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Editorial

The Scale of Loudness

IN the July number of *Hochfrequenztechnik*, Dr. K. W. Wagner discusses the difficulties encountered in giving numerical values to the subjective sensation of loudness, and he makes a proposal for a new scale of loudness. He distinguishes between the strength of a sound (Lautstärke) which is to some extent an objective quantity determined in a prescribed manner from the air pressure in a wave, and its loudness (Lautheit) regarded as a subjective sensation.

The strength of a sound is not determined entirely by objective means since the first step is to adjust the strength of a pure tone having the standard frequency of 1,000 until it appears to be equally loud, and it is on this 1,000 cycle sound that the objective measurement of pressure is made. The ear finds the same kind of difficulty in matching the loudness of two different sounds as does the eye in matching the brightness of two different colours, and as the eyes of different persons may differ in their sensitiveness to various colours, giving colour blindness in extreme cases, so the ears may vary in their sensitiveness to notes of different pitch, deafness to high notes being usually noticeable with advancing years. In all such measurements where the psychological element enters, one is forced to take the average of the results obtained from a number of presumably normal individuals.

Having adjusted the strength of the 1,000 cycle note to equality of loudness with the sound under investigation, its air pressure p is measured and compared with the air pressure p_0 at which a 1,000 cycle note just becomes audible. This latter is taken to be 0.0002 dyne/cm^2. The strength of the sound is then said to be $20 \log_{10} \frac{p}{p_0}$ phons. Although the increasing scale of phons gives a rough measure of the increasing sensation of loudness, there is no accurate scientific basis for this logarithmic law, even when applied to a pure 1,000 cycle note. Roughly speaking, an arithmetical increase in loudness is associated with a geometrical increase in the air pressure of the wave ; this leads to the adoption of the logarithm of the pressure ratio, and the coefficient 20 is chosen so that an increase of strength which is just discernible works out at about 1 phon. By taking p_0 as the denominator, the phon scale starts at zero at the threshold of hearing.

All this is well-established standard practice, but in the opinion of Dr. Wagner—who was until recently the Director of the Heinrich Hertz Institute for high-frequency research in Berlin—it is very bewildering for the layman and operates adversely against those engaged in the design and sale of noiseless instruments and plant.

As an example he quotes the result of much research and expert construction in reducing the noise of typewriters. The noise waves emitted by the new machines have only 18 per cent. of the pressure of those emitted by the old machines, which is really a fine achievement, but it loses nearly

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all its force when a prospective purchaser is told that the noise has been reduced from 70 phons to 55 phons. It is for this reason that Dr. Wagner proposes that the phon should be reserved for acoustic experts and a new measure of loudness introduced for everyday life.

Reference is made to a number of experiments described by Wolff in halving a given loudness and in finding the loudness estimated to be midway between two different loudnesses. The results show the impossibility of assigning accurate values to such sensations. Using ten observers he found that for two similar tones of 85 and 20 phons the estimated midway loudness was 54 phons. This was the average, the individual variations from this being very considerable, having a mean value of 8.1 phons.

When asked to adjust a tone to have half the loudness of one of 85 phons, however, experiments have shown that the average observer adjusts it to 63 phons or more, that is to say, that he places a half of 85 considerably above the mean of 85 and 20. A further disturbing factor is the order in which the two sounds are heard ; if the louder tone precedes the softer the estimated mean tone differs considerably from that obtained if the louder tone follows the softer one. In the case of the 85 and 20 phon tones, this difference amounts to as much as 11 phons. This is understandable if the louder tone fatigues the ear.

It is because of these difficulties in the correlation of the degree of intensity of subjective sensation and a scale of objective measurement and because of the failure of the phon scale to do justice to the achievements of the designers of silent typewriters that Dr. Wagner proposes a new measure of loudness based on the following considerations.

If one had a number of similar sources of sound so set up and synchronised that the pressure waves arriving at the observer were directly additive, then one could call the loudness due to one source alone unit loudness, that due to two sources two units of loudness, and so on ; in other words, the loudness could be taken as directly proportional to the pressure, the magnitude of the unit of loudness being a mere matter of convenience. This is Dr. Wagner's suggested scheme : 1, 2, 3 and 4 units of loudness would correspond to pressures of p, 2p, 3p and 4p and therefore to L, L + 6, L + 9.5 and L + 12 phons where L is the strength in phons of the unit of loudness. Dr. Wagner suggests that L be taken as 40 phons as this gives convenient numbers ; this is equivalent to taking the loudness as equal to $0.01p/p_0$. This would give the following relation between the strength of the sound in phons and the loudness in the proposed units.

Phons	10	20	30	40	50	60	70	80	90	100
Units of Loudness	0.03	0.1	0.32	1	3.16	10	31.6	100	316	1000

In the experiments discussed by Wolff, observers who were given the task of adjusting a sound to be midway between one of 80 and one of 20 phons, arrived at a result not far removed from 50 phons, which the layman would regard as very reasonable. What would he say when told that he had estimated 3.16 units of loudness to be midway between 0.1 and 100 units ? Dr. Wagner maintains that the association of a certain scale with certain subjective sensations is largely a matter of training and usage and that a luggage porter's estimate of weight is based not directly upon his muscular sensations but upon his association of these sensations with the readings on the weighing machine. He emphasises the vagueness of estimates of loudness and refers to Wolff's statement that when one says that one sound is half as loud as another, one is using the term in much the same way as when one says that one mathematical problem is not half as difficult as another.

Although, in view of the eminence of Dr. Wagner, we have discussed his proposals, we must confess that we doubt very much whether they will meet with general acceptance. Whatever shortcomings the logarithmic phon scale may possess, we feel sure that as a measure of loudness it is preferable to the proposed proportional scale. What is the use of telling a prospective purchaser that the noise of a typewriter has been reduced to less than a fifth if it only sounds like a reduction of 20 per cent. ? G. W. O. H.

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The Measurement of Secondary Emission in Valves*

By L. R. G. Treloar, B.Sc., F.Inst.P.

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

SUMMARY.—The various methods by which the measurement of the primary and secondary currents in positive-grid valves has been attempted are critically examined, and an original method is described by which accurate measurements of secondary-emission coefficients in valves are obtainable. A study, by this method, of the secondary emission of variously prepared caesium-oxide surfaces, is described.

Scope of the Paper

A DOUBLE interest attaches to the study of secondary emission in valves. First, a knowledge of the primary-current characteristics in valves employing two or more positively charged electrodes may be required, and this can only be obtained by the elimination of the secondary currents which are always present under such conditions. Secondly, researches of this kind are capable of yielding information concerning secondary-emission phenomena which, besides being of immediate interest in the design and operation of valves, may also have a much more general scientific value.

From this second aspect, it may perhaps be admitted that up to the present, with one or two exceptions, the secondary-emission data derived from valve studies have not been of such quality as to inspire confidence in their general validity.

In this article, the various methods by which the measurement of the primary and secondary currents in positive-grid valves has been attempted are critically discussed, and an original method is described by which accurate measurements of secondary-emission coefficients are obtainable. A study, by this method, of the secondary emission of variously prepared caesium-oxide surfaces, is described.

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Some Fundamental Conceptions

The division of the total cathode current between the grid and anode of a positive-grid triode may be regarded as being determined by the form of the electron paths. In the absence of space charge, and neglecting disturbing influences such as the initial velocities of emission of the electrons, the electron paths will be determined solely by the electrostatic field pattern, which will itself depend only on the ratio of the anode and grid voltages. It follows that the division of the primary current between these two electrodes will satisfy the equation

$$ {}_{p}i_a / i_c = f(V_a / V_g) \quad \ldots \quad (1) $$

where ${}_{p}i_a$ is the primary anode current and i_c the cathode (i.e. anode + grid) current.

By the same argument, the current division in a tetrode having a positive voltage V_{g2} on the screen grid and a negative voltage V_{g1} on the control grid may also be represented by equation (1), provided that the ratio V_{g2}/V_{g1} is kept constant.

There is no theoretical method available for determining with sufficient accuracy the function f for a given electrode system. Recourse must therefore be had to experiment, and there are several investigations on record which have had as their objective such a determination. The problem has been tackled by a variety of methods, the more important of which (including the author's, now published for the first time), are listed below.

1. The positive ion method.
2. The low-voltage method.
3. The magnetic field method.
4. The electrode-temperature method.
5. De la Sablonière's method.
6. The suppressor-grid method.

These will be considered in turn.

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1. The Positive Ion Method

A tungsten filament, when raised to a sufficiently high temperature, possesses the property of ionising caesium vapour by mere contact. Hence if caesium vapour is introduced into a triode having a tungsten filament, the filament, when heated, becomes in effect a source of positive ions. If negative potentials are applied to the anode and grid, a positive ion current will flow to these electrodes. It can readily be shown that for a given field pattern the ion paths will be identical with the electron paths in a field of opposite sign, hence the division of the cathode current between the two electrodes, which is determined by the paths of the particles, will likewise be the same in the two cases. In other words, the form of equation (1) will be the same both for positive ions and for electrons.

It was upon this principle that the work of Hyatt[1] was based. He found that below about 100 volts no secondary electrons were produced by the bombardment of the metal surfaces by *Cs* ions, hence in this region it is possible to study the primary-current division directly. He found for the ion current the relation

$$ {}_p i_a / i_c = \text{constant} $$

to hold for values of V_a/V_g ranging from 0.2 to 0.95, and, further, the constant value obtained was found to be in close agreement with that to be expected if the ions all travelled in straight lines from the filament to the anode (or grid) (i.e. the "projected area" ratio for the grid).

Now it can be argued theoretically and it has been shown experimentally by various methods that the current division cannot be independent of V_a/V_g, hence it is a little difficult to understand why Hyatt obtained this result. Nevertheless, provided that the ratio V_a/V_g does not differ too greatly from unity, the assumption of a constant current division determined by the electrode geometry undoubtedly provides a fair approximation to the truth, and has been used by a number of other workers.

It may be mentioned that Hyatt and Smith[2] applied the method with conspicuous success in a study of the secondary emission of molybdenum.

The assumption of rectilinear paths, when applied with due appreciation of the conditions, is also a very valuable means of arriving at the approximate current division in multi-electrode valves where no other method is applicable.

Actually, the electron paths will be rectilinear, not when $V_a = V_g$, but when there is no charge on the grid. In the case of a cylindrical electrode system this will occur when

$$ V_g/V_a = (\log g/c)/(\log a/c) $$

c, g, and a being the radii of cathode, grid and anode respectively.

2. The Low-Voltage Method

For most clean metals the secondary-emission coefficient is comparatively small for primary energies less than about 10 volts, so that by working with very low electrode voltages (and space currents) it should be possible to render the effects of secondary emission comparatively unimportant. This method of arriving at the form of the current-division law (equation (1)) has been studied in great detail by Lange[3], among others, who showed what precautions must be taken if the law thus obtained is to be valid at higher voltages. The difficulties that arise are due to the following causes :—

1. The voltage drop along the filament.

2. The initial velocities of the primary electrons.

3. Contact potential differences between the electrodes.

The first of these effects may be eliminated either by (1) the use of an interrupted current to heat the filament, the electrode currents being measured only when the heating current is off, or (2) working at such low filament temperatures that the voltage drop along the portion of the filament which is effectively emitting is negligibly small.

The second effect is more difficult to correct for. Lange showed that, assuming a current characteristic for a triode corresponding to zero velocity of emission, it was possible to calculate, for a cylindrical system, the actual characteristic corresponding to any filament temperature. It should be possible in this way to find, by a process of trial and error, the zero-velocity characteristic corresponding to a given experimentally determined characteristic.

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A method of arriving at the contact potential differences between the electrodes in a triode has also been worked out by Lange. The method is not applicable to tetrodes.

Even when all the above corrections have been applied the low-voltage method of calibration is open to criticism on account of the inexactitude of the fundamental assumption that the secondary emission is negligible at low voltages. From Haworth's data[4], for example, it may be inferred that the secondary-emission coefficient for molybdenum rises from about 0.1 at 4 volts to 0.2 at 10 volts, whilst Farnsworth[5] obtained coefficients in the neighbourhood of 0.2 for both nickel and copper at primary voltages as low as 2. The conclusion must therefore be drawn that measurements of secondary emission by the low-voltage method are liable to a considerable error from this cause.

3. The Magnetic Field Method

In another method of determining the primary current characteristics in a triode, also investigated by Lange, the secondary current is suppressed by the application of a magnetic field parallel to the axis of the electrodes. If the field strength is suitably chosen, it is possible to cause all the secondary electrons to return to the electrodes from which they are emitted, the comparatively fast primary electrons being unaffected.

Complete suppression of the secondaries can be secured only when the ratio V_a/V_g is in the neighbourhood of 1. Hence, though useful as a check, the method does not in itself yield very much information on the determination of the primary current characteristics. It cannot be applied to tetrodes, owing to the low velocity of the primary electrons in the neighbourhood of the control grid.

4. The Electrode-Temperature Method

In this method use is made of the fact that the energy of emission of secondary electrons is generally small compared with the energy of the primary electrons. If the temperature of an electrode (normally the anode) is measured, it is possible to calculate the energy dissipated in that electrode by the primary current and hence the magnitude of the primary current.

Let us assume that the temperature of the anode of a triode is being measured (e.g. by means of a thermocouple). Curves may be obtained giving the variation of anode temperature with anode wattage (with $V_g = 0$) and the variation of anode temperature with grid wattage (with $V_a = 0$), there being in either case no secondary current to be considered. From these curves it is possible to say that 1 watt dissipated in the grid produces the same change in anode temperature as k watts dissipated in the anode, where k has a numerical value less than 1. The valve is now run with positive voltages on both electrodes and the temperature rise is recorded. Let W be the wattage which would have to be dissipated in the anode, with $V_g = 0$, to produce this same temperature rise. Taking the case where $V_g > V_a$, so that the secondary current (i_s) flows from anode to grid, we have

$$\text{Wattage in grid} = V_g \cdot {}_pi_g + (V_g - V_a)i_s = W_g$$

and $\quad \text{Wattage in anode} = V_a \cdot {}_pi_a$

the subscripts p denoting primary currents. The energy dissipated in the grid will produce the same effect on the anode temperature as kW_g watts in the anode, therefore

$$W = V_a \cdot {}_pi_a + [V_g \cdot {}_pi_g + (V_g - V_a)\, i_s]k$$

This may be written

$$W = V_a \cdot {}_pi_a + [V_g(i_c - {}_pi_a) + (V_g - V_a)({}_pi_a - i_a)]k$$

where i_a is the measured anode current. This equation may be solved for ${}_pi_a$, the only unknown quantity. An equation may similarly be derived for the case in which $V_g < V_a$.

Certain corrections may have to be applied in practice if accurate results are to be obtained. These are due to the following causes :—

1. The cooling of the cathode produced by drawing space current from it.

2. The energy gained by the primary electrons in passing through the electrode surfaces (measured by their work functions).

3. The energy of emission of the secondary electrons.

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In a careful study of the characteristics of triodes by this method, Myers[6] corrected for effects (1) and (2) above, but did not consider (3). Now the average energy of emission of secondary electrons is generally about 10 volts (4, 5), which is a considerable fraction of the primary energies with which Myers' experiments were concerned. It is clear that the electrode voltages employed must be greater than 200 if the errors introduced by the neglect of this factor are not to exceed 5 per cent.

At comparatively high electrode voltages the above corrections may be dispensed with, and the electrode temperature method should then be capable of producing results of a high degree of absolute accuracy. The fact that the method has not received very much attention must presumably be attributed to the difficulty in carrying out the experiments with the requisite degree of accuracy. Unfortunately, errors in the determination of the temperature produce disproportionately large errors in the estimation of the primary current.

The method does, however, possess the advantages that it is equally applicable whether or not space charge is present, and that it may be applied to tetrodes as well as to triodes.

5. De la Sablonière's Method

De la Sablonière's method, published in 1933[7], stands in a class by itself and is in some respects the most interesting method

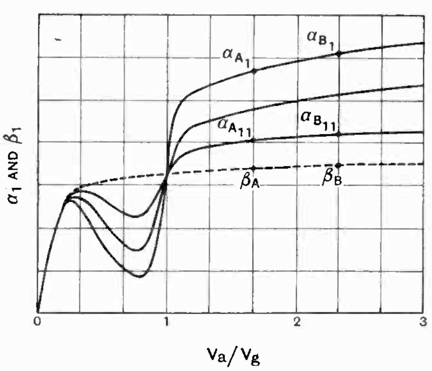

Fig. 1.

which has yet been proposed for solving the present problem. The method is described with reference to the tetrode, but it is applicable also to the triode, and will now be considered in this connection.

The characteristics of the valve are taken at a number of different grid voltages, and with space currents sufficiently small to eliminate any space-charge effects. These characteristics are plotted in the form shown in Fig. 1, which gives the relation between $\alpha_1 = i_a/i_c$ and V_a/V_g, for different values of the parameter V_g. The corresponding curve for the primary anode current is expressed in the form $\beta_1 = {}_pi_a/i_c$, and is independent of the value of V_g. For the purpose of analysis the α_1-curves may be divided into two regions: the A region, to the right of $V_a/V_g = 1$, in which the secondary current is wholly from grid to anode, and the B region, to the left, in which it flows in the opposite direction. In the A region the ratio γ_1 of the secondary current leaving the grid to the primary current arriving will be given by

$$\gamma_1 = {}_si_g/{}_pi_g = (\alpha_1 - \beta_1)/(1 - \beta_1) \quad .. \quad (2)$$

If ϵ_1 is the secondary-emission coefficient for the grid (i.e. the value which γ_1 would have if all the secondaries emitted from the grid reached the anode) we may write

$$\gamma_1 = \delta_1\epsilon_1 \quad .. \quad .. \quad .. \quad (3)$$

where δ_1 may be regarded as the "saturation coefficient" of the secondary emission, and ϵ_1 is constant along a given α_1-curve.

It will be remembered that in deriving equation (1), which states that the division of the primary current between grid and anode depends solely on the ratio V_a/V_g, the assumption was made that the primary-electron paths were determined by the electrostatic field pattern. The further assumption introduced by de la Sablonière is that the paths of the secondary electrons are also determined by the field pattern, in which case the fraction of the secondary electrons emitted by the grid which arrive at the anode will similarly depend only on the ratio of the electrode voltages, i.e.

$$\delta_1 = F_1(V_a/V_g) \quad .. \quad .. \quad .. \quad (4)$$

Thus for a given value of abscissa the value of δ_1 is the same for all the α_1-curves.

Turning now to the B region, the method requires that the curves for α_2 be plotted against V_g/V_a as abscissa, where $\alpha_2 = i_g/i_c$,

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the primary grid current characteristic being given by $\beta_2 = {}_p i_g / i_c$. If the assumption which has just been applied to the grid secondaries is now applied to the anode secondaries we may write, for this region,

$$\gamma_2 = \delta_2 \epsilon_2 \quad \ldots \quad (5)$$

where $\delta_2 = F_2(V_g/V_a)$ .. .. (6)

Let A_1 B_1 and A_{11} B_{11} (Fig. 1) be corresponding pairs of points on two α_1-curves, and let β_A and β_B be the corresponding points on the β_1-curve. Then from equations (2), (3) and (4) the following relation is readily obtained

$$\frac{\alpha_{A_1} - \beta_A}{\alpha_{A_{11}} - \beta_A} = \frac{\alpha_{B_1} - \beta_B}{\alpha_{B_{11}} - \beta_B} \quad \ldots \quad (7)$$

Hence if one point (say β_A) on the β_1-curve is known, it is possible from equation (7)

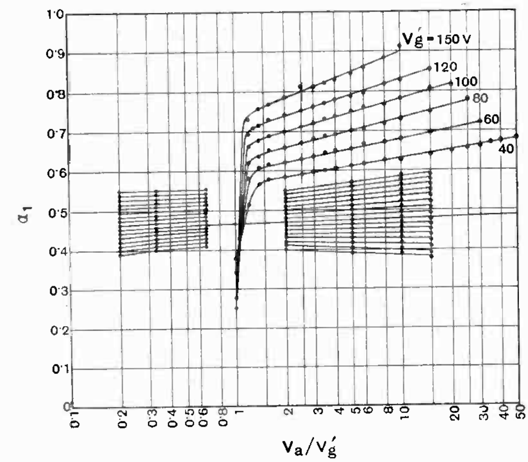

Fig. 2.

to determine the whole of the curve. Unfortunately, no point on the β_1-curve is known, and to get over this difficulty de la Sablonière chooses a number of arbitrary starting points and thus obtains a family of "possible" β_1-curves. (See Fig. 2, which is reproduced from the original paper.) The process is now repeated for the α_2-curves, in the B region, by the application of an equation analogous to (7) and a number of "possible" β_2-curves are obtained, which, when transposed to the α_1-diagram appear on the left of abscissa 1 (Fig. 2). It is seen that the family of β_1-curves to the left of abscissa 1 converges as V_a/V_g increases, whilst that to the right diverges. The true β_1-curve is found by selecting the two curves, one from each of these families, which, when produced, coincide.

