENNA PERFORMANCE: PART II.—Fitch & Duttera. (*See* 2337.)

2578. AMPLIFICATION OF WIDE-BAND MODULATED WAVES AT TRANSMITTER AND RECEIVER: THE HEFOD SYSTEM.—Hayasi. (*See* 2424.)

2579. FOREWORD ON THE HISTORICAL DEVELOPMENT OF GERMAN OVERSEAS WIRELESS COMMUNICATION.—Kummerer. (*Telefunken Hausmitteilungen*, March 1939, Vol. 20, No. 80, pp. 5–10.)

2580. THE DEVELOPMENT OF THE TRANSOCEANIC SHORT-WAVE TRANSMITTING SERVICE IN GERMANY [Transmitters: Modulation (including Comparison between Double- and Single-Sideband Working): High-Speed Keying: Aerial Feeding Equipment (including Use of Boucherot-Bridge Circuit, the $\lambda/2$ "Roundabout-Way" Feeder, "Phase Transformer," "Symmetrising Loop," and Concentric "$\lambda/4$ Wave-Trap Pot," All in connection with Asymmetry to Earth)].—Buschbeck. (*Telefunken Hausmitteilungen*, March 1939, Vol. 20, No. 80, pp. 11–29.)

2581. WIRELESS TELEPHONE CIRCUITS AS LINKS IN THE WORLD TELEPHONE NETWORK.—Strecker & Hölzler. (*Telefunken Hausmitteilungen*, March 1939, Vol. 20, No. 80, pp. 63–79.)

2582. DEVELOPMENT AND SCOPE OF THE GERMAN OVERSEAS WIRELESS SERVICE.—Gerlach. (*Telefunken Hausmitteilungen*, March 1939, Vol. 20, No. 80, pp. 80–84.)

2583. RADIO TELEPRINTING [for Avoidance of Errors from Atmospherics and Other Interference].—Le Matériel Téléphonique. (*Wireless World*, 30th March 1939, Vol. 44, p. 294.) On the "seven-frequency" system dealt with in 3414 of 1938.

2584. DECREASING THE LIABILITY TO ERRORS OF WIRELESS TELEGRAPHY LINKS BY MEASURES TAKEN IN THE L.F. PART OF THE SYSTEM [Siemens-Hell Facsimile System (and Criticism of the French "Seven-Frequency" Method): Baudot-Verdan and Note-Frequency systems: Hudec's Impulse Method].—Reche, Arzmaier, & Zimmermann. (*Telefunken Hausmitteilungen*, March 1939, Vol. 20, No. 80, pp. 53–62.)

2585. PAPERS ON WIRELESS PRINTING TELEGRAPH SYSTEMS.—Sugiyama & others. (*See* 2318.)

2586. RELATION BETWEEN THE POWER RADIATED BY A SHIP STATION AND THE NUMBER OF "METRE-AMPERES" [as specified by Safety of Life at Sea Convention].—Marique. (*L'Onde Élec.*, Feb. 1939, Vol. 18 [wrongly printed 19], No. 206, pp. 92–96.)

An investigation based on the International Radiomaritime Committee's measurements over distances chiefly between 10 and 70 km, all the results over distances greater than about 150 km being discarded to avoid, as much as possible, the influence of the indirect way. In logarithmic co-ordinates, the relation $W = M.A/K$ is represented by a straight line. These lines have been traced (figure on p. 94) for $K = 25$ and $K = 50$, values which seem to include the majority of the results, and for $K = 35$, which seems to represent the mean relation for the wavelength 660 m (which was employed to avoid jamming). It is noticeable that the points nearest to the line $K = 50$ (minimum radiation) correspond not to low aerials but to aerials of actual (geometrical) heights of 30, 40, 42, & 50 m. The actual height is not, therefore, a criterion of good radiation: this confirms the writer's doubts (p. 92) as to the wisdom of replacing the "effective" height by the actual height, in view of the importance of the superstructures and of the fact that the wireless cabin is usually on the upper bridge. Comparison of the classical formula 2 with the $W = M.A/K$ relation and the values in Table I indicates that the coefficient α (ratio of effective to actual heights) ranges, for ships' aerials, from 0.33 to 0.66 for the 660 m wave.