In his very careful study of the characteristics of a number of tetrodes and triodes by this method, de la Sablonière obtained consistent results, provided that the voltages on the electrodes were not too high and the values of V_g/V_a did not differ from 1 by too large a factor, which proved that within certain limits his fundamental assumptions were justified. Outside these limits the discrepancies which appeared were attributed to the variation of the secondary emission coefficient with the angle of incidence of the primaries, an effect which, according to more recent work, becomes of increasing importance as the primary voltage is increased.

It was found, further, that constant values of γ were not attained, indicating that complete saturation of the secondaries (corresponding to $\delta = 1$) was not achieved, even with the highest permissible values of V_a/V_g or V_g/V_a.

De la Sablonière's method is certainly more reliable than the low-voltage method for the determination of the primary currents, and it possesses the advantage over the remaining methods described in this article that it does not require the construction of special valves in the laboratory. It seems likely, however, that it would be applicable only to valves of the transmitting type, owing to the high electrode voltages required, for at lower voltages the initial velocities of the secondary electrons would invalidate the underlying assumption.

Another difficulty with this method is that it cannot be used for the accurate study of secondary-emission coefficients, for which purpose it is essential that the secondary-emission from one of the electrodes should be easily saturated. But when this occurs the corresponding "possible" β-curves, instead of diverging (or converging) become approximately parallel, and the accuracy with which the correct pair of curves can be selected becomes very considerably reduced. In the extreme case, when the secondary emission from both electrodes is easily saturated, the method breaks down completely; each set of curves then becoming a series of parallel lines.

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6. The Suppressor-Grid Method

In this method, which is of fairly general applicability, the secondary currents are eliminated by the interposition of an auxiliary grid at cathode potential between the two positive electrodes. The characteristics obtained from such a valve are used as a basis for the determination of the primary-current characteristics in a similar valve, without the suppressor-grid, in which the secondary-emission measurements are actually made. The method will be illustrated by reference to a particular tetrode used by the author for the measurement of secondary-emission coefficients.

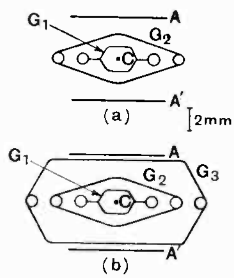

Fig. 3.—*Cross-sections of electrode systems.*

The tetrode employed is shown in cross-section in Fig. 3 (a), and the equivalent pentode in Fig. 3 (b). C was a tungsten filament, 0.05 mm. in diameter, G_1 the control grid, G_2 the screen grid, constructed of nickel mesh, G_3 the suppressor grid, and $A\ A'$ the anode. The length of the electrode system was 30 mm. To avoid spurious charges, which are liable to occur if mica separators are used in the assembly, the electrodes were supported from a glass bead at the end remote from the pinch.

The pentode characteristics were determined with different screen voltages, using a total current of 100 μA, the space current being controlled by means of a negative voltage on G_1, and not by the filament temperature. When i_a/i_c was plotted against V_a/V_{g2} (the latter on a logarithmic scale),

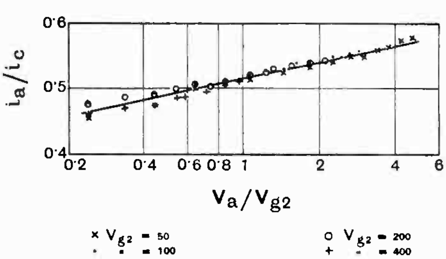

Fig. 4.—*Pentode characteristic.*

the curve shown in Fig. 4 was obtained. As was to be expected from equation (1) the points corresponding to different values of V_{g2} all fell on the same line, within the limits of experimental error. This proves that the effects of space charge and secondary emission had been eliminated.

The anode of the tetrode was in the position occupied by the suppressor-grid in the pentode. The potential distribution in the neighbourhood of the screen grid (and hence also i_a/i_c) will therefore be the same for the tetrode as for the pentode if the potential V'_a of the tetrode anode is equal to the effective potential in the plane of the suppressor-grid. The latter is given by the formula[8]

$$V_{\text{eff}} = \frac{V_{g3} + DV_a + RV_{g2}}{1 + D + R}$$

where D is the penetration factor (Durchgriff) of the anode, and R that of the screen

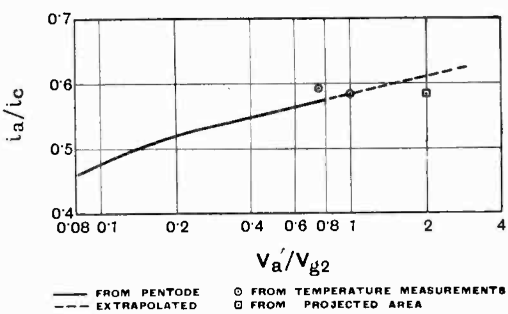

Fig. 5.—*Tetrode characteristic.*

grid, through the suppressor-grid. For the case of plane-parallel electrodes $R/D = d_a/d_s$, d_a and d_s being the respective distances of anode and screen grid from the suppressor-grid. Hence the transformation of the pentode into the tetrode characteristic is effected by the relation

$$\frac{V'_a}{V_{g2}} = \frac{V_a/V_{g2} + d_a/d_s}{1 + 1/D + d_a/d_s}$$

in which V'_a refers to the tetrode. In this equation all the quantities on the right-hand side are measurable. $1/D$ is numerically equal to the increase in V_a required to maintain i_a constant when V_{g3} is reduced by 1 volt. The measured value of D was .19, and d_a/d_s was $0.5/1.7 = 3.0$. The tetrode characteristic resulting from this transformation is shown in Fig. 5.

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Another valve, differing from the first only in having a more open-pitched suppressor-grid ($D = .30$) yielded a tetrode characteristic in agreement with the former to within 2 per cent., though on account of the less effective suppression of the secondaries the range of abscissae over which the effects of secondary emission were absent was more restricted.

It was thought desirable to obtain a check on the accuracy of the primary-current characteristic for the tetrode by an independent method. The results of measurements made by the electrode-temperature method, using an identical tetrode having a thermocouple attached to its anode, are shown in Fig. 5. As a further check the point on the characteristic corresponding to zero charge on the grid was determined, the ordinate being obtained from the known "projected area" ratio for the screen grid, and the abscissa estimated from the geometry of the electrode system.

The primary-current characteristic for this particular tetrode being thus determined, measurements of secondary-emission coefficients for different anode materials could be made by using valves of identical construction. The i_a/i_c characteristic will not be greatly affected by the variations in electrode dimensions and spacing from valve to valve which are likely to occur, and the "projected area" ratio for the screen grid, which is the most critical geometrical factor, can be quite accurately maintained.

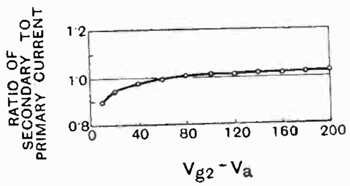

Fig. 6.—*Saturation curve for secondary emission.*

It has already been mentioned that if the secondary emission measurements are to have a precise physical significance, it is essential that the secondary current from the electrode under test should be saturated. In the tetrode studied the saturation of the secondary current from the anode was facilitated by (1) the use of a small clearance between screen grid and anode, (2) the construction of the anode in the form of two plates (with the object of preventing secondaries emitted from one part of the anode being collected by another part) and (3) the use of a screen grid with a comparatively large ratio of wire to "hole.")

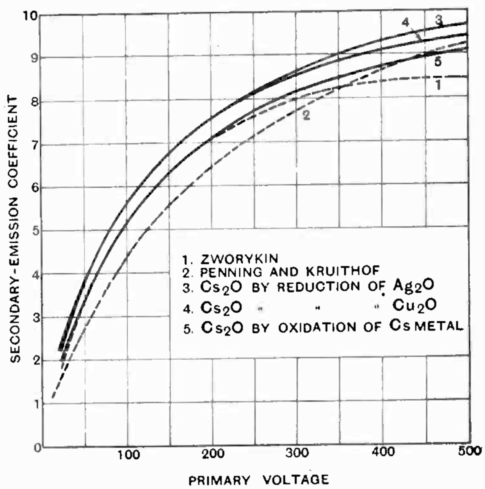

Fig. 7.—*S.E. coefficients for caesium oxide.*

The effectiveness of the saturation is shown by Fig. 6, which gives the apparent secondary-emission coefficient for a particular anode for different values of $V_{g2}-V_a$. The primary potential in this case was 85 volts.

Caesium-Oxide as a Secondary Emitter

The author has made a particular study, by the method just described of caesium-oxide secondary-emitting surfaces. This material has usually been prepared by first oxidising metallic silver (by means of a discharge) and then baking the metal oxide in caesium vapour at a temperature in the neighbourhood of 200 deg. C. The resultant Cs_2O is intimately mixed with finely dispersed metallic silver, which occurs as a reaction product, and when suitably activated is covered with a film of metallic Cs of approximately monatomic thickness. Curve 1, Fig. 7, shows the secondary-emission coefficient for this material as given by Zworykin, Morton and Malter[9], and curve 2 that given by Penning and Kruithof[10]. Curve 3 is the result of the author's measurement in a tetrode, for caesium-oxide on a

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silver base, prepared in the usual manner. Curve 4 was obtained when copper was substituted for silver as the base metal, the oxidation in this case being effected by simply baking in oxygen. The material to which curve 5 relates was prepared in an entirely different manner. Metallic Cs was first deposited on a silver plate, oxidised to Cs_2O, and activated by baking in Cs vapour. The oxide film, which was orange in colour, appeared to be of about the same thickness as that obtained in the more usual way.

All these results were taken in sealed-off valves gettered with barium, which had been aged for several hours with a space-current of about 1 mA. This ageing usually resulted in an increase in the secondary-emission coefficients by from 10 to 20 per cent.

Evidently it is not a matter of importance what metal is left dispersed through the Cs_2O coating, or even whether there is any metal present as such at all, provided that the coating can be properly activated. This is a particularly interesting result because it has been suggested by Timofeew and Pyatnitzki[11] that it is the silver particles embedded in the oxide that are responsible for the initiation of the secondary-emission process in the normal caesium-oxide film.

Acknowledgment

The author desires to tender his acknowledgment to the Marconiphone Company and the General Electric Company on whose behalf the work was done which has led to this publication.

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The Industry

LEAFLETS issued by The Mullard Wireless Service Company Ltd., 225, Tottenham Court Road, London, W.1, describe three recently introduced Mullard measuring instruments. These are: Modulated Oscillator, Type GM2881; Cathode-Ray Oscillograph, Type GM3152; Calibrated A.F. Oscillator, Type GM2304.

Marconi-Ekco Instruments, Ltd., of Electra House, Victoria Embankment, London, W.C.2, has issued a new comprehensive catalogue of laboratory and test equipment.

Four chapters on valve functions, as well as full data on American valves, are contained in the R.C.A. Receiving Tube Manual, copies of which are obtainable in this country from Holiday and Hemmerdinger, 74, Hardman Street, Deansgate, Manchester, 3, at 1s. 8d., post free.

"Silentbloc" rubber mountings are now being used for protecting radio apparatus from the effects of vibration in aircraft, etc. Details of such applications are given in a booklet issued by Silentbloc, Ltd., Victoria Gardens, Ladbroke Road, London, W.11.

The Osram Valve Guide for 1938/9, a handy pocket-size booklet giving data on all Osram valves, is now available. Copies are obtainable free from the General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2.

I.E.E. Lecture Improvements

MEMBERS of the Institution of Electrical Engineers will be pleased to know that a microphone is to be installed at the lecture table with loud speakers around the Theatre. The Common Room is also to be wired with loud speakers so that on occasions when the Theatre is full, a still greater number will be able to listen to the lecture in comfort.

Those taking part in debates will, it is understood, be invited to come up to the microphone to deliver their remarks.

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The Wireless Exhibition, 1938

A Technical Survey

AS might be expected, television formed one of the main items of technical interest at the British National Radio Exhibition at Olympia. Especial efforts have been made by designers to reduce the cost of television apparatus and the most general method has been to reduce the size of the cathode-ray tube. There are some notable exceptions, but in general the buyer who pays less gets a smaller picture.

The use of a small tube reduces cost not merely because the tube itself is cheaper but also because its smaller size permits the use of a smaller cabinet, and because less deflecting power is needed. This last naturally presupposes that the small tube is designed to have a smaller deflecting angle than the large one. Furthermore, with the smaller picture area equivalent brilliancy can be obtained at a lower tube voltage, again saving cost directly and also indirectly through reducing the deflecting power.

The interior of the Murphy T56 television receiver showing the chassis tilted back for inspection.

The tube voltage, however, cannot normally be reduced as much as one might expect from a comparison of the picture areas because the size of the spot increases as the voltage is lowered. Obviously, a small spot is more important with a small picture than with a large, so that on this score the tube voltage should be increased as the picture is made smaller.

Everything depends on the design of the tube, however, and in general, a satisfactory spot size is secured with small tubes operating at voltages which are certainly not greater than those adopted for larger tubes, and which are usually lower.

The methods of focusing and deflecting the cathode-ray beam have not yet been generally settled and examples of every kind are to be found. Electromagnetic methods are widely adopted, but so are electrostatic, and it is difficult to say which is the commoner; a few firms, however, use a mixture. H.M.V. and Marconiphone, for instance, adopt electromagnetic deflection but electrostatic focusing in their 9in. and 12in. tube models, but use an all-electromagnetic system in their smaller sets. G.E.C. and R.G.D. adopt all-electrostatic tubes, and Cossor have both types. The Model 54, for instance, has a 6in. electrostatic tube which is so designed that the line deflecting voltages do not need to be fed to the tube in push-pull form.

Another set produced by this firm has magnetic focusing but is very unusual in that a permanent magnet is used. The magnet surrounds the tube neck at the appropriate point and its effective field is roughly adjusted by a metal tube which slides along the neck of the tube around the electrode assembly. The final focus adjustment is obtained electrically by the adjustment of the gun voltage.

One development in tubes which is not unimportant is a considerable reduction in the length of many specimens. It has been brought about largely by the desire to mount

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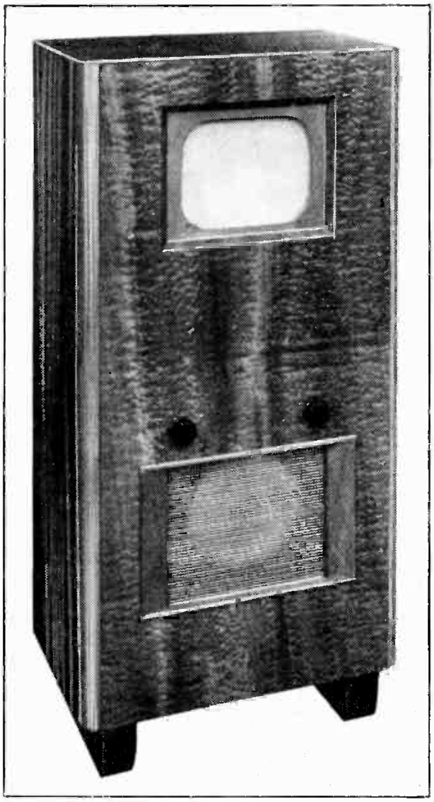
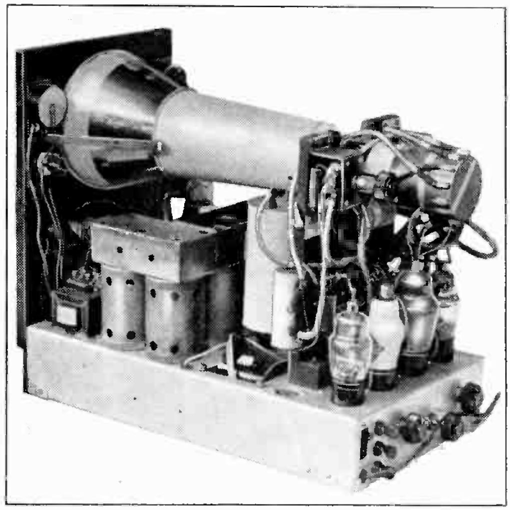
the tube horizontally for direct viewing and at the same time to preserve small cabinet dimensions. These tubes naturally have a very large deflection angle and consequently demand large deflecting power. They are invariably designed for electromagnetic deflection and it is probably impossible to secure full deflection without distortion of the spot by electrostatic means.



The Baird Model T20 has only two controls—sound volume and picture brilliance.

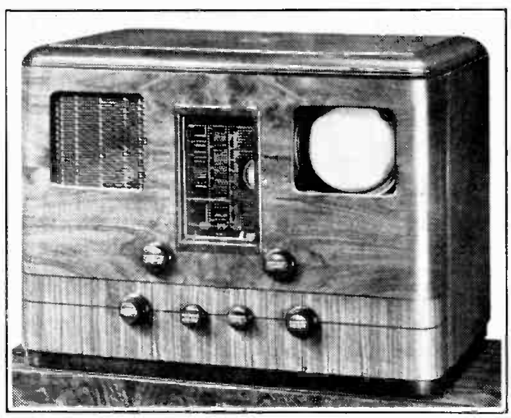
A good example of the use of this type of tube is the Murphy A56V receiver. As shown in one of the photographs the tube is mounted on the main chassis, which carries the receiver and time-base equipment, and the chassis is mounted nearly vertically so that the tube is nearly horizontal. In this position the whole of the under side of the chassis is readily accessible. The chassis is, however, hinged so that it can be tilted down to the horizontal, to make the upper side accessible.



The chassis of the Cossor Model 54 which has an electrostatic tube.

The receiver itself is a superheterodyne having one R.F. stage and a triode-hexode frequency-changer. There are three I.F. stages and a diode detector directly coupled to an R.F. pentode which acts as a vision-frequency amplifier and is in its turn directly coupled to the C.R. tube. The D.C. component of the signal is thus preserved. A duo-diode is used to separate the synchronising signals.

The saw-tooth oscillators are gas-triodes and the output valves tetrodes. These valves are coupled to the deflecting coils by transformers. Equipment is included for



The H.M.V. Model 904 with 5in. electromagnetic tube and all-wave broadcast receiver.

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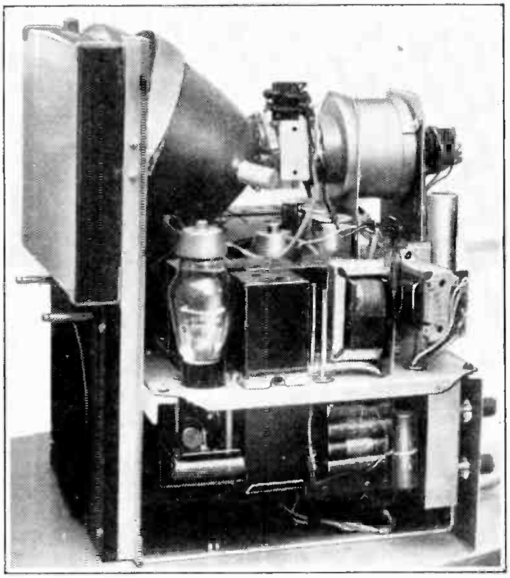
reception of the sound accompaniment to television, and the whole apparatus is priced at £30 with a 9in. tube.

H.M.V. and Marconiphone have sets at 29 gns. with a 5in. tube, but the sound equipment includes an " all-wave " receiver. For vision there is one R.F. stage and the triode-hexode frequency-changer is followed by three I.F. stages and an anode bend detector. The tube, which has electromagnetic deflection and focusing, is directly coupled to the detector, from the anode circuit of which the sync separator is fed. This comprises a diode, and an R.F. pentode which feeds the sync pulses through separate channels to the line and frame time-bases.

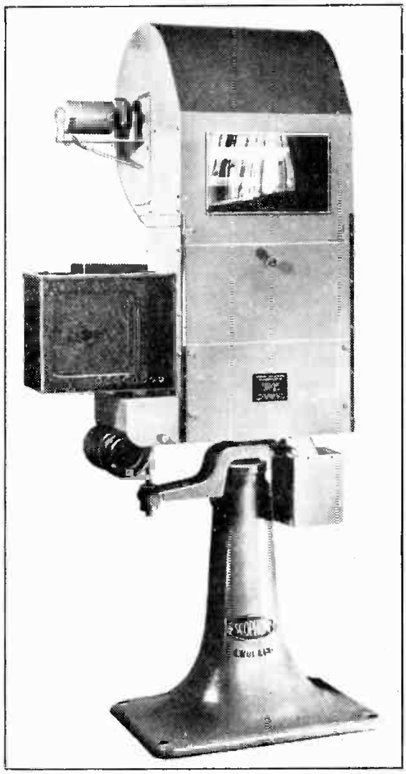
Squegging oscillators are used to generate the saw-tooth voltages and the tetrode output valves feed the deflecting coils



The Pye Model 815 has a " short " tube with electromagnetic focusing and deflection.

through a transformer in the case of the line circuit, and through an R.C. coupling in the case of the frame. The first four valves of the receiver are common to both sound and vision and the former signal is picked out after the second I.F. valve and applied to a diode detector. For broadcast use, the first three valves are switched over to function in a standard type of superheterodyne.