The Safety of Life at Sea Convention established a relation between the number of metre-amperes and the range, the receiver being assumed to be a galena detector: the values are given in the first two columns of Table II. Choosing the feeblest radiation ($K = 45$ for $\lambda = 600$ m) since a question of safety is involved, the field intensities at the limit of the theoretical range can be calculated: these indicate that the Convention requires a field of about 60 μV/m at the range limits of the various categories of transmitter.

2587. RADIOTELEPHONE FOR SMALL YACHTS.—Byrnes. (*RCA Review*, Jan. 1939, Vol. 3, No. 3, pp. 335–339.)

2588. AMATEUR RADIO TO FURNISH COMMUNICATION WITH GATTI AFRICAN [Congo] EXPEDITION.—Ruth. (*QST*, April 1939, Vol. 23, No. 4, pp. 29 and 90.)

GENERAL PHYSICAL ARTICLES

2589. On a Generalisation of Kaluza's Theory of Electricity [Treatment involving Fifth Dimension].—Einstein & Bergmann. (*Science*, 24th March 1939, Vol. 89, Supp. p. 6: summary only.)

2590. "Les Interprétations physiques de la Théorie d'Einstein" [Book Review].—Dive. (*Rev. Gén. de l'Élec.*, 25th March 1939, Vol. 45, No. 12, p. 354.)

2591. On Fluctuations in Electromagnetic Radiation [Recalculations for Quantised Field].—Born & Fuchs. (*Proc. Roy. Soc.*, Series A, 21st March 1939, Vol. 170, No. 941, pp. 252–265.)

2592. Theory of "Spiral" Orbits of the Electron in a Coulomb Field.—Frenkel & Rojansky. (*Physik. Zeitschr. der Sowjetunion*, No. 2, Vol. 13, 1938, pp. 181–197: in English.)

2593. On the Magnetic, Electric, Electrodynamic, and Electromagnetic Actions in Rigid or Deformable Bodies.—Roy. (*Rev. Gén. de l'Élec.*, 25th March 1939, Vol. 45, No. 12, pp. 377–381.)

MISCELLANEOUS

2594. Application of the Cathode-Ray Tube to the Electrical Solution of Differential Equations [Solutions shown on Tube Screen: Circuits for Two Differential Equations].—Kleinwächter. (*Arch. f. Elektrot.*, 15th Feb. 1939, Vol. 33, No. 2, pp. 118–120.)

2595. An Auxiliary Equation for Use with the Heaviside Expansion Theorem [for Making or Breaking a Circuit].—Coulthard. (*Phil. Mag.*, April 1939, Series 7, Vol. 27, No. 183, pp. 404–406.)

2596. The Operational Calculus: II [Development of Heaviside's Rules: Solution of Linear Integro-Differential Equations with Constant Coefficients].—Pipes. (*Journ. of Applied Phys.*, April 1939, Vol. 10, No. 4, pp. 258–264.) For I *see* 2166 of May.

2597. The Calculation of the Energy in an Oscillating System by the Operational Calculus.—Rimski-Korsakov. (*See* 2290.)

2598. The General Theory of Relaxation Methods applied to Linear Systems [Operational Equations, Integral Equations, and Differential Equations treated by Method of Steepest Descents: Successive Approximations converging to Accurate Solution].—Temple. (*Proc. Roy. Soc.*, Series A, 7th March 1939, Vol. 169, No. 939, pp. 476–500.)

2599. Approximation Formulae for a Well-known Difference of Products of Two Cylinder Functions.—Buchholz. (*Phil. Mag.*, April 1939, Series 7, Vol. 27, No. 183, pp. 407–420.)

2600. "Tensor Analysis of Networks" [Book Review].—Kron. (*See* 2284.)

2601. The Matrix Method of Treating Alternating-Current Phenomena.—Noda. (*Memoirs of Ryojun Coll. of Eng.*, March 1939, Vol. 12, No. 1, pp. 1–31: in English.)

2602. A Note on Graduation by the Method of Least Squares.—Nair. (*Sci. & Culture*, March 1939, Vol. 4, No. 9, pp. 529–530.)

2603. Positive and Negative [in Cartesian Co-ordinates]: an Alternative (Non-Rotative) Convention.—Turnbull. (*Electrician*, 14th April 1939, Vol. 122, p. 470.)

2604. "Lanchester's 'Potted Logs,' Part II" [Book Review].—(*Electrician*, 31st March 1939, Vol. 122, p. 413.) Including a table in anti-log form to the base 1.059 463, of interest to musicians.