The superheterodyne is now almost universal, but the straight set is retained by H.M.V. and Marconiphone in their large tube models which are unchanged from last year.



Scophony Junior Projector giving pictures 5ft. by 6ft.

Pye and Invicta also use a straight set and feed the C.R. tube directly from the detector.

In addition to what may be termed the standard size models and the new small tube types, this year sees an increase in large screen projection models. Baird, H.M.V., Philips and Pye all have apparatus of this type. A cathode-ray tube of some 4–5in. diameter is used and operated at 20,000–25,000 volts. A very small but exceedingly bright picture is secured which is projected on to a screen by a lens with an aperture of the order of f/2. The screen size varies with different firms, but is usually about 20in. by 16in. The colour of the picture also varies, a yellowish or green tinge being not uncommon. Baird, however, have achieved a good black and white, the inevitable slight coloration tending to sepia.

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The Scophony large-screen apparatus is entirely different for mechanical scanning is used. For line there is a stainless steel polygon revolving at 30,375 r.p.m. and for frame a mirror drum. A 300-watt mercury lamp is used as the light source and is modulated by the supersonic light relay, which enables 200 picture elements to be projected simultaneously. This relay consists of a cell through which the light passes. Supersonic waves are set up in the liquid in the cell by the vibration of a quartz crystal and an effect similar to that of a diffraction grating is secured, the effects, however, being controllable by the signal through the variation of the amplitude of vibration of the crystal.

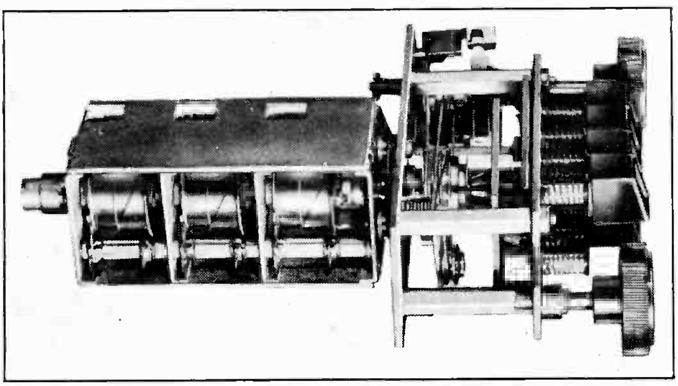
Broadcast Receivers

Few if any changes of a fundamental character were to be found in the circuit design of receivers exhibited at Olympia this year. During the past few months the energies of designs departments would appear to have been absorbed by purely mechanical problems arising from the necessity of producing at least one set with "press-button" selection of a group of stations.

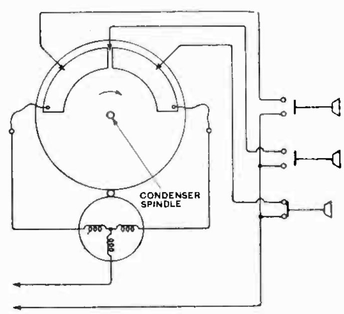
Many alternative methods of providing this service have been evolved. On analysis they all fall into one of three groups: (1) Mechanical location of a conventional rotary tuning condenser at fixed points; (2) Electrical rotation of conventional tuning condenser to pre-determined settings; (3) Separate pre-tuned circuits for each station selected by press-button switches.

The first of these categories includes both rotary and press-button devices. The former is probably the simplest of the mechanical drives and finds application in receivers by Cossor and Ultra. A disc with adjustable radial arms terminating in spigots drives the main condenser spindle. Each arm, which is provided with a telephone dial finger hole, may be brought in succession into a locating slot or spring catch to hold the condenser to the appropriate tuning point.

In the press-button mechanical systems various methods have been devised for translating the linear motion into a rotary torque for driving the conventional type of condenser. These include link motions, heart-shaped cams, and rack and pinion drives. All systems with press-button control are fitted with a "latch-bar" device for retaining each button against the pressure of the return spring. The bar is common to all buttons, and when one is depressed all the others are automatically released.



Philips "Direct Action" press-button tuning assembly with linear motion gang condenser elements.



Schematic connections of automatic "homing" selector used in motor-driven tuning systems.

The necessity of translating linear to rotary motion is avoided in the Philips "Direct Action" system by the use of specially designed condenser elements of spiral form which mesh longitudinally. The press-button tappets make direct contact with a rectangular plate attached to the ceramic rod carrying the moving elements of the triple-gang condenser.

In the motor-driven systems the conventional type of three-gang tuning condenser may be employed so that there is

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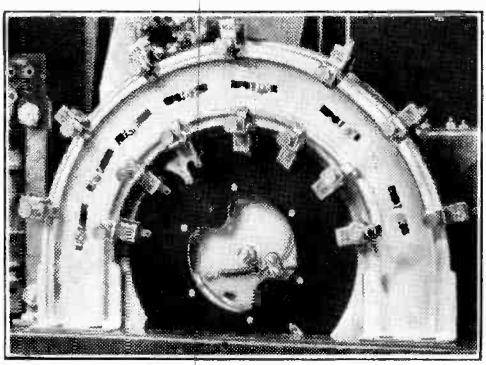
again no obstacle to the inclusion of a radio-frequency amplifier before the frequency-changer as there is in the case of switch operated pre-tuned circuits. The motor is of the reversible induction type and is generally deliberately overloaded to obtain



Station selector plate in Murphy A52 receiver. Medium- and long-wave contacts are clamped to the inner and outer rails. Contacts for the principal short-wave bands are carried by slots in the back plate.

a high starting torque and to reduce the time interval when changing stations. Often a thermal cut-out is included to protect the motor from unreasonable use.

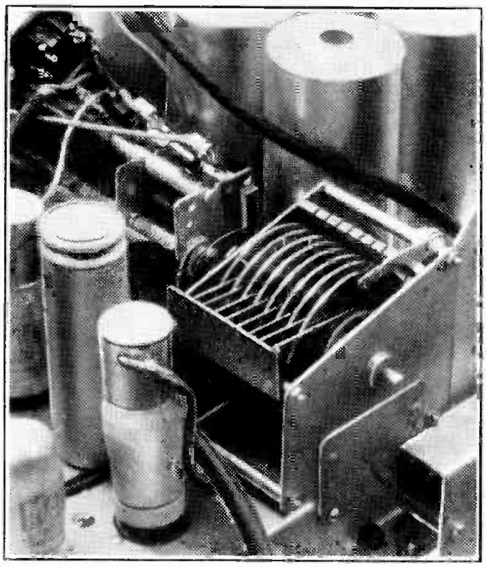
A commutator with a narrow insulated gap is coupled to the condenser spindle and stops the rotation when the contact brush reaches the gap. Overrunning due to the inertia of the armature is avoided by the use of a centrifugal friction or dog-clutch and the lateral movement of the armature may also be used to operate a loud speaker silencing switch while the mechanism is in motion.

The commutator carries two contact plates which are connected to the "shading" windings on the poles of the motor, so that the direction of rotation is determined by the position of the station brush in relation to the insulated gap which automatically "homes" towards the brush in circuit. A series of discs, one for each station, may be located by friction on a common spindle as in the R.G.D. and Philips systems or the contacts may be clamped to a semi-circular track surrounding a single commutator.

The Philips motor-driven mechanism differs from others in that the "homing" is achieved mechanically. The selector drums are geared to the condenser and have spiral tracks equivalent to a length of 12 inches giving low percentage errors of location. The grooves on either side of the central locating notch are cut to different depths and when the plunger, which is inserted when a button is depressed, reaches the bottom of the groove the appropriate movement is transmitted through a contact arm to a reversing switch at the end of the assembly.

In the Philips system the mechanical accuracy of location of the main tuning condenser is well within the required limits. The general practice, however, is to rely on the motor mechanism to bring the tuning only within range of the automatic frequency control circuits incorporated in the receiver. This method has been adopted in the Murphy A52 for medium and long-wave stations. Press-button selection of broadcast bands on short waves is also included, but without A.F.C., and one of the valves so released is employed for double frequency changing on short waves with manual "spade" tuning over the limited range of each band.

All systems in which automatic tuning is a mechanical auxiliary to a normal receiving set must face the problem of waveband



Separately adjustable selector discs are provided for each station in the R.G.D. automatic tuner.

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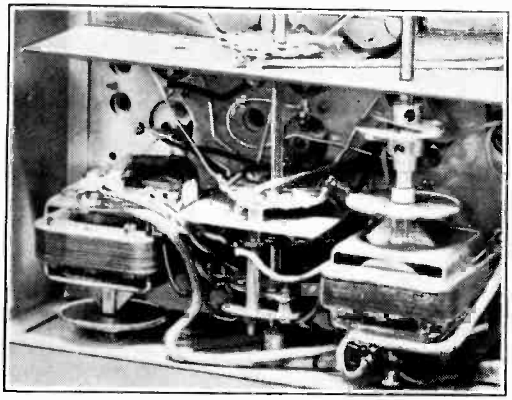
switching. In the Murphy set a mechanical shutter ensures that only station names appropriate to the setting of the waverange switch appear opposite the press-buttons.



Separate motors for tuning and waverange control are used in the R.G.D. receiver.

Against the disadvantages of having to work the waverange switch is the fact that a complete range of fresh stations or wavebands is available on each range.

Automatic wave-changing is to be found in the R.G.D. and Ekco motor driven systems. In the former separate motors controlled by double contacts on each switch button search simultaneously for the correct waverange and tuning point. The latter relies on a single motor, the drive being first diverted through a relay-operated dog clutch to a separate waverange selector disc, before being returned to the main tuning commutator.

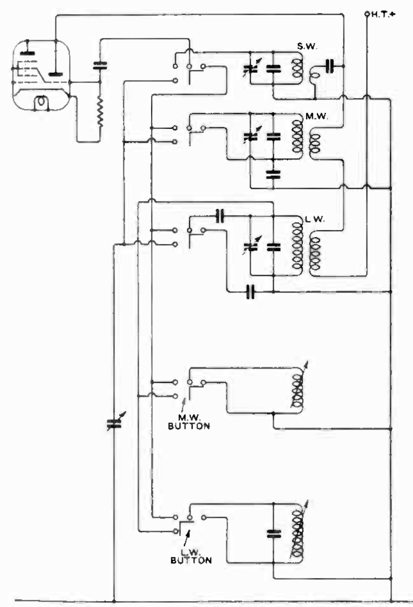
Pre-set tuned circuits separately selected by press-button switches afford an obvious solution of automatic tuning and have been widely adopted in the less expensive press-button sets. The success of the system is wholly dependent on the frequency stability of the capacities and inductances used, and it is for this reason that these components are usually mounted low down in the chassis away from the heat generated by the valves.

Specially designed trimmers have been evolved with electrodes consisting of silver coatings plated directly on the ceramic dielectric. Inductances are of the iron dust cored type and the present trend is towards the use of adjustable cores for tuning the pre-set circuits with silvered mica fixed condensers constituting the greater part of the tuning capacity.

Inductance-tuned circuits lend themselves to a simplification of the wave-band switching problem and in the Bush receivers no separate manipulation of a wave-range switch is necessary, even when changing from press-button to normal manual tuning. Separate press-buttons are included for each wave band and as these are controlled by the common latch-bar they are all automatically released when one of the pre-tuned station buttons is depressed. Both medium- and long-wave stations are tuned with the long-wave coil as a "master" inductance, higher frequencies being reached by connecting adjustable iron-cored coils of lower inductance in parallel. In this and other receivers employing permeability tuning the aerial circuit is generally capacity tuned, a low L/C ratio being accepted for the long-wave pre-set stations.

Circuit Developments

One feature of this year's receivers which is worth noting is the general trend away



Schematic connections of oscillator circuits in the Bush permeability-tuned press-button receiver. For simplicity only one medium- and one long-wave pre-tuned circuit are shown.

from the pentode as an output valve. Nearly everywhere it is replaced by the tetrode.

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This is not unexpected, however, for it was noted last year that valve makers were producing tetrodes in preference to pentodes.

Little change in actual circuits seems to have taken place, the superheterodyne still being supreme. Variable selectivity has dropped out of favour, probably owing to the difficulty of obtaining an entirely satisfactory system and of persuading a non-technical public to use it properly. Dynatron, however, fit an elaborate system in which the I.F. coil coupling is changed in steps by switches and at the same time the circuit damping is altered. Although a superheterodyne, the receiver is converted to a straight set for local reception.

As a result of push-button tuning there is a considerable increase in automatic frequency-control systems. These usually employ a control valve which is arranged to behave substantially as a reactance, the value of which depends on its mutual conductance. This valve is connected across the oscillator circuit of the receiver, and the oscillator frequency can be varied by changing the bias of the control valve. The requisite bias is developed by the discriminator and this usually consists of two diode detectors with their outputs connected in opposition. If the detectors have equal inputs the total output is zero; if the inputs are unequal the total output is the difference of their individual outputs and of the same polarity as the stronger.

In the H.M.V. sets and in one Murphy model, the inputs are derived from two tuned circuits mistuned on opposite sides of the intermediate frequency. In another Murphy model, however, all circuits are tuned to the same frequency, and the different inputs are obtained through the phase difference between the primary and secondary currents of an I.F. transformer.

Test Gear

With a few exceptions the measuring apparatus seen at Olympia this year was intended mainly for that form of testing appropriately described as servicing. Actually this covers a wide field of measurement, since in addition to set testing provision must be made for checking valves, condensers and resistances.

Valves perhaps change more than any other single item, new types being introduced at quite frequent intervals. In order to cope with present and future types the Automatic Coil Winder Co. have designed a new panel for their Avo Valve Tester, which replaces the two in use hitherto and at the same time is far more flexible and easier to accommodate to take new types.

Avo Universal Valve Panel.

This panel, which costs £3 3s., has one valveholder only of each kind and these are joined to nine rotary switches that connect the various sockets, in any order required, to the main test panel. This unit remains unchanged and indicates the condition of a valve on the basis of mutual conductance measurements.

Everett Edgcumbe were showing in addition to an inexpensive valve test-set priced at £5 15s. 9d. a modified version of their Service Valve Tester in which mutual conductance is now obtained by the same method of measurement that is employed in their higher grade laboratory equipment. It still retains its servicing features and is reasonable in price.

A valve test-set with which a complete analysis of any receiving or low-power transmitting valve can be effected was shown by Marconi-Ekco Instruments.

Test oscillators have not undergone much change this year, some new models have been introduced while sundry improvements have been made to existing ones. In the new Avo all-wave oscillator the frequency range has been extended to 80 Mc/s. Admittedly second harmonics are used for the highest range, viz., 40–80 Mc/s, but this

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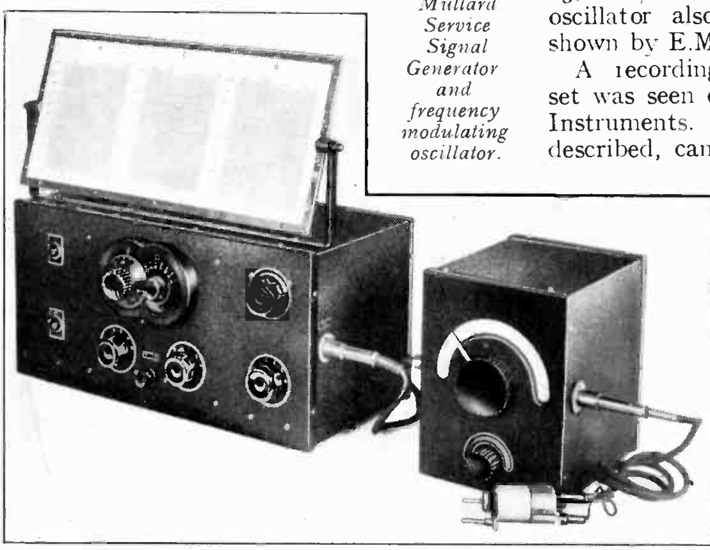
is a common practice in all but the most expensive equipment and has been found to be entirely satisfactory for the ordinary requirements of receiver testing.

E.M.I. Service were showing a new test oscillator with a range of 60 Mc/s to 86 kc/s, while apparatus of this kind was also to be seen among the test equipment made by Cossor, Everett Edgcumbe, Hunt, Marconi-Ekco, Mullard, Pye and Weston.

In the Cossor Ganging Oscillator there is provision for both amplitude and frequency modulation. For the former a 400 c/s oscillator is used while the latter is effected by electronic means, the R.F. output being "Wobbled" ± 15 kc/s each side of the mean frequency. Only the addition of a C.R. oscillograph is thus needed for the visual examination of response characteristics.

Frequency modulation can also be applied to the Mullard Service Signal Generator, electronic means again being employed but a separate unit is required. In common with all other R.F. generators of this kind internal amplitude modulation at 400 c/s is provided, the depth of modulation being fixed at 30 per cent.



Mullard Service Signal Generator and frequency modulating oscillator.

In oscillators not having a modulation control, or means for monitoring, 30 per cent. is adopted as the standard. Another useful feature included in all the new signal generators is that the internal modulating oscillator can be employed to provide an audio signal for testing A.F. equipment.

Since modulation at one frequency will not meet all requirements of testing it is customary to include switching to permit modulation from an external source.

The Marconi-Ekco beat-frequency oscillator is normally mains operated but if required batteries can be used without any internal modifications. Its L.T. consumption, however, is 6 amps at 4 volts and about 60 mA. are required at 250 volts for the H.T. supply. It includes five valves (plus rectifier) and an output meter and covers a frequency range of 10 to 13,000 c/s with an accuracy of ± 2 c/s.

An audio oscillator of this type is also made by Mullard. Their model, Type G.M.2304, has five valves, plus a mains rectifier and an electron beam tuning indicator for checking the calibration against the A.C. supply mains. There are two calibrated dials, one has a limited range with an open scale up to 1,500 c/s, the other covers the full audio spectrum up to 15,000 c/s. There was a beat-frequency oscillator also among the test apparatus shown by E.M.I. Service.

A recording-type audio-frequency test-set was seen on the stand of Marconi-Ekco Instruments. The Audiograph, as it is described, can be operated either with an electrical input or from the output of a microphone. One of its many applications would be the investigation of the fidelity of response of loud speakers, a permanent record in the form of a curve being obtained.

It includes a continuously variable A.F. oscillator of the beat-frequency type, a rotating drum carrying the record chart and a recording stylus. The range of frequencies covered is 30 to 12,000 c/s by motor drive and 10 to 20,000 c/s by manual control. In the standard model the recorded variations in output cover a range of 40 db. Another new test set developed by this firm is a Wave Analyser with which direct measurements can be effected of the individual

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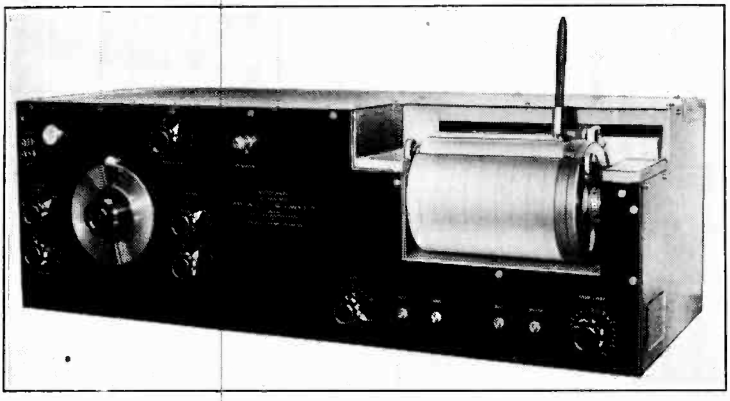
harmonics in any complex wave form. It has a frequency range of 20 to 15,000 c/s.

Apparatus for the measurement of capacitance was shown by E.M.I. Service in the form of a mains energised bridge with a visual indicator for balance and having a range of 10 $\mu\mu$F to 80 μF. Power factor and leakage currents of electrolytic condensers are obtainable with this instrument. A bridge which by means of switching can be adapted for the measurement of capacitance, resistance or inductance was included among test equipment shown by Mullard. This is mains operated also and balance is indicated by a miniature electron beam tube and a high-gain valve amplifier. The capacitance range covered by the calibrated scales is 1 $\mu\mu$F to 10 μF, but this can be extended by using external standard condensers. Resistance measurements of from 0.1 ohm to 10 megohms can be effected by reference to the directly calibrated scales, but in addition the bridge can be employed to indicate percentage difference between a standard, which may be resistance, capacitance or inductance, and a component of the same nominal value.

In one position of the switch a bridge with one open arm for the insertion of external standards is provided. It will thus be seen that its scope is very wide indeed.