2605. New Developments in the Construction of Slide Rules.—Wasmus. (*E.T.Z.*, 2nd March 1939, Vol. 60, No. 9, pp. 271–272.)

2606. On the Double Refraction of Micro-Waves in Oak.—Lindman. (*See* 2244.)

2607. Progress in the Technique of the Ultra-Short Waves [Micro-Waves from 100 to 8 cm, in 5 Ranges: with Table of Suitable Methods of Generation and Reception, and Special Applications, for Each Range].—Ponte. (*Bull. de la Soc. franç. Radioélec.*, Supp. Number, 1938, Vol. 12, No. 5, pp. 114–119.)

2608. Electron Bombardment of Biological Materials: I.—Cooper & others. (*See* 2494.)

2609. The Localisation of Minerals in Animal Tissues by the Electron Microscope [by Ashing the Sections on Surface of Barium- and Strontium-Coated Cathode].—Scott & Packer. (*Science*, 10th March 1939, Vol. 89, pp. 227–228.)

2610. A Laboratory Method of Measuring the Energy Absorbed by a Living Organism in an Ultra-High-Frequency Field.—Fridman. (*See* 2445.)

2611. Multiphase Vector Recording and Its Practical Application to Electrocardiography [Triograph with 3 Pairs of Plates successively displaced by 60°: Its Circuits for Triograms, Linear, & Two-Phase Diagrams: Circuit for Triograms from Ordinary Two-Phase Tube: N-Phase Recording (Schönhardt's Law): the Quadrugraph, with Two-Phase Tube in Star Connection: Its Additional Use for Two-Phase Recording with Elimination of Einthoven Disturbance Functions].—Hollmann. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 20, 1939, pp. 83–95.) For previous work *see* 1703 of 1938.

2612. Nerve Conduction with Distributed Capacitance [Theory giving Formulae for Initial Velocity of Impulse, Asymptotic Velocity of Propagation, etc.].—Weinberg. (*Phys. Review*, 15th Jan. 1939, Series 2, Vol. 55, No. 2, p. 240: abstract only.)

2613. SHORT-WAVE [6, 12, & 15 m] DIATHERMY AND ITS APPARATUS.—Amweg. (*Bull. Assoc. suisse des Élec.*, No. 21, Vol. 29, 1938, pp. 584–588.)

2614. THE VALUE OF APPLIED RADIO-GEOLOGY FOR SCIENCE AND ENGINEERING.—Fritsch. (*Bull. Assoc. suisse des Élec.*, No. 3, Vol. 30, 1939, p. 81: summary only, in German.)

2615. RADIESTHESIS IN MEDICINE [Wavelength of Person in Perfect Health 8 m, Shortened by Disease or Fatigue: Diagnosis, and Control of Results of Treatment: etc.].—Maury. (*Electrician*, 10th Feb. 1939, Vol. 122, p. 180: summary only.)

2616. RADIESTHESIS: II [particularly the Deflection of the "Pendular Waves" of Various Substances] & III [Value to Electrical Treatment Apparatus Makers and Biologists].—Macbeth: Turenne. (*Electrician*, 24th March & 14th April 1939, Vol. 122, pp. 369–370 & 472–473.) For I *see* 1318 of March.

2617. "THE SECRET OF LIFE: COSMIC RAYS AND RADIATIONS OF LIVING BEINGS" [Book Review].—Lakhovsky. (*Electrician*, 10th March 1939, Vol. 122, p. 322.)

Translated from the French: to be published during the spring. The work covers topics such as instinct in animals, bird migration, and health & disease, etc: with special bearing on cancer and its cure. For previous references to Lakhovsky's researches *see* 1934 Abstracts, p. 110 (r-h column) and 2892 of 1936.

2618. SUPERSONIC WAVES IN THE SERVICE OF MEDICINE [Short Survey].—Fehr. (*Funktech. Monatshefte*, March 1939, No. 3, pp. 93–94.)

2619. THE ABSORPTION OF SUPERSONIC WAVES IN HUMAN TISSUE AND ITS DEPENDENCE ON FREQUENCY.—Pohlman. (*Physik. Zeitschr.*, 1st March 1939, Vol. 40, No. 5, pp. 159–161.)