Many kinds of bridges were shown by Marconi-Ekco, one of the most versatile being the Universal Impedance Bridge, covering inductance, capacitance, resistance, coil magnification and condenser loss.

Measurement of capacitance by a resonance method at a radio frequency is effected in the Avo Capacity Tester. Though it has a comparatively limited range, viz. 0 to 0.1 μF, its particular feature of merit is the high order of accuracy obtainable over the whole range, which incidentally is covered by six scales.



Marconi-Ekco Audiograph for recording the characteristics of sound amplifying equipment.

This year a new range of valve-voltmeters were shown by the G.E.C. and made by Salford Electrical Instruments. There was a five-range instrument with full-scale deflections of from 0–1 volt up to 0–50 volts and obtainable for either mains or battery operation. For very high frequency measurements this firm has developed an acorn valve-voltmeter with ranges of 1, 3 and 15 volts. Its input capacitance is 3.5 $\mu\mu$F and its impedance is 10,000 ohms at 50 Mc/s.

E.M.I. Service Capacity Tester.

This model is battery operated. A high-frequency diode valve-voltmeter was also seen in which the valve is housed at the end of a flexible metal tube. The method of operation is to charge a condenser through

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the diode and then measure the voltage by means of an electrostatic voltmeter. As this plugs in the front of the instrument any range of voltages can be covered by using the appropriate meter.

Valve-voltmeters were also shown by Marconi-Ekco Instrument and by Weston.

Valves

Television has had a stimulating effect on the valve industry and many new types of valves have been produced to suit its special requirements. The principal difficulty is to obtain reasonably high amplification per stage with a band-width of 2.5–4 Mc/s. It can, in fact, only be done with valves of high mutual conductance and low inter-electrode capacitance.

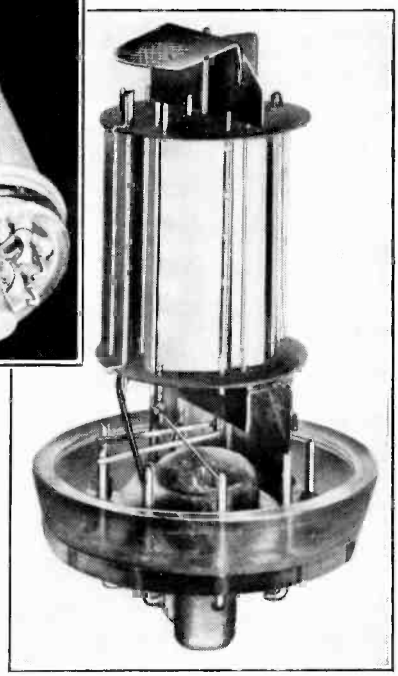
To this end Mazda have produced the SP41 with a mutual conductance of 8.4 mA/V. and an effective capacitance of 20 $\mu\mu$F. (sum of grid $-$E and anode $-$E capacitances). The total current consumption for anode and screen is 13.9 mA. Osram have the KTZ41 with g = 12 mA/V. at a current of 23.25 mA. and with a capacitance of 24.5 $\mu\mu$F.

Mullard have produced the EE50; an entirely different kind of valve. It has g = 14 mA/V. and capacitance 14.4 $\mu\mu$F. The current is difficult to compute; there is an anode and screen current of 10.7 mA. and a reverse current of 8.0 mA. to another electrode. Furthermore, voltage stabilisation by feeding the electrodes from a voltage divider is rather important.

The valve is of the secondary emission type. It has a cathode and heater, control grid and screen-grid, the last being operated at 250 volts. On one side of the screen grid is a gauze anode and beyond that a secondary-emitting cathode. Between screen and anode is a shield at cathode potential, the purpose of which is to prevent the secondary cathode from being spoilt by cathode volatilisation. A second screen in the form of a semi-circle lies on the other side of the screen-grid and this also is maintained at cathode potential. This screen produces an electrostatic field which deflects the electrons passing through the screen-grid around the other shield. They then come under the influence of the anode at 250 volts, pass through its mesh to the secondary cathode at 150 volts, and the secondaries return to the anode.

The valve is of unusual construction, being built on a glass ring, through which the leading-out rods pass to form the actual pins of the "base." All connections are brought out through this ring, but in spite of this the grid-anode capacitance is less than 0.003 $\mu\mu$F.

For time-base work R.F. tetrodes with a top-anode connection are now available, this being necessary on account of the high peak voltages existing with electromagnetic deflection. Cathode-ray tubes are also made in numbers and Cossor, Ediswan, Hivac, Marconiphone, Mullard, Osram, and Vacuum Science Products now make wide ranges of types. Inexpensive tubes with 1.5in. to 3in. screens for oscillographic uses are quite common and there are tubes up to 16in. for television. Vacuum Science Products make unusually long tubes which consequently need little deflecting power, and this firm also produces a transmitting tube with



The complete Mullard EE50 secondary-emission valve is shown above and an interior view on the right.

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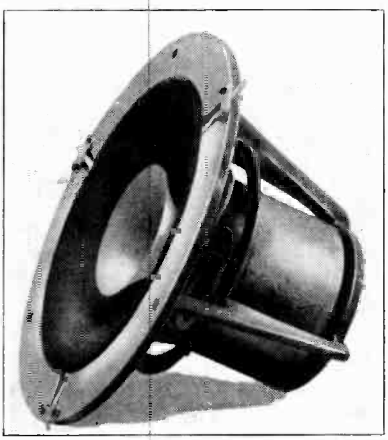
built-in picture for television set testing. Electron multipliers and photo-cells are also among its products.

Electro-Acoustics

The design of moving-coil loud speaker units showed no fundamental change from last year, but performance in the permanent magnet types has improved now that manufacturers have had time to find the best methods of applying nickel-aluminium-cobalt and other alloys. In the better class of instruments flux densities of the order of 14,000 lines/cm² are common in spite of the greater volume of their gaps.

With the approach to finality in the form taken by moving coil units, designers are turning their attention to baffles and to the performance of reproducers as a whole. The indications are that the "infinite" box baffle with totally enclosed back may prove to be the next move towards the ideal domestic loud speaker.

As a means of preventing the interference between back and front of the diaphragm with a baffle of small physical dimensions the idea is attractive, but when a conventional loud-speaker unit is employed the relative improvement in the output at low frequencies is too often destroyed by the high compliance of the enclosed volume of air.



Goodmans twin-diaphragm loud speaker with free suspension for use in a closed-back box baffle.

To circumvent this difficulty Goodmans Industries have developed a special unit, with "free-edged" twin-cone diaphragm and a large-diameter rear centring spider. Practically the whole of the restoring force is provided by the air enclosed in the cubicle box baffle. A massive field magnet ensures an adequate degree of damping to prevent abnormal excursions of the diaphragm on transients. The inside walls of the baffle are lagged and the unit itself is of skeleton construction to reduce internal reflections at high frequencies which might react on the diaphragm. Without the compliance contributed by the baffle the fundamental resonance is 22 c/s and in the cabinet this rises to 40 c/s.

Tannoy "Co-ax" loud speaker and "Power Microphone."

Developments in public address equipment have not been very numerous but the modern application of an early principle by Tannoy Products is worthy of note. We refer to their "Power Microphone," an instrument designed to modulate direct currents up to 4 or 5 amps, which when applied to a small bowl loud speaker of the re-entrant horn type is capable of delivering amplified speech at a level equivalent to 8 watts without the use of intermediate amplifiers. A series of parallel carbon microphones in a holder provided with radiating fins is used with a press-button switch to close the circuit only when speak-

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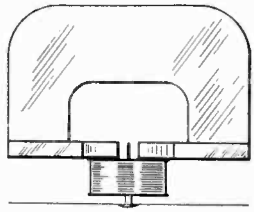
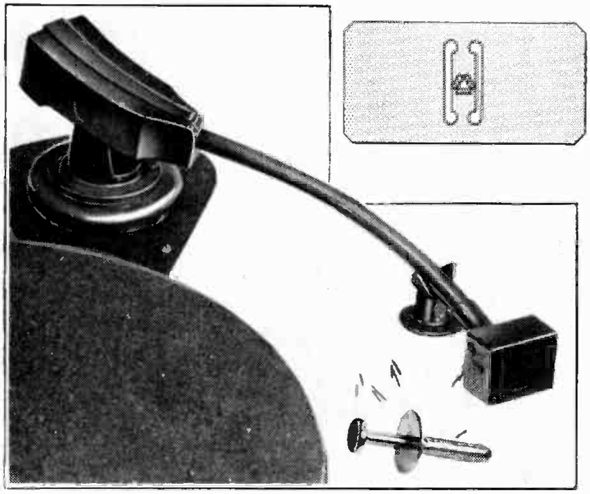
ing. Quality is remarkably good and as the instrument is designed for use close to the mouth it is insensitive to extraneous noise.

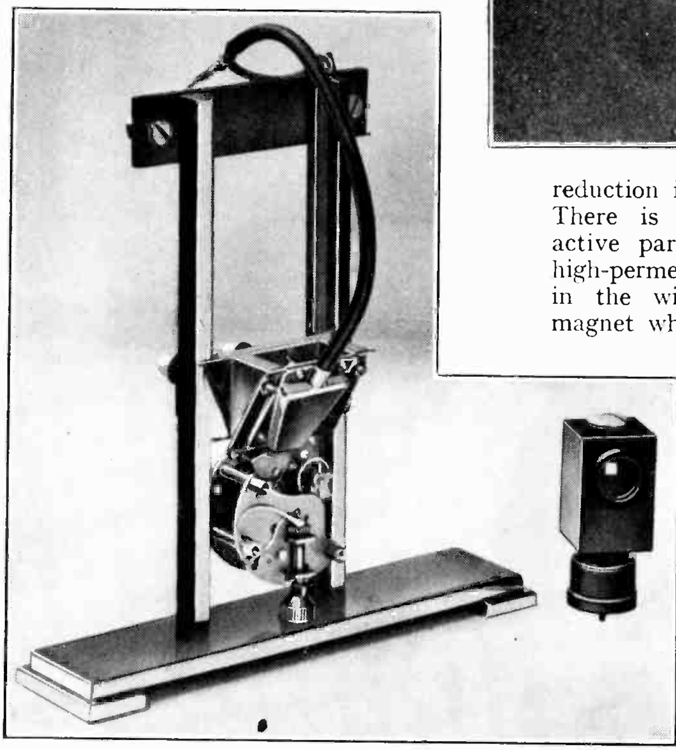
Microphones suitable for calibration work in the acoustic laboratory were shown by R. A. Rothermel and many other interesting applications of piezo-electric crystals were shown. These included a compact vibration galvanometer with a frequency response from 30 to 10,000 c/s, a crystal comparator for rating watch movements by beats against a standard, and a series of vibration pick-ups for industrial use. Piezo-electric gramophone pick-up heads suitable for attachment to existing tone arms are now available from this firm.

One of the most interesting developments in pick-up design was to be found in the new H.M.V. "Hypersensitive" pick-up fitted to the more expensive radio-gramophones made by The Gramophone Co., Ltd. It is of small physical size and special needles have been produced to take full advantage of the reduction in mass of the armature system. There is no needle set screw and the active part of the armature is a small high-permeability tip. This is included in the wide air gap of the permanent magnet which has not the customary lower flux return poles. The pick-up coil is outside the main flux and relies on variations in the leakage lines surrounding the lower part of the armature. Non-linear distortion is considerably reduced and the restoring force required for centring is small; this is provided by a pen steel torsion strip. As a consequence the vertical weight required to keep the needle in contact with the groove under all conditions, does not exceed $1\frac{1}{4}$ oz. and record wear is reduced to negligible proportions.





The H.M.V. "Hypersensitive" pick-up employs miniature needles and a special tool is provided to facilitate handling. (Inset) Only one pair of pole pieces is employed and the pick-up coil is outside the main flux. A pierced pen steel base carries the hollow armature.



Rothermel-Brush piezo-electric comparator for rating watch movements and (right) vibration oscilloscope.

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Aerial Coupling Systems for Television*

By W. E. Benham

§1. Introduction

THE problem of transferring to the receiver the energy picked up by the aerial is largely one of achieving correct matching of aerial to transmission line, and of transmission line to receiver. Complications arise out of the fact that both aerial and receiver input circuit possess a frequency characteristic.

The ramifications of the problem may be understood by reference to Fig. 1, in which A represents a dipole aerial, T_1 a coupling between A and a length l of transmission

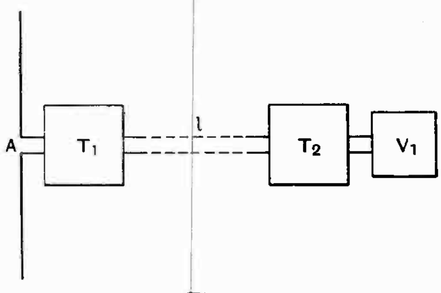

Fig. 1.

line, T_2 coupling the "home" end of the transmission line and the first valve V_1 of the receiver. The complex impedances of A and of V_1 involve that the couplings T_1, T_2 can at best only match perfectly at one frequency. The problem is solved when this one frequency is that of the signal it is desired to receive, subject to the phase and amplitude distortion of the side-bands being within reasonable limits.

§2. Simplifications

The present article makes no attempt to cover all aspects of this complicated situation, and several simplifications will be introduced forthwith. It will be understood that these are justified only as a rough approximation, and that, when a solution is obtained for one part of the chain $AT_1lT_2V_1$ corrections for phase and amplitude distortion elsewhere will involve departures from the values of circuit components determined by the approximative solution.

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

An obvious generality which may be cited as leading to considerable simplification is that of so damping down the various circuits (*e.g.* by use of parallel or series resistances) as to flatten the tuning, thereby reducing both phase and amplitude distortion of the side-bands to negligible proportions. If, in particular, we use a flatly tuned aerial, the coupling T_1 may be omitted if the impedance of the aerial over the vision band is always substantially equal to the radiation resistance, and also that this resistance is equal to the characteristic impedance Z_0 of the line.

Now, the aerial tuning may be flattened without insertion of series resistance by the simple expedient of using stout copper tubing rather than wire in its construction. The increase in capacitance and decrease in inductance thereby resulting leaves the natural frequency of the aerial substantially unaltered, but lowers the inductance to resistance ratio. This is so because the resistance is always nearly equal to the radiation resistance, i^2r losses being relatively unimportant. About ⅜in. diameter tubing is commonly favoured.

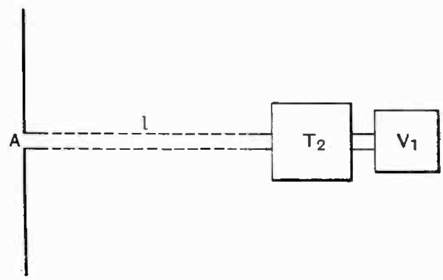

Fig. 2.

We have on this basis the simplified arrangement of Fig. 2. Our second assumption will be that the impedance Z_i looking into T_2 is substantially equal to Z_0 over the vision band, so that the transmission line may be considered removed from the problem, and we have the aerial voltage e working into the impedance Z_0, as in Fig. 3. The replacement of Fig. 2 by Fig. 3 also assumes negligible attenuation of the line,

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but this assumption could be dismissed by making e the attenuated voltage. Our main assumption, that concerning the impedance Z_i, is possible of satisfaction by making T_2V_1 consist of a "constant r" network, but this procedure would involve the use of a valve the resistive component of the input impedance of which was 75 ohms (for $Z_0 = 75$).

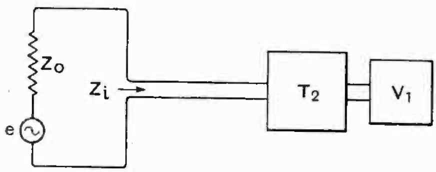

Fig. 3.

While such a valve could be designed the mutual conductance would be somewhat low at about 1.5 mA/V, and at the same time the value of the voltage applied to the input terminals of the valve could not exceed $e/2$.

§3. Band-pass Coupling—Outline of Theory

For the purposes of greater efficiency T_2 may be a band-pass coupling. The impedance Z_i will then, as is well known, be purely resistive at one or three frequencies, according as to whether the coupling coefficient is less than or greater than the critical value for which $\omega^2M^2 = R_1R_2$ (magnetic coupling). If the real part of Z_i is plotted as abscissa, the imaginary part as ordinate, a cissoidal type of curve, originally demonstrated by E. Mallett[1], results, in the case $\omega^2M^2 > R_1R_2$. When such a diagram is prepared with equal scales for R_i and X_i, as in Fig. 5, the phase angle of Z_i ($= Z_{\overrightarrow{AB}}$) may be read directly as the angle between the line joining the origin to any part of the curve (radius vector) and the axis of $R_{\overrightarrow{AB}}$ (initial line).

Our assumption that $Z_{\overrightarrow{AB}}$ is purely resistive would be satisfied as a rough approximation over the range $f34$ to $f37.2$ Mc/s in the case where the circuit components of Fig. 4 have values as follows:

$$L_1 = L_2 = 1\mu\text{H}\ ; \quad C_1 = C_2 = 20\mu\mu\text{F}\ ; \quad R_2 = 20 \text{ ohms}\ ; \ R_{L_1} = 2 \text{ ohms} \qquad (1)$$

The value of Z_0 has, of course, no effect on the value of $Z_{\overrightarrow{AB}}$.

Fig. 4 will now be explained. It is intended to be the full expression of Fig. 3 with the details of T_2 and V_1 specified in a manner which lends itself rather better to analysis than if the more usual representation of valve input impedance as a resistance in parallel with a capacitance had been employed. The condenser C_1 is necessary in order to give the primary circuit a resonant frequency. Thus, if C_1 is short-circuited, the coil L_1 could resonate only in virtue of its self capacitance C_0 (not shown), and, since L_1C_0 would then be directly shunted by Z_0, resonance could occur only under conditions for which

$$\frac{L_1}{C_0Z_0} < 2\sqrt{\frac{L_1}{C_0}} \text{ or } Z_0 > \sqrt{\frac{L_1}{4C_0}} \quad .. \qquad (2)$$

Taking $L_1 = 1\mu$ H, $C_0 = 1\mu\mu$F, we find $Z_0 = 500$ ohms, a value which is out of the question on the basis of our various simplifications. In other words Z_0 must be around 75 ohms, and the primary circuit would then be overcritically damped in the event: C_1 short-circuited, and the coupling as a whole could give but a single humped response corresponding to the resonance of L_2C_2. While there are certain advantages in the use of a single humped response curve,

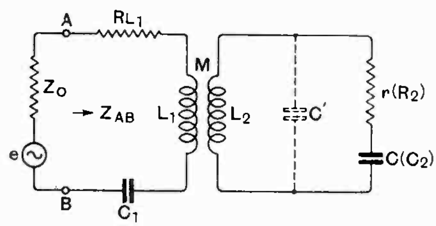

Fig. 4.

for television purposes particularly, we will continue on the basis of a band-pass arrangement, for which the inclusion of a condenser at C_1 (Fig. 4) is necessary. Actually a double hump could perhaps be obtained by the use of a condenser C'_1 in parallel with L_1, but its value would have to be nearly 100$\mu\mu$F, giving a very low Q value for the primary as follows:—

$$Q_1 = \frac{\omega L_1}{(R_1 + L_1/C'_1Z_0)} < \left(\frac{\omega L_1}{L_1/C'_1Z_0}\right)$$
$$= \omega C'_1 Z_0 = 2.1 \quad . . \ (\text{at } f45 \text{ Mc/s}) \qquad (3)$$

where R_1 is the coil resistance (usually about 1 ohm). In this example R_1 has been neglected, but for large values of C'_1 (and so

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smaller values of L_1) L_1/C'_1Z_0 would become less than its present value of about 26.7 ohms, and, even if $L_1/C'_1Z_0 = 1$ only in which case L_1 would be still further reduced to,

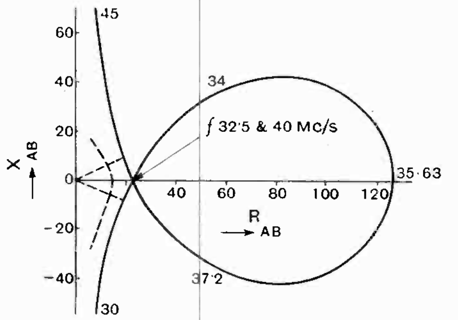

Fig. 5.—*Full line curve, $k = 0.2236$. Dotted curve, $k = 0.0707$.*

say, 0.04μH, the value of Q_1 could never rise above about 6 in value. Compare these figures with those of example (1), which will be taken as our " standard example " for the arrangement of Fig. 4. We have, with C_1 $20\mu\mu$F,

$$Q_1 = \frac{\omega L_1}{R_1 + Z_0} \doteq \frac{1}{\omega C_1 Z_0}$$
$$= 2.38 \text{ (at } f\,45 \text{ Mc/s)} \quad .. \quad .. \quad (4)$$

which, as it stands, shows very little advantage over (3), but which would be 80 per cent. better at f35.6, the frequency actually corresponding to the standard example. Thus later on C_1 will be reduced to about $15.9\mu\mu$F. Moreover, an " unseen " advantage is the fact that L_1 is greater, permitting a correspondingly larger value of L_2 while preserving equality of primary and secondary circuits, a feature which will later be seen to be advantageous from the point of view of gain.