2620. ON A DIAPHRAGM OF A VIBROMETER FOR SUBMARINE ACOUSTICAL MEASUREMENTS.—Hayasaka. (*See* 2418.)

2621. AN IMPROVED THREE-CHANNEL CARRIER TELEPHONE SYSTEM, *and* A TWELVE-CHANNEL CARRIER TELEPHONE SYSTEM FOR OPEN-WIRE LINES.—O'Leary & others: Kendall & Affel. (*Bell S. Tech. Journ.*, Jan. 1939, Vol. 18, No. 1, pp. 49–75: pp. 119–142.)

2622. TELEMETERING BY THE AMPLITUDE-MODULATION METHOD.—T. Tomituka. (*Electrot. Journ.*, Tokyo, April 1939, Vol. 3, No. 4, pp. 79–80.)

In such a system of telemetering, the modulation percentage of the carrier wave is controlled by the deflection of the meter. With the usual static method the arrangement is complicated and the reliability low, but "this defect can be removed if a part of the meter is made to rotate mechanically. Three methods for this improvement are described. Next is stated the simple compensation method by which the characteristic rectification of a cuprous-oxide rectifier becomes apparently linear." Finally a direct-reading modulation meter is described: this is a type of cross-coil electrodynamometer which is fed by the modulated wave after its rectification and conversion into a current containing direct and alternating components, and which indicates the ratio of these components, and thus the modulation percentage.

2623. BROADCAST NOVELTIES AT THE LEIPZIG SPRING FAIR, 1939 [Receivers, particularly Transportables: Non-Directional Crystal Microphones: "Crystal Low-Speaker" to replace Earphones in Hospitals, etc: AEG Six-Ray C-R Oscillograph: etc.].—Herrnkind. (*Funktech. Monatshefte*, March 1939, No. 3, pp. 90–93.)

2624. NOVELTIES IN RADIOELECTRIC CONSTRUCTION IN FRANCE [Paris Exhibition of Components, Valves, & Accessories].—Adam. (*Génie Civil*, 8th April 1939, Vol. 114, No. 14, pp. 301–305.)

Including a "dual sensitivity" tuning indicator (cathode-ray "clover-leaf" type, one pair of leaves closing for 6 volts, the other for 18); secondary-emission valves: standard artificial aerials; improved wave-change switches; automatic tuning and remote control; flexible coaxial cable; etc.

2625. ON A POSSIBLE EXTENSION OF THE BIBLIOGRAPHIC SERVICE OF *L'Onde Électrique* [Proposed Separate & Supplementary Service of Cards every 2 or 3 Months].—(*L'Onde Élec.*, March 1939, Vol. 18 [wrongly printed 20], pp. 97–98.)

Each card will carry one complete abstract and two decimal-classification numbers (one of the "universal" system and the other of a special technical classification): there will also be a space for a third number for any special system of the subscriber. Each abstract will have at least two cards, one white (for filing by "subject") and the other coloured (for filing by "author"). If the abstract requires filing under more than one subject, or if there are several authors, there will be a corresponding number of cards. It is considered that a systematic selection of all the "really interesting" articles in the principal technical journals of Germany, America, England, Italy, and Japan (and eventually of other countries in addition) will lead to an annual output of some 300–400 separate abstracts, involving perhaps 1000–1200 cards. It is estimated that the special subscription will be of the order of 200–300 francs: those interested should notify the Editor of their sympathy towards the scheme.

2626. A TELEFUNKEN WHALING TRANSMITTER [Very Small Automatic Transmitter, with 6 Mile D.F. Range, for tracing Killed and Floating Whales].—(*Telefunken Hausmitteilungen*, March 1939, Vol. 20, No. 80, p. 121.)

2627. [Anti-Aircraft] SHELLS THAT BURST WHEN THEY "SEE" TARGET.—Bofors Ordnance Factory. (*Sci. News Letter*, 25th Feb. 1939, Vol. 35 [not 36, as printed], No. 8, p. 126.)

2628. THE DISTANT CONTROL OF MODEL AEROPLANES [in America: a New Sport].—(*Funktech. Monatshefte*, March 1939, No. 3, p. 79.)

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

DIRECTIONAL WIRELESS

500 359.—Cathode-ray indicator for use when navigating an aeroplane along a course marked out by overlapping radio beams.

Marconi's W.T. Co. and C. S. Cockerell. Application date 7th August, 1937.

500 481.—Direction-finding system in which the received signals are applied in different phases, with a timing frequency, to a cathode-ray indicator.

Marconi's W.T. Co. and C. S. Cockerell. Application date 7th August, 1937.

500 524.—Balancing circuits for increasing the directional response of spaced aerials of the Adcock type.

C. Lorenz Akt. Convention date (Germany) 10th July, 1937.

500 526.—Geared arrangement of cams for automatically correcting "quadrantal error" in a direction-finder working over a range of wavelengths.

Telefunken Co. Convention date (Germany) 17th July, 1937.

500 592.—Direction-finder with cathode-ray indicator designed to be used under conditions of severe interference.

J. P. Jeffcock. Application date 20th August, 1937.

501 248.—Screening system for a direction-finder of the kind in which two or more rotatable frames are spaced apart about a common shaft.

Telefunken Co. Convention date (Germany) 15th June, 1937.

501 251.—Direction-finder for "homing" in which the received signals are applied, together with a timing frequency, to a cathode-ray tube indicator.

Telefunken Co. Convention date (Germany) 8th July, 1937.

501 550.—Automatic direction-finder in which the point of intersection of two indicating needles is used to determine the bearing-line.

Marconi's W.T. Co. and T. A. Vallette. Application date 4th September, 1937.

501 893.—Beacon station for transmitting "overlapping beam" signals for marking-out a navigational course.

Marconi's W.T. Co. (assignees of D. G. C. Luck). Convention date (U.S.A.) 18th August, 1937.

502 408.—Direction-finding system in which the signal pick-up on two "crossed" frame-aerials is periodically reversed or modulated by a condenser rotated at constant frequency.

Bronzavia, S. A. Convention date (Belgium) 19th August, 1936.

RECEIVING CIRCUITS AND APPARATUS

(See also under Television)

500 111.—Tuning control device for a wireless receiver in which the receipt of a worth-while signal automatically changes the normal driving-gear to one giving "fine tuning."

Electric and Musical Industries (assignees of E. N. Muller). Convention date (Luxembourg) 1st July, 1936.

500 818.—Phase-shifting network controlled through one of the I.F. valves in a superhet to give automatic selectivity.

British Thomson-Houston Co. Convention date (U.S.A.) 22nd October, 1936.

500 828.—Superhet receiver with a specially-designed I.F. amplifier which supplies A.V.C. voltage separately from the signal current fed to the second detector, and so does not overload the latter.

British Thomson-Houston Co. Convention date (U.S.A.) 17th December, 1936.

500 873.—Tuning arrangement in which the control knob automatically brings a new wave-band into operation, together with its appropriate scale, as the indicator needle reaches the limit of its movement on the first scale.

Pye; C. E. M. Butler; and E. V. Root. Application date 12th August, 1937.

501 238.—Series-condenser arrangement for automatically varying the tuning of a wireless set by the application of a direct voltage.

Philips' Lamp Co. Convention date (Switzerland) 1st May, 1937.

501 254.—Receiving circuit, particularly designed for detecting phase-modulated signals, but readily adapted to receive ordinary amplitude-modulated signals.

Marconi's W.T. Co. (assignees of M. G. Crosby) Convention date (U.S.A.) 22nd September, 1937.

501 346.—Tuning arrangement in which the end ways movement of the control shaft changes a direct drive for rapid tuning into an indirect drive for "fine" tuning.

Marconi's W.T. Co. and H. C. Norwood. Application date 25th August, 1937.

501 370.—Means for controlling and reversing the movement of the driving motor in an automatically-tuned wireless set of the push-button or selector type.

F. A. Mitchell. Application date 1st September 1937.

501 446.—Radio receiver with a low-pass filter for controlling the gain and cut-off frequency as well as the tone response.

Marconi's W.T. Co. Convention date (U.S.A.) 25th July, 1936.

501 529.—Superhet circuit in which a dynatron valve is used to generate local oscillations which can be varied for automatic-tuning control.

Standard Telephones and Cables; R. M. Barnard; and W. Kram. Application date 30th August, 1937.

501 934.—Automatic-tuning system combined with automatic "braking" of the tuning controls.

E. K. Cole and A. W. Martin. Application date 18th September, 1937.

502 178.—Multi-band receiver with switch-controlled inductances and a common variable condenser, including an auxiliary condenser which may act as a padding or as a coupling element.

B. J. Banfield. Application date 12th August, 1937.

502 421.—Wiring board for assembling the component parts of a wireless receiver.

K. Yoshida. Application date 16th September, 1937.

TELEVISION CIRCUITS AND APPARATUS

FOR TRANSMISSION AND RECEPTION

500 225.—Scanning system in which a rotating multiple-spiral disc is used in combination with an "interceptor" disc rotating at lower speed and placed in the adjacent image plane of the optical system.