Returning to our explanation of Fig. 4, the condenser C' represents stray plus tuning capacitance, and $[C, r]$ the input circuit equivalent of the valve V_1. Now, the condenser C' may be considered omitted, and the values (C_2, R_2) used, having the following significance (to an accuracy of 1 per cent. for $0 < f < 50$ Mc/s)

$$\left.\begin{aligned} C_2 &= C + C' \\ R_2 &= \left(\frac{C}{C + C'}\right)^2 r + R_{L_2} \end{aligned}\right\} \quad .. \quad (5)$$

It might at first sight be thought that the effective value of r would be simply $Cr/(C + C')$, but at a given frequency it is easily proved that the square of $C/(C + C')$ is involved. Thus, if r is small (as obtains for $0 < f < 50$ Mc/s) in comparison with $(\omega C)^{-1}$, only half the current passes through Cr, the other half passing through C', in the particular case $C = C'$. This means only 1/4 the power dissipation in r as compared with $C' = 0$. The apparent electron loading resistance acting in series with the lumped capacitance $C + C'$ is thus given by $rC^2/(C + C')^2$. The value of r is ascertained in Appendix I.

Now the impedance $Z_{\rightarrow AB}$ is given by

$$Z_{\rightarrow AB} = Z_1 - \frac{p^2M^2}{Z_2} - Z_0 \quad .. \quad (6)$$

$$\left.\begin{aligned} \text{where } p &= \omega\sqrt{-1} \\ M &= k\sqrt{L_1L_2} \\ k &= \text{coefficient of coupling (magnetic)} \\ Z_1 &= R_1 + pL_1 + \frac{1}{pC_1} \\ Z_2 &= R_2 + pL_2 + \frac{1}{pC_2} \\ R_1 &= R_{L_1} + Z_0 \end{aligned}\right\} \quad (7)$$

If we abbreviate further by writing

$$\Phi = Z_1Z_2 - p^2M^2 \quad .. \quad .. \quad (8)$$

then the voltage e_2 across V_1 (*i.e.*, across the extremities of C_2R_2) is given by

$$e_2 = -\frac{Me}{C_2}\Phi^{-1}(1 + pC_2R_2) \quad .. \quad (9)$$

$$\doteq -\frac{Me}{C_2\Phi} \quad .. \quad .. \quad .. \quad (9)a$$

Equation (9*a*) can be shown to be equal to equation (9) to an accuracy of better than 1 per cent. in $\left(\frac{e_2}{e}\right)$ in the standard example. For f45 Mc/s the error in the modulus is 1.3 per cent., and may still be neglected for the purposes of design. There is admittedly an absolute error in phase of 11.3 per cent. at f45 Mc/s, but this error does not change appreciably over the vision frequency band.

If we plot the resistance-reactance diagram of Φ we obtain a family of parabolæ, such as appear in Fig. 6. The reciprocal of the radius vector is proportional to e_2/e; M and C_2 being fixed parameters for each parabola.

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Prof. Mallett had a parabola for the determination of double humps in the secondary *current*.[1] It is considered that it is e_2/e that is of greater practical importance in the present connection, but one curve of i_2/e is indicated as ψ on Fig. 6. I have mentioned this point to a number of authorities, and am surprised to find that there seems to be no general agreement. The issue is, of course, complicated by the presence of resistances which are in general a function of the frequency. In the problem at present under investigation the resistances are sensibly independent of frequency, since the coil resistances are small compared with Z_0 and $rC^2/(C + C')^2$, both of which are independent of ω (C' will be kept constant).

On Fig. 6 radii vectores are inserted in broken line at such places as correspond to a pair of minimum values. Thus, the curves

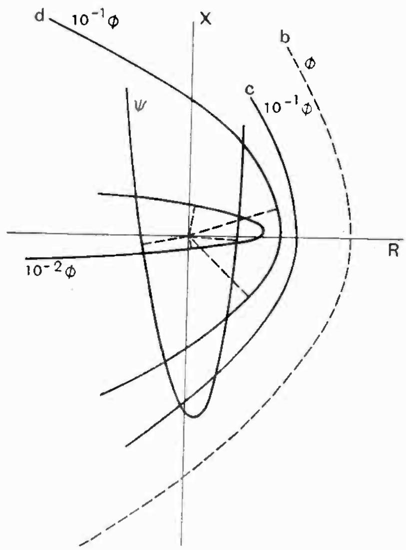

Fig. 6.

c and b have only one minimum value, so radii vectores are not drawn. Fig. 7 makes the matter clear. There is on Fig. 6 no curve corresponding to curve a of Fig. 7; curves b, c of Figs. 6 and 7 correspond, and the curve $10^{-2}\Phi$ corresponds to the full line curve of Fig. 8. In order to avoid confusion, values of f are not marked as parameters, but may be gauged by reference to Figs. 7 and 8. The curve marked ψ corresponds to circuit constants equal to those for which $10^{-2}\Phi$ is drawn. While the ϕ curves are in general asymmetrical in respect of the pair of minimum radii vectors, the ψ curve is substantially symmetrical. The reasons for this are similar to those already given by Prof. Howe in a recent editorial.[2]

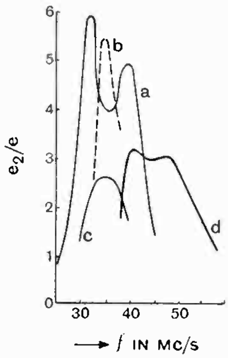

Fig. 7.—*Curve a; $L_1 = L_2 = 1\ \mu H$, $C_1 = C_2 = 20\ \mu\mu F$, $k = 0.2236$, $Z_0 = 18\Omega$. Curve b; $L_1 = L_2 = 1\ \mu H$, $C_1 = C_2 = 20\ \mu\mu F$, $k = 0.0707$, $Z_0 = 18\Omega$. Curve c; $L_1 = L_2 = 1\ \mu H$, $C_1 = C_2 = 20\ \mu\mu F$, $k = 0.2236$, $Z_0 = 90\ \Omega$. Curve d; $L_1 = L_2 = 0.794\ \mu H$, $C_1 = C_2 = 15.88\ \mu\mu F$, $k = 0.2236$, $Z_0 = 60\ \Omega$.*

With a little practice these parabolæ may be prepared with reasonable speed and used generally for the design of band-pass filters. While Prof. Mallett could himself hardly have overlooked such a point, the method does not, for some reason, appear to be in general use. It is hoped that the present article will be of assistance, therefore, and I would stress the belief that the type of representation presented herewith is the only analytical method which renders the problem of coupled circuits amenable as to quantitative estimates of pass curves at reasonable speed combined with sufficient accuracy.

Referring again to Fig. 5, wherever the loop crosses the axis of real impedance the phase angle of the impedance $\underset{\longrightarrow AB}{Z}$ is zero. In the particular example chosen the phase angle (corresponding to points on the loop) is a maximum or minimum when $f = 34$ and 37.2 Mc/s, the values being $\pm 31° 48'$. At these two frequencies the value of $\underset{\longrightarrow AB}{R}$ is 58 ohms. At f35.63 Mc/s the phase angle is

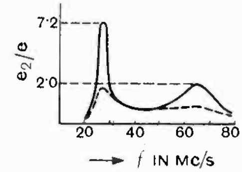

Fig. 8.—*Response curve in the case $k = 0.707$, $Z_0 = 18\ \Omega$ ($Z_0 = 90\ \Omega$, dotted).*

zero and $\underset{\longrightarrow AB}{R}$ is 127 ohms. If we choose our carrier frequency to be 35.63 Mc/s, the band-

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pass coupling is used to best advantage. It is, at the same time, to be noted that if the side-bands extend to 34 and 37.2 Mc/s there is an impedance mismatch as well as a variable phase angle. Added to which there is difficulty, particularly at these frequencies, in repeating results from one band-pass filter to another apparently similarly constructed. Nevertheless, the band-pass can, with reasonable precautions, be adopted for television work. The phase distortion being substantially symmetrical with respect to carrier frequency, there will be no sign of it in the demodulated signal[3]: provided double side-band working is employed.

§4. Design of Band-pass Coupling for Standard Vision Frequency Band

As may be seen from Fig. 7, the pass region of curve (*d*) is roughly $f41$ to $f48$ Mc/s, the humps being of nearly equal height. This result is obtained, first by varying the value of Z_0 between 18 and 90 ohms, using coupling and other constants otherwise as in the standard example, when for $Z_0 = 60$ ohms a curve similar in shape and height to (*d*), but corresponding in position to curves *a*, *b* and *c*, is found. Inductance and capacitance values are then all reduced in the ratio 0.794 : 1, which brings about the desired frequency shift, in well-known manner. The analysis brings out the advantage of a low characteristic impedance from the point of view of voltage step-up from the dipole aerial, and it is probable that the advantage here is such as to exceed the disadvantage arising out of increased attenuation of the line. The latter could, moreover, be made to have an attenuation no greater than for $Z_0 75$ by arranging for a small increase in the dimensions of the conductors.

It appears in practice to be best to dispense entirely with a variable condenser on the secondary side, final adjustments to the filter being made by varying C_1 and L_2. Since we could allow a total not exceeding $16\mu\mu$F on the secondary side we choose a valve whose input capacitance does not exceed this figure, or somewhat less, and connect L_2 by means of leads of some 16 s.w.g., the length of which can be varied while adjusting the filter. Once the lead length has been determined, variations in C during valve life will not be sufficient to involve readjustment of this length, though minor adjustments to C_1 may be necessary. The value of r is some 20 ohms and variations are practically without effect on the pass curve (the main damping of the filter being on the primary side in this case).

It would be an advantage if valve manufacturers would supply the following figures in addition to those usually given.

(1) Value of input capacitance C under operating conditions.

(2) The inductance of leads connecting electrodes proper to pins or contacts —particularly cathode lead and grid lead.

The Alexandra Palace transmits 3 Mc/s side-bands substantially unattenuated, so that the ideal band-pass would be flat between $f42$ and $f48$ Mc/s. Fig. 7 (*d*) is probably as near approach to this ideal as is necessary in practice; such correction to the top as may be thought necessary could most conveniently be introduced at some later stage in the receiver.

§5. Side-band Phase Distortion

Prof. Howe[4] has discussed this question in relation to a paper by D. M. Johnstone and E. E. Wright[3]. The quantitative aspect is briefly re-examined in the accompanying article.

§6. A Note on Unequal Circuits

Loh[5], following Aiken[6], discusses the gain characteristics of a two-stage amplifier, one stage of which works into a coupled tuned circuit while the other works into a single tuned circuit, and finds that when the resistances of the coupled circuits are made unequal in a certain way superior gain and bandwidth for the amplifier results. If I understand Loh's paper correctly the unequal resistance condition for the coupled circuits permits incidentally a 60 per cent. higher Q for the single tuned circuit. Despite this higher value for Q_3, increased overall bandwidth is obtained (compare Fig. 3 with Fig. 2 of Loh's paper), a result which is of considerable practical interest.

If a single stage, using coupled circuits, is considered apart, I do not think the effect of unequal resistances is particularly beneficial. The humps may move farther apart, but the dip between humps becomes more pronounced. Similar effects are also produced if the inductances or capacitances are made unequal. In case the inductances are changed, keeping everything else constant,

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it is possible to equalise the height of the two humps in e_2/e, as shown on Fig. 9, but the dip between humps also becomes more pronounced. This might, of course, be compensated for by loosening the coupling, and it is conceivable that the use of unequal circuits would then be found to be generally beneficial in regard to bandwidth. The increased gain described by Loh, however, would be due to the following circuit and not to the coupled circuit, which, according to my calculations, has maximum gain when the primary and secondary circuits are equal.

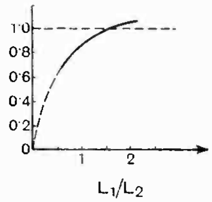

Fig. 9.—*Ratio* $\frac{\textit{hump at higher frequency}}{\textit{hump at lower frequency}}$ *is function of* L_1/L_2 *for M and other circuit constants fixed.*

It is perhaps appropriate to mention here that curves *c* of Figs. 6 and 7 of the present paper correspond to a degree of coupling which exceeds *critical* coupling, defined by $\omega^2M^2 = R_1R_2$, but which is less than *transmutational*[5] coupling defined as $\omega^2M^2 = R_1^2 + R_2^2$. The double humps begin to *appear* only for couplings in excess of transmutational coupling. On the other hand, it is important to note that a loop on the $Z_{\overrightarrow{AB}}$ diagram (Fig. 5) is obtained provided critical coupling only is attained. The double hump property may be detected from the $Z_{\overrightarrow{AB}}$ diagram by drawing minimum radii vectores, as shown in broken line. Professor Howe drew my attention to this point. It does not follow, however, that these humps will necessarily appear in the pass curve (vide Fig. 7, as Z_0 is increased). In order to understand this it is necessary to appreciate that $Z_{\overrightarrow{AB}}$ is (unlike e_2/e) entirely independent of Z_0, which (vide equation 7) is present in the Z_1 of equation 6.

§7. Conclusion

As pointed out in §2, departures from the values given, even after making due allowance for changes in valve input capacitance and lead inductance, may be found necessary owing to the simplifications introduced. The design of band-pass coupling given in §§3 and 4 is along conventional lines, except that prominence is given to the effect of electron loading, which, when expressed as a resistance in series with the valve + stray capacitance may account for 90 per cent. of the total loss resistance on the secondary side when a tuning condenser is not used. In the particular case under discussion the secondary damping is unimportant in comparison with that on the primary side, but this would not always be so.

Mutual inductance between valve input and output leads[7] has been neglected. There would in general be no justification for this but in the present instance the effect of damping on the secondary side is, as already explained, slight in comparison with that due to the low value of Z_0. One or two notes on the effect of self-inductance of leads (which with appropriate design of valve will be ultimately more important than mutual inductance) will be found in Appendix II.

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2 Howe, G. W. O.: Editorial, *Wireless Engineer*, July, 1937, Vol. 14, No. 166, p. 347.
3 D. M. Johnstone and E. E. Wright: *Wireless Engineer*, Oct., 1936, Vol. 13, No. 157, pp. 534–536.
4 Howe, G. W. O.: *Wireless Engineer*, Oct., 1936, Vol. 13, No. 157, pp. 517, 518.
5 Loh, Hou-Shou: *Proc. Inst. Rad. Eng.*, April, 1938, Vol. 26, pp. 469–474.
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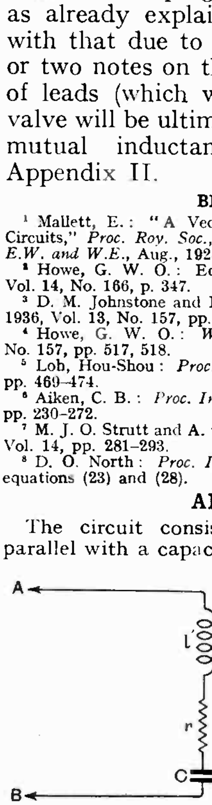
7 M. J. O. Strutt and A. van der Ziel: *E.N.T.*, September, 1937 Vol. 14, pp. 281–293.
8 D. O. North: *Proc. Inst. Rad. Eng.*, 1936, 24, 1, 108. See equations (23) and (28).

APPENDIX I

The circuit consisting of a resistance R_0 in parallel with a capacitance C_0 is equivalent, in the case of sinusoidal signals, to the circuit consisting of a resistance r in series with a capacitance C, where



$$\frac{1}{R_0} = \frac{\omega^2C^2r}{1 + \omega^2C^2r^2} \quad \text{(i)}$$

$$C_0 = \frac{C}{1 + \omega^2C^2r^2} \quad \text{(ii)}$$

These relations may be solved for r and C in terms of R_0 and C_0, the result being

$$r = \frac{R_0}{1 + \omega^2C_0^2R_0^2} \quad \text{(iii)}$$

$$C = C_0[1 + 1/\omega^2C_0^2R_0^2] \quad \text{(iv)}$$

At television frequencies the impedances are such that, if they refer to a typical R.F. pentode, $\omega^2C_0^2R_0^2 \gg 1 \gg \omega^2C^2r^2$, so that, to a good approximation,

$$r = \frac{1}{\omega^2C_0^2R_0} \quad \text{(iii}a\text{)}$$

$$C = C_0 \quad \text{(iv}a\text{)}$$

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D. O. North[8] has given for the total grid to ground input admittance, subject to reasonable simplifying assumptions, the parallel components:

$$\frac{1}{R_0} = \frac{gm}{180}\Big[(9\theta_1^2 + 44\theta_1\theta_2 + 45\theta_2^2) - \frac{2\theta_2}{k+1}(17\theta_1 + 35\theta_2) + \frac{20\theta_2^2}{(k+1)^2}\Big] \quad \text{(v)}$$

$$C_0 = \Big[\frac{4}{3}C_1 + C_2\Big] + \frac{2}{3}gm\tau_2\Big[1 - \frac{1}{k+1} + \frac{1}{3(k+1)^2}\Big] \quad \ldots \quad \ldots \quad \text{(vi)}$$

where

$\theta_1 = \omega\tau_1$ = first (cathode-grid) space transit angle.

$\theta_2 = \omega\tau_2$ = second (grid-screen) space transit angle.

τ_1, τ_2 = corresponding electron transit times.

$k = \sqrt{V_S/V_L}$, where V_S = screen volts, V_L = lumped volts at control grid.

C_1 = cold capacitance of first space $\doteqdot A/4\pi d_1$.

C_2 = cold capacitance of second space $\doteqdot A/4\pi d_2$.

A = effective area of (plane) electrodes in use.

If we use equations (iiia) and (iva) in conjunction with equation (v) we find

$$r = \frac{\frac{1}{20}gm\tau_1^2\Big[1 + 44\tau_2/9\tau_1 + 5\tau_2^2/\tau_1^2 - \frac{2\tau_2}{9\tau_1(k+1)}\Big(17 + 35\frac{\tau_2}{\tau_1}\Big) + \frac{20\tau_2^2}{9\tau_1^2(k+1)^2}\Big]}{\Big(\frac{4C_1}{3}\Big)^2\Big[1 + \frac{3C_2}{4C_1} + \frac{gm\tau_2}{2C_1}\Big(1 - \frac{1}{k+1} + \frac{1}{3(k+1)^2}\Big)\Big]^2} \quad \ldots \text{(vii)}$$

from which we note that r is independent of ω, though at very much higher frequencies more terms from the exact expression would have to be included in (v) and these would actually give rise to terms of r containing ω. Now it may be shown that $gm\tau_1 \doteqdot 2C_1$, the approximation, as distinct from identity, arising from initial velocity considerations. If we use this approximate relation (vii) becomes

$$r \doteqdot \frac{9}{80gm}\cdot\frac{\Big[1 + 44\tau_2/9\tau_1 + 5\tau_2^2/\tau_1^2 - \frac{2\tau_2(17\tau_1 + 35\tau_2)}{9\tau_1(k+1)\tau_1} + \frac{20\tau_2^2}{9\tau_1^2(k+1)^2}\Big]}{[1 + 3C_2/4C_1 + \tau_2/\tau_1(1 - 1/(k+1) + 1/3(k+1)^2)]^2} \quad \ldots \quad \ldots \quad \ldots \quad \text{(viia)}$$

One may, alternatively, express τ_2/τ_1 in terms of d_2, d_1 and k by means of the relations

$$\tau_1 \doteqdot 3d_1/\sqrt{2eV_L/m}\,; \quad \tau_2 \doteqdot 2\tau_1 d_2/3d_1(1+k) \quad \text{(viii)}$$

Then

$$r \doteqdot \frac{9}{80gm}\left[\frac{1 + \frac{88d_2}{27d_1(1+k)} + \frac{20d_2^2}{9d_1^2(1+k)^2} - \frac{68d_2}{27d_1(1+k)^2} - \frac{280d_2^2}{81d_1^2(1+k)^3} + \frac{80d_2^2}{81d_1^2(1+k)^4}}{\Big\{1 + \frac{3d_1}{4d_2} + \frac{2d_2}{3d_1(1+k)}(1 - 1/(k+1) + 1/3(k+1)^2)\Big\}^2}\right] \quad \ldots \quad \text{(ix)}$$

As to whether r is greater than or less than the value $9/(80gm)$ corresponding to the cathode grid space alone depends on the geometry and on the operating conditions, *i.e.*, on d_1, d_2 and k. There is no reason why r should not be less than $9/(80gm)$, since the capacitance (which, in view of (iva), is given by (vi)) now carries a greater current than would C_1 alone, so that considerably greater power loss results for a given value of r. In the case $d_2 = d_1$; $k = 4$, r will be found to be less than $9/(80gm)$, but in the more interesting case $d_2 = 5d_1$, $k = 4$ we find $r \doteqdot 2.9/(80gm) = 45$ ohms for $gm = 5$ mA/V.

In view of the clumsy nature of the expressions, I generally adopt the procedure of regarding the capacitance C_2 as part of the stray capacitance and free from loss, and transfer all the loss resistance in series with the cathode-grid capacitance $4C_1/3$. In this case it may be shown that

$$r_1 \doteqdot \frac{9}{80gm}\Big(\frac{\tau_1 + 4\tau_2}{\tau_1 + \tau_2}\Big) \quad \ldots \quad \ldots \quad \text{(x)}$$

and the effective value of r, for comparison with (viia) or (ix), will be

$$r \doteqdot \frac{9}{80gm}\Big(\frac{\tau_1 + 4\tau_2}{\tau_1 + \tau_2}\Big)\frac{C_1^2}{(C_1 + 3C_2/4)^2} \quad \ldots \quad \text{(xi)}$$

and the value of R_2 for use in connection with Fig. 4 will be, C' being still the stray (plus tuning) capacitance:

$$R_2 = R_{L2} + \frac{9}{80gm}\Big(\frac{\tau_1 + 4\tau_2}{\tau_1 + \tau_2}\Big)\frac{C_1^2}{(C_1 + 3C_2/4 + 3C'/4)^2} \quad \ldots \quad \ldots \quad \ldots \quad \text{(xii)}$$

while the C_2 of Fig. 4 is connected with the present capacitances by the relation

$$C_2 = \Big(\frac{4}{3}C_1 + C_2 + C'\Big) \quad \ldots \quad \text{(xiii)}$$

C_1, C_2 having the significance given above in this Appendix.

APPENDIX II

The effective impedance of l', r, C in series, looked at from AB, is given by

$$Z' = pl' + r + \frac{1}{pC}$$

Thus

$$r' = r \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(x)}$$

$$\frac{1}{pC'} = \frac{1}{pC}(1 + p^2 l'C)$$

or

$$C' = \frac{C}{1 - \omega^2 l'C} \quad \ldots \quad \ldots \quad \text{(xi)}$$

If the impedance presented by C is large compared to r and pl', the current through C, for a given potential existing between A and B, is increased in the ratio $1/(1 - \omega^2 l'C)$. The power dissipated in r is increased, therefore in the ratio $1/(1 - \omega^2 l'C)^2$, and this last factor also represents approximately the effect of lead inductance in increasing the apparent electron damping when expressed as a parallel conductance, as in equation (v). The inductance of the electrodes themselves will not usually be of importance at technical frequencies (say $0 < f < 50$ Mc/s) but must be taken into account at frequencies in excess of 300 Mc/s.

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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

3829. Experimental Investigation of Electromagnetic Waves on Dielectric Wires [Properties of First and Second Order Waves: Effect of Conductivity on Attenuation].—E. Kašpar. (*Ann. der Physik*, Series 5, No. 4, Vol. 32, 1938, pp. 353–360.)

Confirmation and extension, with improved apparatus, of work carried out by the writer in 1932. Results agree with those of Southworth on the same subject (3601 of 1937 and back reference).

3830. Experiments with Micro-Waves around 4.8 cm.—Esau & Ahrens. (*See* 4144.)

3831. Experiments on the Propagation of 16 cm Electromagnetic Waves [Modulated Magnetron Wave of 10 Watts Power with Parabolic Reflectors gave Optical-Sight Signals between Mountains distant 152 km: Good D.F. at Receiver: Advantage of Slight Inclination of Earth's Surface towards Emitter: Interference Fringes at Receiving Site].—H. Gutton & S. Berline. (*Comptes Rendus*, 1st Aug. 1938, Vol. 207, No. 5, pp. 325–326.)

3832. Long-Distance [Ultra-Short-Wave] Radio Reception and the E Region of the Ionosphere [Case of Reception on 56–60 Mc/s over Distances of about 900 miles with Strong Abnormal E Region at Height of 120 km].—H. R. Mimno. (*Nature*, 23rd July 1938, Vol. 142, pp. 163–164.)

3833. Passive Relays [" Refractors "] for Metre and Decimetre Waves.—Loeb. (*See* 4145.)

3834. Reflection of Wireless Waves [and the " Cloud " or " Patch " Theory of Reflection from Low Levels: Structure of True Ionospheric Regions likely to produce Occasional Reflection of Television Signals].—J. H. Piddington. (*Wireless World*, 28th July 1938, Vol. 43, pp. 68–70.)

3835. Application of the Phase Integral Method to the Analysis of the Diffraction and Refraction of Wireless Waves round the Earth [including Ultra-Short Waves].—T. L. Eckersley & G. Millington. (*Phil. Trans. Roy. Soc. Lond.*, 10th June 1938, Vol. 237, No. 778, pp. 273–309.)

For the " phase integral method " *see* Abstracts, 1931, p. 548, and 1932, p. 514 (T. L. Eckersley). It is here applied to the determination of the electromagnetic field produced by a vertical dipole above a spherical earth of finite conductivity, with special reference to the case when both transmitter and receiver are elevated above the surface. A general outline of the mathematical analysis is given in § 2, the " proper value " relations in § 3; the form of the diffraction curve for points on the surface of the earth is determined in § 4. The analysis is extended to points above the surface of the earth in § 5; for points sufficiently distant from the sender, the physical interpretation of the formulae is that a process of diffraction is followed by an unattenuated path out into space, this process however being " referred not to the curved surface of the earth but to a fictitious sphere of radius $|r_1|$ somewhat greater than the radius of the earth." An approximate relation (eqn. 5.12) is found between the height of the receiver above this sphere and the decibel gain in signal strength produced by raising it to this height from the surface of this sphere. The radius of this sphere corresponds to a height above the surface of the earth given for ultra-short waves by eqn. 5.15; " as we go up from the surface of the earth, we do not get out of the diffraction shadow when we reach the edge af the optical shadow represented by the tangent plane to the earth at T, but only when we reach the tangent plane to the sphere of radius $|r_1|$ at a height h_1 above T. Points on this plane correspond to . . . zero attenuation. . . . The edge of the diffraction shadow gets more ill defined as the wavelength increases."

§ 6 gives the detailed height/gain analysis

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height/gain curves are given in Figs. 8, 9. Fig. 10 shows a typical set of curves giving the signal strength for 1 kw radiated as a function of distance from the transmitter for various heights of the receiver above the ground. The absolute values at the surface of the earth are derived in § 7; the field strength from a vertical dipole on the earth's surface is given by eqn. 7.7. The effect of air refraction is considered in § 8; a form of the refractive index with practically constant gradient and tractable phase integral is chosen. The attenuation factor is given by eqn. 8.8; "the effect of air refraction is to reduce the attenuation" and may be large for a short-wave transmitter. The height/gain relation is found to be reduced. "The theory is entirely adequate to explain the effects which are to be expected on short waves." An appendix derives an expression in which more than one term of the diffraction formula is taken into account.

3836. EARTH ABSORPTION WITH HORIZONTAL DIPOLES [Theory].—K. F. Niessen. (*Ann. der Physik*, Series 5, No. 5, Vol. 32, pp. 444–458.)

Author's summary:—"When an infinitesimal horizontal dipole aerial is at a height h above the earth's surface (regarded as plane), a fraction T of the total energy emitted by the sender is absorbed in the earth. . . . This fraction is calculated here by means of some linear integrals, which can easily be integrated for given type of earth, wavelength, and height. . . . The method of calculation allows the finite conductivity of the earth to be taken into account." Further numerical work on the subject is promised.

3837. THE SIMPLE RAY THEORY AS APPLIED TO HORIZONTALLY AND VERTICALLY POLARISED SHORT WAVES.—McPetrie. (In paper referred to in 4051, below.)

3838. THE POSSIBLE DISTANCES OF THE EFFECTIVE POINTS OF REFLECTION AT THE IONOSPHERE FROM THE GREAT-CIRCLE PATH.—Barfield & Ross. (In paper dealt with in 3970, below.)

3839. EFFECT OF A LONGITUDINAL MAGNETIC FIELD ON THE CONDUCTIVITY AND REFRACTIVE INDEX OF IONISED AIR [Experiments].—B. N. Singh. (*Phil. Mag.*, Aug. 1938, Series 7, Vol. 26, No. 174, pp. 244–252.)

Theoretical expressions for the conductivity (eqn. 7) and square of the refractive index (eqn. 8) of an ionised gas in the presence of a longitudinal magnetic field are first given; they take into account the collisional frequency. Experimental measurements on ionised air in a discharge tube at a frequency of 8.1×10^7 c/s are described; the results are shown in Figs. 2, 3. The values of electron density and collisional frequency were determined by the probe method. The measured curves do not show the infinity at the gyro-frequency of the incident waves which would be given by the approximate formulae *neglecting* the collisional frequency; fair agreement with the formulae *including* this is found.

3840. CONDUCTIVITY AND DIELECTRIC CONSTANT OF AN ELECTRON STREAM [Calculations].—H. E. Hollmann & A. Thoma. (*Ann. der Physik*, Series 5, No. 5, Vol. 32, pp. 459–464.)

For the writers' "inversion theory" *see* 2914 (and 4039) of 1937, and 1353 of April. From this, new formulae are here derived, using Maxwell's equations, for the conductivity (eqn. 4) and dielectric constant (eqns. 5, 6) of an electron stream. These are expressed as functions of the transit-time angle (Fig. 1) and are intended to replace Benner's formulae (1930 Abstracts, p. 152). "It is shown that a zero or negative dielectric constant cannot be obtained, since a state is reached in which the electrons execute plasma oscillations, for which the theoretical assumptions are no longer valid."

3841. THE PROPAGATION OF ELECTRIC WAVES IN IONISED GASES IN THE SPACE BETWEEN TWO COAXIAL CYLINDERS [in Negative Space of Continuous Discharge in Air without Magnetic Field: Measured Velocity of Short Waves: Some Wavelengths have Small Velocity, Large Absorption and Pressure Variation].—V. Majeru. (*Comptes Rendus*, 11th July 1938, Vol. 207, No. 2, pp. 131–134.)

3842. TIDES IN THE UPPER ATMOSPHERE [Curve showing Lunar Variation of Equivalent Height of E Region: Tide at 110 km 5900 Times That at Ground Level but of Same Phase].—E. V. Appleton & K. Weekes. (*Nature*, 9th July 1938, Vol. 142, p. 71.)

3843. MIXED REFLECTION IN MEDIA OF VARIABLE OPTICAL INDICES: APPLICATION TO THE IONOSPHERE [Theory].—I. & C. Mihul. (*Comptes Rendus*, 18th July 1938, Vol. 207, No. 3, pp. 220–222.)

The writers describe the results of calculations which show that a rapid increase of ionisation with height, *i.e.* a sharp boundary, is not a necessary condition for a high coefficient of reflection of electromagnetic waves; they find that, under certain conditions, the optical retardation of the reflected elementary wave produced by the fact that the incident wave has penetrated further into the ionised medium before reflection may be compensated by the advance in phase (relative to the incident wave) which they calculate from Fresnel's formulae, so that the resultant reflected wave may have a considerable amplitude. The effect of this possibility on the transmission of broadcasting and of short waves is discussed.

3844. THE EFFECT OF A THUNDERSTORM ON THE UPPER ATMOSPHERE [Effect on Ionisation Density of E Layer investigated by Bailey's Corrected (1937) Method: during Day, less than 1% of Flashes cause Notable Increase, during Night a Considerably Larger Percentage: if a Small Constant Electric Field around 0.5 V/m always exists (Kölhorster, Huxley), Thunderstorm will often cause Marked Increase in Ionisation even during Day].—R. H. Healey. (*A.W.A. Tech. Review*, April 1938, Vol. 3, No. 4, pp. 215–227.) For previous work *see* 874 of 1936.

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3845. BRIGHT SOLAR ERUPTIONS AND THE IONOSPHERE [Record showing Increase of Ionisation at Equivalent Height 125 km probably due to Solar Eruption: Radio Transmission Conditions improve or deteriorate as Effect of Eruption according to Height at which Ionisation is Produced].—R. Naismith & W. J. G. Beynon. (*Nature*, 6th Aug. 1938, Vol. 142, pp. 250–251.)

3846. RECENT LARGE SUNSPOTS [Data of Three Spots in July].—(*Nature*, 16th July 1938, Vol. 142, p. 110.)

3847. THE EXPLORATION OF THE IONOSPHERE CARRIED OUT AT THE "G. MARCONI EXPERIMENTAL RADIO CENTRE," TORRECHIARUCCIA.—A. Bottini. (*La Ricerca Scient.*, 15th/30th June 1938, Series 2, 9th Year, Vol. 1, No. 11/12, pp. 574–580.)

3848. ABSORPTION OF LIGHT BY THE LOWER ATMOSPHERE [Importance of Absorption by Various Atmospheric Constituents, particularly Water Vapour].—A. & É. Vassy. (*Comptes Rendus*, 4th July 1938, Vol. 207, No. 1, pp. 63–65.)

3849. NEW MEASUREMENTS OF THE VERTICAL DISTRIBUTION OF OZONE IN THE ATMOSPHERE [by Photographs of Ultraviolet Solar Spectrum at Various Heights of Balloon Ascent: Tropospheric Minimum of Ozone Pressure: Fluctuations in Lower Atmosphere: Explanation based on Vertical Atmospheric Mixing and Chemical Decomposition of Ozone in Troposphere and at Earth's Surface].—V. H. Regener. (*Zeitschr. f. Physik*, No. 9/10, Vol. 109, 1938, pp. 642–670.)

3850. CONCENTRATION AND MEASUREMENT OF ATMOSPHERIC OZONE [Refinement of Chemical Method of Measurement for Lower Atmosphere: Mean Value of London Measurements].—F. A. Paneth & J. L. Edgar. (*Nature*, 16th July 1938, Vol. 142, pp. 112–113.)

3851. OZONE ULTRA-VIOLET EMISSION SPECTRA [Wavelengths of Bands superposed on Continuous Spectrum].—J. Janin. (*Comptes Rendus*, 11th July 1938, Vol. 207, No. 2, pp. 145–146.)

3852. THE IDENTIFICATION OF AURORAL RADIATIONS [Comparison with Bands emitted by Gaseous Nitrogen, not with Bands of Solid Nitrogen, as made by Vegard].—J. Kaplan. (*Phys. Review*, 15th July 1938, Series 2, Vol. 54, No. 2, p. 148: *Zeitschr. f. Physik*, No. 11/12, Vol. 109, 1938, pp. 744–749.)

3853. THE PRODUCTION OF THE AURORA SPECTRUM IN THE LABORATORY [Recent Photographs of Discharge Spectra showing Auroral Afterglow: Bluish-White Colour of Afterglow].—J. Kaplan. (*Zeitschr. f. Physik*, No. 11/12, Vol. 109, 1938, pp. 750–752.)

3854. THE QUESTION OF THE FORMATION AND EXCITATION OF MOLECULAR IONS IN ACTIVE NITROGEN [Discussion of Kaplan's Proposed High-Pressure Mechanism for Excitation of Negative Bands in Nitrogen Afterglow: Bands should come from Long-Lived Molecular Ions arising from the Discharge].—U. Stille: Kaplan. (*Zeitschr. f. Physik*, No. 7/8, Vol. 109, 1938, pp. 491–502.) *See* Kaplan, 3981 of 1936, and Cario & Stille, 21 of 1937 and 410 of February.

3855. ENHANCEMENT OF THE SODIUM D LINES IN THE TWILIGHT SKY LIGHT [Remarks on Observation of Yellow Sky Radiation 5893 AU].—R. Bernard: Cabannes, Dufay, & Gauzit. (*Nature*, 23rd July 1938, Vol. 142, p. 164.)

3856. THE COLOUR OF THE NIGHT SKY [Experimental Results on Energy Distribution along Spectrum].—R. Grandmontagne. (*Comptes Rendus*, 25th July 1938, Vol. 207, No. 4, pp. 275–277.) For photometer used *see* 1292 of 1937.

3857. ANNUAL VARIATIONS IN THE LIGHT OF THE NIGHT SKY [Experimental Curve compared with Rayleigh's Results].—R. Grandmontagne. (*Comptes Rendus*, 1st Aug. 1938, Vol. 207, No. 5, pp. 321–323.) For Rayleigh's work *see* 3773 of 1935.

3858. SEPARATION OF AN ELECTROMAGNETIC [Wave] FIELD INTO TWO WAVES TRAVELLING IN OPPOSITE DIRECTIONS [Determination of Their Vectors from Vectors of Original Field: Illustrative Diagrams: Vectorial Definition of Simple Surge].—F. Emde. (*Elektrot. u. Masch:bau*, 31st July 1938, Vol. 56, No. 31, pp. 394–395.)

3859. ON THE PHASE OF THE MAGNETIC FIELD [Correction of Certain Errors, due to Neglect of Phase Considerations, in the Work of Other Writers: including von Mises' Book ("Differentialgleichungen der Physik," especially where Spherical Coordinates are used for Wave Diffraction) and Macdonald's Treatment of Waves in an Infinitely Long Wire].—K. F. Niessen. (*Physica*, Aug. 1938, Vol. 5, No. 8, pp. 769–774: in German.)

3860. MAGNETIC PERMEABILITY, AT HIGH FREQUENCIES, OF THIN FILMS OF IRON, IN THE HYPOTHESIS OF A VERY THIN NON-MAGNETIC SUPERFICIAL LAYER [based on Lecher-Wire Experiments: the Existence of a "Critical Thickness"].—S. Procopiu. (*Rev. Gén. de l'Élec.*, 2nd July 1938, Vol. 44, No. 1, p. 16: summary only.)

If Lecher wires of brass are covered with a very thin skin of iron, the waves emitted by a h.f. oscillator and propagated along these wires are shorter than they would be in the absence of this skin. The writer, using Laville's 1924 formula for the coefficient of absorption of waves as a function of the magnetic permeability of the wire material, calculates this variation of wavelength due to the skin of iron on three assumptions, the last of which is that the permeability of the iron depends

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on the thickness of the film and becomes unity for one definite ("critical") thickness. "In these conditions, the formula obtained shows that the wavelength does not change if a thickness of iron equal to the critical thickness is deposited on the brass wires. The experiments carried out at the laboratory of the University of Jassy show that such is actually the case for a thickness of iron of 35–70 mμm. Inversely, it is possible to calculate the wavelength for which the penetration is equal to the critical thickness of iron and for which, consequently, the permeability of the iron is equal to unity; this is found to be of the order of a millimetre, which agrees satisfactorily with the results of Arkadiew's experiments."

3861. THEORY OF INTENSITY ANOMALIES IN DIFFRACTION [Wood's Optical Anomalies: Connection with Some Diffraction Anomalies in X-Rays and Electron Beams, etc.].—U. Fano. (*Ann. der Physik*, Series 5, No. 5, Vol. 32, pp. 393–443.)

3862. THE CONCEPT OF DEGREE OF COHERENCE AND ITS APPLICATION TO OPTICAL PROBLEMS [for Treatment of Intermediate States (of Partial Coherence) between Coherence (Complete Dependence of Phase) and Incoherence (Complete Independence): Application to Interference of Extended Light Sources].—F. Zernike. (*Physica*, Aug. 1938, Vol. 5, No. 8, pp. 785–795: in English.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

3863. REPLY TO THE REMARKS OF A. JONESCU ON MY PAPER "CONTRIBUTIONS TO THE STUDY OF THE NATURE OF THE OSCILLATING SPARK DISCHARGE."—I. Purcaru. (*Zeitschr. f. Physik*, No. 5/6, Vol. 109, 1938, p. 431.) For Purcaru's paper *see* 966 of 1935.

3864. POSITIVE-POINT-TO-PLANE DISCHARGE IN AIR AT ATMOSPHERIC PRESSURE [Investigation of Current/Voltage Characteristics: Fundamental Processes: Conditions of Corona Onset, Nature of Starting Currents, etc.].—A. F. Kip. (*Phys. Review*, 15th July 1938, Series 2, Vol. 54, No. 2, pp. 139–146.)

3865. DIRECT-STROKE CURRENTS INVESTIGATION ON A 154 kV TRANSMISSION LINE.—H. Rokkaku & S. Katoh. (*Electrot. Journ.*, Tokyo, Aug. 1938, Vol. 2, No. 8, pp. 175–180.)

3866. THE INCIDENCE OF LIGHTNING AND THE STRUCTURE OF THE GROUND.—V. Fritsch. (*Rev. Gén. de l'Élec.*, 30th July 1938, Vol. 44, No. 5, pp. 152–154.) Long French summary of the paper in German referred to in 2217 of June.