Radio-Akt. D. S. Loewe. Convention date (Germany) 8th August, 1936.

500 254.—Optical projection system and diffusing surface for the viewing-screen of a television receiver.

C. O. Browne and H. E. Holman. Application date 31st July, 1937.

500 430.—Cathode-ray television transmitter in which the mosaic-screen electrode consists of a large number of wires set parallel, the ends being coated with a "molecular layer" of photo-sensitive material.

J. Kessler. Application date 4th August, 1937.

500 502.—Scanning-system for cathode-ray television with means for adjusting the ratio of width to length of the frame or raster.

Hazeltine Corpn. (assignees of M. Cawein). Convention date (U.S.A.) 24th December, 1936.

500 587.—Cathode-ray television transmitter in which a frame electrode is placed in front of a sensitive mosaic screen.

W. Heimann. Convention date (Germany) 13th August, 1936.

500 809.—Scanning system for television designed to allow a "close-up" view to be shown when desired.

The General Electric Co. and F. Poperwell. Application date 6th September, 1937.

500 842.—Television system with means to prevent undesired impulses during the "fly-back" scanning stroke and in which a signal for controlling background illumination is transmitted.

Hazeltine Corporation (assignees of H. M. Lewis). Convention date (U.S.A.) 27th May, 1937.

500 876.—Separating the line-synchronising impulses from the picture signals in television in a single-valve circuit which also develops "line" impulses of equal energy.

F. W. Cackett (communicated by the Telefunken Co.). Application date 13th August, 1937.

500 978.—Television system in which a "close-up" view can be shown by suitably varying the control voltages applied to the electrodes of the scanning tube.

Fernseh Akt. Convention date (Germany) 20th August, 1936.

500 991.—Resistance-capacitance coupling for a television amplifier, designed to prevent low-frequency distortion.

Radio-Akt. D. S. Loewe. Convention dates (Germany) 14th November and 12th December, 1936.

501 046.—Valve circuit for amplifying pulses with "steep" leading-edges, such as the saw-toothed waves used for scanning in television.

Telefunken Co. Convention date (Germany) 16th June, 1936.

501 058.—Electron-optical system for sharply focusing the electron stream in a cathode-ray television transmitter or receiver.

C. S. Bull. Application date 21st August, 1937.

501 179.—Cathode-ray tube with a double "gun" arrangement for scanning the opposite sides of a "target" electrode so as to allow of a time delay between the impact and collection of light signals to be televised.

Standard Telephones and Cables (assignees of R. R. Riesz and H. S. Wertz). Convention date (U.S.A.) 29th May, 1937.

501 211.—Means for applying A.V.C. control to a short-wave superhet receiver, particularly for television, without allowing the resulting changes in control-grid capacitance to detune the I.F. stage.

Marconi's W.T. Co. Convention date (U.S.A.) 29th August, 1936.

501 349.—Method of applying A.V.C. to a television receiver without eliminating useful variations in the average or background illumination of the picture.

Marconi's W.T. Co.; D. J. Fewings; and R. J. Kemp. Application date 25th August, 1937.

501 375.—Cathode-ray tube fitted with two "guns" for scanning the opposite sides of a photo-sensitive screen on which the picture to be televised is projected.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 6th November, 1936.

501 437.—Electron-optical system for focusing the stream from a cathode-ray tube with a convex cathode.

Marconi's W.T. Co. (communicated by Radio Corporation of America). Application date 24th May, 1937.

501 532.—Television receiver with a viewing mirror which, although adjustable, is normally maintained at a fixed inclination to the fluorescent screen.

Telefunken Co. Convention date (Germany) 29th August, 1936.

501 535.—Cathode-ray receiver in which a "flooding" beam of electrons is prevented from interacting with the normal scanning stream.

Baird Television and T. C. Nuttall. Application date 31st August, 1937.

501 624.—Method of producing a thin uniform layer of luminescent material for the screen of a cathode-ray tube.

The General Electric Co.; H. G. Jenkins; and A. H. McKeag. Application date 26th November, 1937.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

500 363.—Transmitting system of the kind in which the carrier-wave level is automatically adjusted to the intensity of modulation.

Marconi's W.T. Co. and W. A. E. Quilter. Application date 7th August, 1937.

500 755.—Ultra-high-frequency oscillator valve arranged to produce discharges shorter than the mean free path of the molecules of the contained gas.