3867. THE PROTECTIVE ACTION OF A SINGLE POLE LIGHTNING ARRESTER.—A. A. Akopjan. (*E.T.Z.*, 11th Aug. 1938, Vol. 59, No. 32, p. 860: summary only.)

3868. "ASSOCIATION OF TERRESTRIAL MAGNETISM AND ELECTRICITY: TRANSACTIONS OF EDINBURGH MEETING" [in 1936: Book Review].—LaCour. (*Rev. Gén. de l'Élec.*, 30th July 1938, Vol. 44, No. 5, p. 130.)

3869. UPPER AIR METEOROLOGICAL INVESTIGATIONS AND RADIO METEOROGRAPHS [including a Comparison of Constant- and Variable-Frequency Types: Vaisala's Meteorograph allowing for Undesired Frequency Changes].—R. R. Bajpai. (*Sci. & Culture*, Calcutta, July 1938, Vol. 4, No. 1, pp. 6–14.)

3870. AN ELECTRIC HYGROMETER AND ITS APPLICATION TO RADIO METEOROGRAPHY.—F. W. Dunmore. (*Journ. of Res. of Nat. Bur. of Stds.*, June 1938, Vol. 20, No. 6, pp. 723–744.)

3871. A NEON TUBE COUPLED AMPLIFIER CIRCUIT FOR RADIO COSMIC-RAY RECEIVERS [for the Tape Recording of Signals from Sounding Balloons].—S. A. Korff. (*Review Scient. Instr.*, Aug. 1938, Vol. 9, No. 8, pp. 256–257.)

PROPERTIES OF CIRCUITS

3872. COEXISTENT THERMAL AND THERMIONIC FLUCTUATIONS IN COMPLEX NETWORKS [Verification of Previously Found General Formula for Thermal Fluctuations in Network of Linear Conductors: Extension to cover Networks generating Thermionic Fluctuations also: Application to Wide-Band Photocell Amplifier: Practical Recommendations for Improved Signal/Noise Ratio].—F. C. Williams. (*Journ. I.E.E.*, July 1938, Vol. 83, No. 499, pp. 76–86.) For the previous work *see* 433 of February.

3873. DAMPING REDUCTION AND SENSITIVITY IN HETERODYNE RECEPTION.—Kautter. (*See* 3916.)

3874. SPHERICAL CIRCUITS [Relation between Dimensions and Natural Frequency].—Hollmann: G. W. O. H. (*See* 3900.)

3875. COAXIAL AND BALANCED TRANSMISSION LINES: SOME USES AT HIGH RADIO FREQUENCIES [particularly as Resistances, Filters, and Wide-Band Transformers: Analysis and Design Formulae].—M. Reed. (*Wireless Engineer*, Aug. 1938, Vol. 15, No. 179, pp. 414–422.)

3876. GRAPHICAL SOLUTIONS FOR A TRANSMISSION LINE TERMINATED BY AN ARBITRARY COMPLEX LOAD IMPEDANCE [*e.g.* Television Aerial Feeders].—Roberts. (*See* 3930.)

3877. COMPLEX EFFICIENCY AND IMAGE IMPEDANCE: SIMULTANEOUS TRANSMISSION CHARACTERISTIC OF TRIPOLE NETWORK: ASYMMETRICAL, CONSTANT-IMPEDANCE WAVE SEPARATOR.—A. Matsumoto. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 205–211.) For previous work *see* 451 of February.

3878. THE EQUIVALENT CIRCUIT OF THE TRANSFORMER [and a Defence of the Extremely Useful "Asymmetrical Circuit" with Only One Series Inductance, when used with Hemmeter's "Total Leakage Factor"].—W. Kautter: Pitsch. (*Funktech. Monatshefte*, July 1938, No. 7, pp. 222–223.) Prompted by Pitsch's article (2703 of July).

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3879. THE MECHANISM OF SYNCHRONISATION IN THE LINEAR TIME BASE [Theoretical Study of Thyratron Action].—G. F. H. Harker. (*Phil. Mag.*, Aug. 1938, Series 7, Vol. 26, No. 174, pp. 193–213.)

3880. SWITCHING PROCESSES IN CIRCUITS WITH INDUCTANCE AND VARYING OHMIC RESISTANCE.—Bähring. (*See* 4035.)

3881. SUBHARMONICS IN CIRCUITS CONTAINING IRON-CORED REACTORS [Results of Approximate Analytical Method compared with Differential-Analyser Solutions of the Non-Linear Differential Equation].—I. Travis & C. N. Weygandt. (*Elec. Engineering*, Aug. 1938, Vol. 57, No. 8, pp. 423–431.)

3882. CRITICAL CONDITIONS IN FERRORESONANCE [by Method of Graphical Solutions].—P. H. Odessey & E. Weber. (*Elec. Engineering*, Aug. 1938, Vol. 57, No. 8, pp. 444–452.)

3883. RESONANT NON-LINEAR CONTROL CIRCUITS [containing Iron-Cored Reactors: including a Regenerative Method of Increasing the Sensitivity of the D.C.-Controlled Circuit].—W. T. Thomson. (*Elec. Engineering*, Aug. 1938, Vol. 57, No. 8, pp. 469–476.)

3884. LINEARITY AND NEGATIVE FEEDBACK [Investigations by C-R Oscillograph into Amplitude-Distortion Reduction obtainable].—J. H. Reyner. (*Wireless World*, 4th Aug. 1938, Vol. 43, pp. 93–94.)

3885. ON THE QUESTION OF DISTORTION IN RECTIFICATION.—E. Knausenberger. (*E.T.Z.*, 18th Aug. 1938, Vol. 59, No. 33, p. 884: summary of Dresden Dissertation, 1937.)

For judging the properties of a h.f. rectifying circuit the knowledge of the relation between the h.f. input voltage and the d.c. output voltage is generally considered of importance. This "back-modulation" characteristic (Rückmodelkennlinie) is determined, in the present paper, both statically and dynamically for audion (leaky-grid), anode-bend, and barrier-layer detection, as well as for the superheterodyne. It is found that the statically determined characteristic holds good also dynamically, so long as the input oscillatory circuits are not mis-tuned and the complex l.f. load does not exceed a certain limiting value. Thus the non-linear distortion can be derived directly from the curvature of the static characteristic. In the course of a close analysis of the composition of the "back-modulation" characteristics for the various circuits, the important influence of the input parallel-oscillatory circuit on the curvature and on the distortions is discussed. These distortions, the "klirr" factor (of non-linear distortion), and the individual amplitudes of the first and second harmonics, are all measured. The amplitude-dependent h.f. resistance of the rectifier, which has an effect on the curvature of the "back-modulation" characteristic provided that it is not very much larger than the oscillatory resistance of the parallel circuit or does not approach, for deep modulation, the constant value $R/2$, is given in the form Rh/j, where j and h represent the current- and voltage-modulation respectively and R is the loading resistance on the rectifier. It is also shown that with mis-tuning of the input parallel-oscillating circuit additional distortions occur which are covered by the changes in the envelope resulting from the mis-tuning, except those departures which are bound up with amplitude-variation of the carrier and variation of the modulation factor, and hence with a displacement of the working point on the characteristic. A formula is thus derived which allows the "klirr" factor of the envelope of a modulated high frequency to be represented as dependent both on the relative amplitudes and also on the phase positions of the two sidebands. Finally, measurements are reported which show that the "klirr" factor of a rectifier circuit can be reduced by the addition of an unmodulated carrier to a modulated carrier of the same frequency.

3886. REDUCTION OF FACTOR OF NON-LINEAR DISTORTION IN H.F. RECTIFICATION BY SUPERPOSITION OF UNMODULATED CARRIER ON MODULATED CARRIER OF SAME FREQUENCY.—Knausenberger. (*See* end of above abstract—3885.)

3887. ON THE INFLUENCE OF THE IMPEDANCE OF THE CURRENT SOURCE IN DIODE RECTIFICATION.—G. Kraus. (*Elektrot. u. Masch:bau*, 3rd July 1938, Vol. 56, No. 27, pp. 345–348.)

Author's summary:—The characteristic of the diode is, in the literature, replaced by an exponential function, one side of a parabola, or straight lines including a bend. On these assumptions the mode of action of the diode has been calculated exactly, but always presuming that the circuit, as seen from the diode, has a zero resistance for the alternating current and its harmonics (Barkhausen, "*Elektronenröhren*"; Urtel, 1933 Abstracts, p. 623). But it is exactly in the common detecting circuits of the broadcast receiver that the current encounters the impedance of an oscillatory circuit or band filter, which is *not* negligibly small, particularly for the fundamental wave of the current. The effect of this has hitherto only been investigated experimentally or calculated in limiting cases (Barkhausen, *loc. cit*; Zenneck, 3617 of 1937; Wilhelm, 1365 of 1937; Knausenberger, *Mix & Genest, Tech. Nachricht.*, 9/3, p. 145—*see* also 3885, above). In the present paper, rectifying and demodulating characteristics, as well as alternating-current consumption, are determined on the assumption that the characteristic of the diode can be replaced by an exponential function (initial-current region) and that the internal resistance of the current source is a resonance resistance. But in Section 1 the calculations are carried out for the case of a resistance-free current source.

3888. LINEAR RECTIFIER DESIGN CALCULATIONS [Investigation of Linearisation of Diode Rectifier by Added Plate-Circuit Resistance: particularly for Monitoring Purposes].—E. A. Laport. (*RCA Review*, July 1938, Vol. 3, No. 1, pp. 121–124.)

3889. THE [Audio-Frequency] AMPLIFIER WITH RETROACTION.—Bohnenstengel. (*See* 3919.)

www.americanradiohistory.com

3890. The Circle Diagram of the Resistance Amplifier.—K. E. Müller. (*Rev. Gén. de l'Élec.*, 23rd July 1938, Vol. 44, No. 4, pp. 127–128.) For the full German paper *see* 1345 of April.

3891. Modified Circuit Connections for the Duplex Feedback Amplifier [for giving Characteristic of Constant-Voltage or Constant-Current Output, independent of Load and Frequency].—Y. Watanabe & N. S. Miyota. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 247–252.)

3892. Linear Characteristics of Simplex Feedback Amplifier [and the Theory of Bridge Feedback in the Unbalanced Case: General Formulae: Output Characteristics and Choice of Types of Feedback: Signal/Noise Ratio], *and* Non-Linear Characteristics of the Simplex Feedback Amplifier.—K. Kobayashi: Kobayashi & Degawa. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 253–265: pp. 266–274.)

3893. Operation of an Amplifier with Triode Valves in Non-Linear Regions of the Characteristics with an Untuned Plate Oscillating Circuit [including a Simplified Graphical Method of Investigation].—J. Fagot. (*Bull. de la Soc. franç. Radioélec.*, 3rd Quarter 1938, Vol. 12, No. 3, pp. 54–76: in French and English concurrently.)

TRANSMISSION

3894. Electron-Inertia Effects in Thermionic Tubes [Frequency decreased by Application of Axial Magnetic Field].—J. S. McPetrie. (*Nature*, 6th Aug. 1938, Vol. 142, p. 254.) *See* also 931 of 1937, and Kownacki & Ratcliffe, 3207 of August.

3895. Study of the Behaviour of Positive-Grid Triodes in Magnetic Fields.—Ch. Biguenet. (*Rev. Gén. de l'Élec.*, 2nd July 1938, Vol. 44, No. 1, pp. 9–15.)

It occurred to the writer that the action of a magnetic field, considered as an auxiliary variable whose action on the movements of electrons is well understood, would help in the study of the action of retarding-field (B-K) valves, whose theory is still very incomplete. "Two writers only, to our knowledge, have studied the behaviour of B-K generators in magnetic fields, and they have devoted themselves particularly to the investigation of the wavelength variations resulting from the fields (Forró, 1929 Abstracts, p. 269, and Jahoda, 1734 of 1936)."

One of the most important facts to learn is the velocity of the electrons at a given instant. To calculate this, it is necessary to study the distribution of the electric field along the probable path of the electron. The writer therefore begins by the investigation, by the compensated probe method, of the potential distribution in the interior of an enlarged model of the valve immersed in a trough of water. The exploring probe is fixed to one arm of a pantograph (*cf.* von Ardenne, 3553 of 1936). The results are shown in Figs. 3 & 4. The ratio of the potential V_g of the grid wires to the potential V'_g of a point M half-way between two of these wires is found, for the particular valve in question, to be between 1.30_5 and 1.31_5, if the plate is at zero potential. Calculation, by the theory of electrica images, gives the formula for this ratio seen at the bottom of the left-hand column of p. 11: this works out to 1.3_1.

Section III describes the experiments on the action of the magnetic field on the electron movement (circuit Fig. 6). With a weak field, it is confirmed that in order to set up oscillations it is necessary to carry the plate to a potential which is the higher, the stronger the magnetic field (this was already reported in an earlier paper—Pierret & Biguenet, 2125 of 1936). It is thus possible to trace the "oscillation characteristic" $H = f(V_p)$ for a given wavelength (Fig. 7, for a TM.AC3). A mathematical analysis of the mechanism of the phenomenon leads to equations for the electron motion which, in certain cases, can be solved graphically. "We have been able to show that the action of a weak magnetic field allows a given oscillatory régime of a triode to be prolonged over a wide region and that during the whole of this prolongation the wavelength remains practically constant [on two of the curves of Fig. 7 the wavelengths at the top and bottom of the curves differ slightly]. A more intense magnetic field has a curving action on the electrons so that their trajectories graze the grid; the triode then functions as a magnetron with the grid as anode, and in these conditions the wavelengths of the oscillations obtained preferentially are the same as those given by the simple triode. The shape of the characteristics show that a resonance phenomenon is involved, in which the grid [with its supports] plays the principal rôle, and that it may be hoped to improve the functioning of a triode by suitably modifying the grid on the lines indicated by these results."

3896. Choke Effects in the Ultra-Short-Wave Transmitter with Retroaction.—O. Döhler. (*Hochf:tech. u. Elek:akus.*, July 1938, Vol. 52, No. 1, pp. 9–14.)

Fig. 1 shows the "three-point" oscillator here investigated, which is compared with a Wheatstone's bridge (Figs. 2, 3). The theory of the circuit is worked out (§ II) from the primary equations. The "retroaction factor" (eqn. 5) and the frequency of the system are investigated for two cases: (1) when the point B (where the direct voltages are connected; Fig. 1) is connected directly to the grid, (2) where B is symmetrically placed with respect to G and A (grid and anode). Fig. 4 shows the frequency and retroaction factor as a function of the impedance between K (cathode) and B for case 1; Figs. 5, 6 show the retroaction factor for various numerical relations. § III describes experiments with the circuit of Fig. 7, wavelength 3 m, with and without chokes in the filament, grid, and anode circuits. It is found that "these chokes do not only prevent energy absorption but play an important part in the retroaction. It is better not to tune the filament chokes to resonance with the sender frequency but to make them, in general, capacitative. It is only advisable to tune the filament chokes as inductances when the short-circuit capacity is put

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near the grid. In this case the retroaction is greatest. A sender with 'acorn' valves (Figs. 9, 15) is described which is suitable for wavelengths 0.50 to 1.20 m, in which the leads to the cathode and to the feed point on the oscillating circuit are in the form of Lecher wires and thus all chokes are absent."

3897. THE PRODUCTION OF DWARF WAVES BY THE OSAKA TUBE.—K. Okabe, M. Hisida, & K. Owaki. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 212–214.) Further development of the work dealt with in 898 of March; *see* also Hollmann, 2330 of June.

3898. THE BEHAVIOUR OF THE HABANN VALVE [Split-Anode Magnetron] AS A NEGATIVE RESISTANCE.—F. W. Gundlach. (*E.N.T.*, June 1938, Vol. 15, No. 6, pp. 183–200.)

The thesis referred to in 2769 of July. These investigations are confined to the frequency range in which the fact that the anode is split is responsible for the oscillation mechanism. An oblique position of the valve electrodes relative to the magnetic field is not considered. The theoretical bases of the oscillation generation are expounded in § B; § B1 gives the fundamental equations for the electron motion, § B2 a graphical method for constructing the electron paths when the space charge is negligibly small. In this the electric potential field is assumed to be known; the curvature of the electron paths is calculated at every point (Fig. 2) and the path built up of small circular pieces. In § B3 an approximate solution of the equations of electron motion is determined and compared with graphical and numerical solutions for some examples (Fig. 3, two-slit magnetron; Fig. 4, unslit diode; Fig. 5, electron path and induction current in two-slit tube). The influence of the electron motion on the anode current is discussed in § B4; at high frequencies the induction effect of the motion is of importance. The fundamental quantities governing the working condition of Habann valves (with split anodes) fundamental symmetrical push-pull circuits Fig. 6, are defined in § B5; of these the most important are the *degree of curvature k* (eqn. 15) and the *degree of rotation* (eqn. 16) (*see* also 477 of 1937). Fig. 7 shows the potential fields in the magnetron discharge spaces. § B6 gives similarity conditions (eqns. 17, 18, 20) for unchanged current distribution (*i.e.* unchanged form of electron paths) with varying parameters; in § B7 the magnetron characteristics are theoretically deduced.

The behaviour of split-anode magnetrons at low frequencies is described in § C. § C1 deals with the static characteristics (Figs. 8, 9), § C2 with the oscillating characteristics (Figs. 10, 11), § C3 with the conditions for optimum working at low frequencies (Figs. 12–15). "Oscillations can be obtained for all degrees of curvature less than unity. In practice, a limit is put to the oscillation region by the fact that the resonance impedances of the connected oscillatory circuits cannot be arbitrarily increased. The larger the oscillatory-circuit resonance impedance, the smaller are the values of k which can be reached and the greater is the efficiency." In § D the behaviour at high frequencies is discussed; the potential distribution here changes while the electron passes from cathode to anode. Figs. 16, 17 show the electron paths and induction currents for starting at the voltage maximum and zero respectively, Fig. 18 the formation of the electron rotation paths, Fig. 19 the oscillation limits for a four-slit magnetron, Fig. 20 the oscillation limits and lines of optimum transit-time excitation. Fig. 21 gives a circuit for determining the h.f. oscillation characteristics, Figs. 22, 23 the oscillation characteristics and anode currents for high and low frequencies. It is found that oscillations can be produced when k lies between unity and the value given by eqn. 27. Shortly before the oscillation limit is reached, an optimum starting-point of oscillations is found at the value of k given by eqn. 29. Here also the smallest resonance impedance is found for which oscillations can be generated with magnetrons; transit-time oscillations begin here, due to a spiral electron path round the cathodes. High values of alternating current can be obtained here on account of the induction effect.

3899. METALLIC ELLIPSOID AS A FREQUENCY STABILISER [for Micro-Wave Oscillators: Superiority to Quartz or Tourmalin and to Coaxial or "Top-Hat" High-Q Circuits: Doublet Aerial ($\lambda/8$ on Each Side) placed on Focal Axis of Ellipsoid with Axes λ and $\lambda\sqrt{3/2}$].—K. Morita & K. Hayashi. (*Electrot. Journ.*, Tokyo, Aug. 1938, Vol. 2, No. 8, pp. 186–190.) *See* also 3168 of August.

3900. SPHERICAL CIRCUITS [Relation between Dimensions and Natural Frequency].—H. E. Hollmann: G. W. O. H. (*Wireless Engineer*, July 1938, Vol. 15, No. 178, pp. 369–370.) Prompted by G. W. O. H.'s editorial (2259 of June).

3901. COAXIAL AND BALANCED TRANSMISSION LINES: SOME USES AT HIGH RADIO FREQUENCIES.—Reed. (*See* 3875.)

3902. IMPROVING THE STABILITY OF THE ELECTRON-COUPLED OSCILLATOR [for Transmitter Frequency Control]: NEW CIRCUITS PROVIDE GREATER FREQUENCY-GENERATOR ISOLATION.—Beveridge: Guimont: Scoville. (*QST*, Aug. 1938, Vol. 22, No. 8, pp. 28–30.)

3903. PRECISION FREQUENCY-CONTROL EQUIPMENT USING QUARTZ CRYSTALS [for Precision within $\pm$ 0.03, 0.005, and 0.001%: Principles, Practical Designs, and Performance: particularly for Broadcast Stations in 500–1500 kc/s Band].—G. Builder & J. E. Benson. (*A.W.A. Tech. Review*, April 1938, Vol. 3, No. 4, pp. 157–214.) A World Radio Convention (Sydney) paper.

3904. CARRIER AND SIDE-FREQUENCY RELATIONS WITH MULTI-TONE FREQUENCY OR PHASE MODULATION [Analysis: Beat Side-Frequencies are of Small Amplitude as regards Out-of-Band Interference and do Not appreciably Widen the Band Width: etc.]—M. G. Crosby. (*RCA Review*, July 1938, Vol. 3, No. 1, pp. 103–106.)