Standard Telephones and Cables (assignees of C. A. Bieling). Convention date (U.S.A.) 20th November, 1936.

500 790.—Push-pull high-frequency amplifier in which neutralising-condensers are used and means are provided to offset the impedance of the leads which connect them to the valve electrodes.

Philips' Lamp Co. Convention date (Germany) 10th September, 1937.

500 883.—Dual-tone system of wireless telegraphy in which one carrier-wave of constant frequency is transmitted for " marking " and another wave of different frequency for " spacing."

W. G. H. Finch. Convention date (U.S.A.) 3rd September, 1936.

501 048.—Magnetron valve arranged to operate with a stable characteristic when handling very short waves.

Telefunken Co. Convention date (Germany) 14th July, 1936.

501 106.—Multiplex signalling system in which several modulators each with its own intermediate frequency feed a common transmitting aerial.

L. Pungs. Convention date (Germany) 11th May, 1937.

501 114.—Frequency-changing valve-circuit designed to deliver at high power harmonics of an applied fundamental frequency.

Standard Telephones and Cables (assignees of C. E. Fay). Convention date (U.S.A.) 5th August, 1937.

501 163.—Amplifying or modulating circuit in which a combination of positive and negative back-coupling is used in order to reduce harmonic distortion.

Akt. Tekade. Convention dates (Germany) 9th and 28th November, 1936.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

500 090.—Valve in which the electrons from the cathode are divided into two separate beams which travel along different curved paths to the output electrode.

Philips' Lamp Co. Convention date (Germany) 14th May, 1937.

500 170.—Construction and arrangement of the electrode system of a high-powered electron-multiplier tube.

Electrical Research Products Inc. Convention date (U.S.A.) 26th August, 1937.

500 189.—Supporting and insulating the target electrodes of an electron-multiplier tube.

F. J. G. van den Bosch. Application date 3rd July, 1937.

500 352.—Valve in which the electrons are formed into a number of substantially-separate streams in order to reduce " shot " effect.

C. S. Bull. Application date 7th May, 1937.

500 356.—Electron-multiplier in which a tubular electrode or " gun " is provided between the cathode and a target or secondary-emitting electrode.

F. J. G. van den Bosch. Application dates 7th August, 1937, *and 13th July,* 1938.

500 589.—High-powered valve fitted with a control grid designed to be substantially free from thermionic emission.

Marconi's W.T. Co. and A. J. Young. Application date 13th August, 1937.

501 316.—Electron-multiplier in which the main discharge-stream is first divided into divergent branches and then combined in a common output.

Farnsworth Television Inc. Convention date (U.S.A.) 30th April, 1937.

502 686.—Electron-multiplier in which an independent voltage is applied to control the effective amplification factor.

Baird Television and E. G. O. Anderson. Application date 22nd September, 1937.

502 901.—Method of ensuring a vacuum-tight joint between an electric discharge tube with a metallic bulb and an insulating cover.

C. Lorenz Akt. (assignees of H. Schedel). Convention date (Germany) 26th August, 1936.

502 968.—Construction of glow-discharge tube for use as a visual tuning indicator for wireless sets.

Marconi's W.T. Co. Convention date (U.S.A.) 26th September, 1936.

SUBSIDIARY APPARATUS AND MATERIALS

500 305.—Adjustment to prevent " back-lash " in a remote tuning-control for a motor-car set.

E. K. Cole and H. G. Jarvis. Application date 22nd September, 1937.

500 996.—Couplings and connections for Lecher-wires and like transmission lines for ultra-short waves.

O. Bormann of Julius Pintsch Ges. Convention date (Germany) 8th February, 1937.

501 152.—Method of damping-out " booming " vibrations in a loud speaker, without reducing the efficiency of the instrument on the higher frequencies.

The General Electric Co. and F. H. Brittain. Application date 20th September, 1937.

501 448.—Multi-vibrator circuit for generating oscillations which are substantially independent, as regards frequency, of casual fluctuations in the voltage supply.

Telefunken Co. Convention date (Germany) 27th July, 1936.

501 515.—Arrangement of the wiring and base contact-pins of a valve of the " Octal " type suitable both for battery and mains operation.

E. V. Robinson and Metropolitan Vickers Electrical Co. Application dates 31st May and 4th June, 1937.

502 899.—Circuit in which a discharge valve is automatically controlled by a magnetic field to prevent current variations.

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