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3905. The Response of a Valve Generator to a Modulating Voltage: the Approximate Solution of a Non-Linear Problem [due to Curvature of Valve Characteristic, making Exact Analytical Solution impossible: the Choice of the Concessions to be made (Small Circuit Power Factor, etc.): Derivation of Simple Algebraic Expression giving Sideband Cutting: Carrier-Frequency Fluctuation produced by Modulation, and Its Reduction: etc.].—E. B. Moullin. (*Wireless Engineer*, July 1938, Vol. 15, No. 178, pp. 371–377.) For a letter from Bell criticising certain points see *ibid.*, August, No. 179, pp. 439–440.

3906. Automatic Contrast Compressor for Broadcast Transmitter [Siemens Design for State Broadcasting Company].—Thilo & Bidlingmaier. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, p. 830: summary only.)

3907. Medium-Wave Transmitter Type B.E.M. 2/20 [for Ships: based on Cairo Conference Regulations].—(*Bull. de la Soc. franç. des Radioélec.*, 3rd Quarter 1938, Vol. 12, No. 3, pp. 77–89: in French and English concurrently.)

RECEPTION

3908. Experiments with Micro-Waves around 4.8 cm.—Esau & Ahrens. (*See* 4144.)

3909. Communication by Phase Modulation [and a New Receiver with Off-Neutralised Crystal Filter].—Crosby. (*See* 3518 of September.)

3910. Binaural Reproduction [New Results with Earphone System: Fine Reprodnction and Accurate Direction, but All Sense appearing in Hemisphere *behind* Head: Necessity for 3-Phase System if Amplitude, Direction, and Sense are to be conveyed?].—H. K. Robin. (*Wireless Engineer*, July 1938, Vol. 15, No. 178, pp. 368–369.)

Simple preliminary tests to elucidate the result suggest that unless there is good reason (by touch, sight, or experience) to the contrary, the brain interprets the sound as originating from behind. For comments by Sayers see *ibid.*, August, No. 179, p. 442.

3911. The Physiological Conditions for the Correct Functioning of Automatic Contrast Expansion Devices.—R. Hildebrandt. (*Funktech. Monatshefte*, July 1938, No. 7, pp. 210–212.)

"These considerations show that it would be most correct to make the regulating speed for decay processes as small as possible: this, however, would mean that the amplification of the expandor would sink so slowly, after a large amplitude, that the contrast would be lost. On the other hand, in order that no distortion of form or time differences may occur for decay processes, the regulating delay must amount to at least 1.5 sec. for a decay process, assuming a maximum contrast-control range of 1 : 4." In building-up processes, on the other hand, it is found that form distortions can be very great before they can be recognised, so that the regulating speed for these processes can be made high. A control-voltage-generating circuit such as that of Fig. 5 enables this inequality of regulating speeds to be obtained.

3912. Is there an Optimum Control Characteristic [for AVC Valves]?—Heymann. (*See* 3953.)

3913. The Systems of Automatic Receiver Tuning [Survey of Electrical, Mechanical, and Electro-Mechanical Systems on the Market].—U. Zelbstein. (*Toute la Radio*, Aug. 1938, No. 55, pp. 287–297.)

3914. New Tuning Indicator [Type 6AD6G] divides Control Range between Two Elements [for Use with a Double-Anode Valve Type 6AE6G].—Nat. Union Radio Corporation. (*Electronics*, July 1938, Vol. 11, No. 7, pp. 42 and 44.)

3915. The Wobbly Oscillator [for Receiver Alignment].—Reyner. (*See* 4056.)

3916. Damping Reduction and Sensitivity in Heterodyne Reception.—W. Kautter. (*E.N.T.*, June 1938, Vol. 15, No. 6, pp. 164–170.)

A circuit is given (Fig. 1) which permits the simultaneous measurement of all quantities of importance in auto-heterodyne reception, in particular the local e.m.f., the received e.m.f. on the grid, the audion anode current, and the l.f. output. This is made possible by the use of a two-stage quartz filter of 15 c/s band width, in parallel with the grid, so that the local and received voltages can be separated. Fig. 2 shows the measured connection between the voltage required in the aerial for 1 mv on the grid, the l.f. output, oscillating voltage, and anode direct current. The "steepness" (anode-current/grid-voltage ratio) for local and received signals is considered theoretically and measured with the circuit shown in Fig. 3. The large local voltage is found to determine the working point on the valve characteristic, and both signals are subject to the same damping reduction. A circuit for measuring the "local attenuation" is shown in Fig. 5, one for the "received-signal attenuation" in Fig. 7, and the results of measurement in Fig. 6. Theoretical consideration of the damping-reduction relations (§ 3) and rectification in heterodyne reception (§ 4) leads to a formula (eqn. 13) for the sensitivity (§ 5) with optimum adjustment. A theoretical comparison is made in § 6 between the sensitivities for telegraphy and telephony reception.

3917. The Selectivity of the Superhet [Good and Bad Ways of obtaining Satisfactory Selectivity: etc.]—R. Wigand. (*Rad., B., F. für Alle*, Aug. 1938, No. 198, pp. 121–126.)

A fact often (and regrettably) forgotten is that six thoroughly bad circuits may only give the same selectivity as one first-class modern circuit, but they give less sideband cutting (Fig. 42). This accounts for the satisfactory performance of many old "straight" receivers, especially American.

3918. Papers on Rectification.—(*See* under "Properties of Circuits.")

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3919. THE [Audio-Frequency] AMPLIFIER WITH RETROACTION.—H. Bohnenstengel. (*Funktech. Monatshefte*, July 1938, No. 7, pp. 199–201.)

For the high-quality reproduction of music it is easy to build amplifiers with completely linear transmission of the whole audible-frequency range. If however the amplifier has to form only a part of a whole receiver, the question of space occupied becomes important, and the use of a.f. regeneration, to reduce the necessary number of valves, comes up for consideration. The difficulty is that such retroaction is liable to upset the linearity of the characteristic, and the writer here examines how far the amplification can be raised by this means without noticeable cutting of the frequency band. In order to modulate an output stage fully with a comparatively small input voltage, retroaction is provided through a special winding on the output transformer; suitable design of the anode circuit ensures that in the middle frequency region the phase displacement between the primary and retroactive grid voltages is practically zero. At very high and very low frequencies a phase displacement occurs, and the distorting effect of this is investigated: it is seen to be of more importance at the lower frequency limit (eqn. 4). The copper resistance of the anode-circuit inductance produces a further phase displacement which must be taken into account, and eqn. 11 gives the final formula for the winding ratio of the retroactive coupling.

3920. SENSITIVITY LEVELLING [in a Multi-Range Receiver: the Appropriate Sensitivity Ratios and Practical Means of obtaining Them].—N. H. Browne. (*Wireless World*, 18th Aug. 1938, Vol. 43, pp. 138–139.)

3921. MODERN IRON-CORED COILS [Recent German Developments, including Cores adjustable within Narrow Limits for Trimming].—(*Wireless World*, 4th Aug. 1938, Vol. 43, pp. 90–92.)

3922. "RADIO INTERFERENCE: REPORT OF THE JOINT COORDINATION COMMITTEE ON RADIO RECEPTION."—National Elec. Light Assoc. & others. (At Patent Office Library, London: Cat. No. 78 747: 4 pp.) *See* 1933 Abstracts, p. 447, for summary.

3923. CONCERNING THE BROADCAST INTERFERENCE CAUSED BY ELECTRIC TRAMWAYS [particularly the Advantages of Carbon Collectors].—Duerler: Trechsel. (*Bull. Assoc. suisse des Élec.*, No. 16, Vol. 29, 1938, pp. 441–443: in French.) Prompted by the article by Trechsel (2743 of July), some of whose conclusions are contested.

3924. ELECTRICAL INTERFERENCE [a Protest from Harlesden, N.W.10].—(*World-Radio*, 12th Aug. 1938, Vol. 27, p. 6.)

3925. THE LISTENER'S BUGBEAR [Unsuppressed Sources of Man-Made Static: the Need for Legislation].—(*World-Radio*, 19th Aug. 1938, Vol. 27, p. 6.) Two letters and a comment by " Log-Roller."

3926. TESTING THE INSULATION OF HIGH-TENSION OVERHEAD LINES IN ACTION [by the " High-Frequency Fault Finder " with Frame Aerial: with Some Results].—B. Koske. (*E.T.Z.*, 7th July 1938, Vol. 59, No. 27, p. 721: summary only.)

3927. TAKING THE SET ABROAD: WHAT IT COSTS IN VARIOUS COUNTRIES.—(*World-Radio*, 5th Aug. 1938, Vol. 27, p. 6.)

3928. BROADCAST LISTENERS IN THE WORLD.—(*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, p. 842.)

3929. AN APPARATUS FOR RECORDING THE STRENGTH OF WIRELESS SIGNALS FROM A MORSE TRANSMITTER, *and* ELECTRO-MECHANICAL RESONANCE DECIPHERERS WITH A LATERAL OSCILLATING VIBRATION METER.—Budden: Lifschitz. (*See* 4105 & 4069.)

AERIALS AND AERIAL SYSTEMS

3930. GRAPHICAL SOLUTIONS FOR A TRANSMISSION LINE TERMINATED BY AN ARBITRARY COMPLEX LOAD IMPEDANCE [*e.g.* Television Aerial Feeders].—W. van B. Roberts. (*RCA Review*, July 1938, Vol. 3, No. 1, pp. 107–120.) For another graphical treatment, *see* Roder, 1933 Abstracts, p. 327.

3931. PASSIVE RELAYS [" Refractors "] FOR METRE AND DECIMETRE WAVES.—Loeb. (*See* 4145.)

3932. THE AERIAL FEEDER OF THE SWISS NATIONAL TRANSMITTER, BEROMÜNSTER [1.5 km-Long Concentric Gas-Filled Cable, with Calit-Disc Insulation: in 3 Lengths, with H.F. Transformers in Jointing Boxes: Telephone Cable in middle of Inner Conductor, for Measuring Purposes].—E. Baumann. (*E.T.Z.*, 11th Aug. 1938, Vol. 59, No. 32, p. 858: summary only.)

3933. THE EFFECT OF THE EARTH ON THE RADIATION IMPEDANCE OF SHORT-WAVE ANTENNAS [Investigation of Correction Factor necessary when Assumption of Earth as Perfect Conductor is Abolished].—Y. Kato. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 275–283.)

3934. DUAL TRANSMISSION: THE OPERATION OF TWO HIGH-POWER BROADCASTING TRANSMITTERS ON A SINGLE AERIAL [Experiences at Westerglen].—(*World-Radio*, 5th Aug. 1938, Vol. 27, p. 12.)

3935. WHICH DIRECTIVE SYSTEM? FACTORS INFLUENCING CHOICE OF DIRECTIVE ANTENNA ARRANGEMENTS [from Single Doublet to Double 230° Zepp with Reflector].—H. Romander. (*QST*, Aug. 1938, Vol. 22, No. 8, pp. 16–17.) For previous work *see* 3205 of August.

3936. SCREENED AERIALS WITH AND WITHOUT AMPLIFIERS.—H. Arnous & W. Hormuth. (*Funktech. Monatshefte*, July 1938, No. 7, pp. 193–198.)

Authors' summary:—To be satisfactory, a screened aerial system must provide a high signal/noise ratio at the receiver input terminals. For

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those cases where the length of the screening need not exceed 10 metres, the screened aerial without transformers may be used. For longer cables the bad effect of the cable capacity can be eliminated by the interposition of aerial-end and receiver-end transformers, by which the signal-voltage attenuation is reduced to a minimum and made practically independent of the cable length. The influence of the effective height of the aerial predominates over the importance of the aerial capacity for the efficiency of the screened system. The rod aerial can therefore be considered, in view of its mechanical, architectural, and interference-eliminating advantages, as the ideal form of aerial. Such a transformer system in its more developed form [*e.g.* with 300 ohm series resistances built into each subscriber's wall socket, to prevent interaction effects] gives good results as an economical community-aerial system for up to 5 subscribers. For a greater number of subscribers an installation with an aperiodic intermediate amplifier is desirable. By an efficient installation design taking into account the particular conditions of the locality, all difficulties connected with the amplifier (harmonics, cross-talk, combination frequencies, etc.) can be avoided. Up to 80 subscribers can be connected to such a community system with amplifier.

3937. CURVES FOR THE EASY CALCULATION OF SAG AND TENSIONS OF OVERHEAD LINES.—F. Besser. (*E.T.Z.*, 14th July 1938, Vol. 59, No. 28, pp. 751–752: to be concluded.)

VALVES AND THERMIONICS

3938. CONDUCTIVITY AND DIELECTRIC CONSTANT OF AN ELECTRON STREAM, *and* EFFECT OF A LONGITUDINAL MAGNETIC FIELD ON THE CONDUCTIVITY AND REFRACTIVE INDEX OF IONISED AIR.—Hollmann & Thoma: Singh. (*See* 3840 & 3839.)

3939. ELECTRON-INERTIA EFFECTS IN THERMIONIC TUBES [Frequency decreased by Application of Axial Magnetic Field].—McPetrie. (*See* 3894.)

3940. NEW INTEGRATION OF THE EQUATIONS OF MOTION OF AN ELECTRIFIED PARTICLE IN SUPERPOSED ELECTRIC AND MAGNETIC FIELDS.—T. Boggio. (*Comptes Rendus*, 11th July 1938, Vol. 207, No. 2, pp. 134–136.)

3941. DETERMINATION OF ELECTRON MOTION IN TWO-DIMENSIONAL ELECTROSTATIC FIELDS [Stretched-Rubber-Membrane Method].—P. H. J. A. Kleynen. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, p. 838: summary of paper in *Philips Tech. Review*.) For use of this principle *see* 3689 of September and back reference.

3942. EFFECT OF MAGNETIC FIELD ON THE INTERNAL RESISTANCE OF A THERMIONIC TUBE [Curves taken with UY 56 Triode inserted between Poles of Permanent Horseshoe Magnet: Internal Resistance can be More than Doubled].—Z. Yamaguchi. (*Electrot. Journ.*, Tokyo, Aug. 1938, Vol. 2, No. 8, p. 195.)

3943. STUDY OF THE BEHAVIOUR OF POSITIVE-GRID TRIODES IN MAGNETIC FIELDS.—Biguenet. (*See* 3895.)

3944. ULTRA-SHORT AND DECIMETRE-WAVE VALVES [and Colebrook's Formula for the Equivalent Input Shunt Resistance: the Writers' Formula giving both Positive and Negative Values of Resistance: Advantage of Transverse Control over Longitudinal: etc.].—H. E. Hollmann & A. Thoma: Colebrook. (*Wireless Engineer*, July 1938, Vol. 15, No. 178, p. 370.) Prompted by Colebrook's article (2324 of June). For a reply by Colebrook & Vigoureux see *ibid.*, August, No. 179, pp. 441–442.

3945. ULTRA-SHORT AND DECIMETRE-WAVE VALVES [of "Deflection" Type].—R. McV. Weston: Harries. (*Wireless Engineer*, Aug. 1938, Vol. 15, No. 179, p. 441.) Prompted by Harries's letter (3212 of August) and containing some additions (Boltzmann, Weintraub, and others) to his list of references.

3946. CORRECTIONS TO "ELECTRON TRANSIT TIME EFFECTS IN MULTIGRID VALVES."—Strutt. (*Wireless Engineer*, Aug. 1938, Vol. 15, No. 179, p. 422.) *See* 3208 of August.

3947. ON ELECTRONIC SPACE CHARGE WITH HOMOGENEOUS INITIAL ELECTRON VELOCITY BETWEEN PLANE ELECTRODES [Extension of Existing Theory by taking Account of Electrons which—after passing through Grid—are returned to Grid by Space-Charge Barrier in Grid/Anode Space].—M. J. O. Strutt & A. van der Ziel. (*Physica*, Aug. 1938, Vol. 5, No. 8, pp. 705–717: in English.) Some of these returning electrons pass for a second, third . . . time into the grid/anode space and strongly affect the potential and current course there.

3948. NEW RCA TUBES [including Type 832 U-H-F Transmitting Valve with Two Beam Power Units, and Types 1852 & 1853 for Experimental Television Receivers].—RCA. (*Communications*, July 1938, Vol. 18, No. 7, p. 38.)

3949. IN AMERICA TODAY [Special Pentodes for Ultra-Short-Wave Television].—(*Wireless World*, 28th July 1938, Vol. 43, pp. 84–85.)

3950. THE OSRAM U52 DIRECTLY HEATED DUAL-ELECTRODE-SYSTEM RECTIFIER FOR FULL-WAVE RECTIFICATION UP TO 250 mA, *and* THE OSRAM KTZ41 INDIRECTLY HEATED "KINKLESS" TETRODE FOR I.F. AMPLIFIER OR AS DETECTOR: CONSIDERABLE GAIN AT U-H FREQUENCIES: SUITABLE FOR WIDE-BAND TELEVISION AMPLIFIERS: LOW NOISE/SIGNAL RATIO.—General Electric Company. (*Journ. Scient. Instr.*, Aug. 1938, Vol. 15, No. 8, pp. 280–281.)

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3951. A NEW CONVERTER TUBE FOR ALL-WAVE RECEIVERS [Defects of Pentagrid Converter (Too Low Transconductance for Oscillator Section: Change of Oscillator Frequency with AVC Voltage: Space-Charge Coupling between Oscillator and Signal Circuits) avoided by Type 6K8 Converter with Many New Features (Rectangular Cathode asymmetrically situated, Separating Shields, etc.): Successful Operation above 100 Mc/s].—E. W. Herold, W. A. Harris, & T. J. Henry. (*RCA Review*, July 1938, Vol. 3, No. 1, pp. 67–77.)

3952. A NEW CONVERTER VALVE [for Elimination of Frequency Drift during Automatic Volume Control: Four-Beam Octode Type FC_4, Two Beams for Oscillator Section and Two for Converter: Specially Shaped Grids resulting in Higher Gain].—J. L. H. Jonker & A. J. W. M. van Overbeek. (*Wireless Engineer*, Aug. 1938, Vol. 15, No. 179, pp. 423–431.) From the Philips laboratories.

3953. IS THERE AN OPTIMUM CONTROL CHARACTERISTIC [for Variable-Mu Valves for AVC: Investigation by Method completely Different from Bergtold's, but reaching Same Conclusions].—O. Heymann. (*Funktech. Monatshefte*, July 1938, No. 7, pp. 219–220.) For Bergtold's treatment *see* 1430 of April.

3954. LINEAR RECTIFIER DESIGN CALCULATIONS [Linearisation of Diode Rectifier by Added Plate-Circuit Resistance].—Laport. (*See* 3888.)

3955. ON THE INFLUENCE OF THE IMPEDANCE OF THE CURRENT SOURCE IN DIODE RECTIFICATION.—Kraus. (*See* 3887.)

3956. BACKGROUND NOISE [Letter setting out Fundamental Differences between the Opposing Points of View in Previous Correspondence].—D. A. Bell: Percival & Horwood. (*Wireless Engineer*, Aug. 1938, Vol. 15, No. 179, pp. 440–441.) *See* 3218 of August.

3957. THE SHOT EFFECT WITH SPACE CHARGE [Calculations: Smoothing Factor: Automatic Control of Anode: Shot Effect for Showers, etc.]—J. M. Whittaker. (*Proc. Camb. Phil. Soc.*, April 1938, Vol. 34, Part 2, pp. 158–166.) For previous work *see* 370 of January.

3958. NOTE ON FLUCTUATIONS AND THE SHOT EFFECT.—E. N. Rowland. (*Proc. Camb. Phil. Soc.*, July 1938, Vol. 34, Part 3, pp. 329–334.) Amplification and further explanation of the work dealt with in 534 & 3689 of 1937. *See* also Whittaker, 370 of January, and 3957, above.

3959. COEXISTENT THERMAL AND THERMIONIC FLUCTUATIONS IN COMPLEX NETWORKS.—Williams. (*See* 3872.)

3960. STEEL VALVES FOR BROADCAST RECEPTION [particularly the New German Types and the Fundamental Differences between These and the American "Metal" Valves: Table of German Types: etc.].—C. Zickermann. (*Zeitschr. V.D.I.*, 6th Aug. 1938, Vol. 82, No. 32, pp. 929–934.)

The new valves are claimed to have the following advantages over glass-envelope valves:—in spite of small cathodes, the rigid construction leads to low noise levels and good temperature distribution; grids and anodes are led out at the same part of the valve, and yet the grid/anode capacity is very small; good capacitive screening between the different systems in multiple-system valves; good properties for short waves; good assembling characteristics; small dimensions and mechanical strength for car-radio types.

3961. ALL-METAL BROADCASTING VALVES [and the Differences between the American Metal-Envelope Valves and the German "Steel" Valves].—K. Steimel. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, pp. 813–815.)

3962. HIGH-POWER VALVES: CONSTRUCTION, TESTING, AND OPERATION.—Bell, Davies, & Gossling. (*Journ. I.E.E.*, Aug. 1938, Vol. 83, No. 500, pp. 176–198: Discussion pp. 198–207.) A summary was referred to in 2346 of June. From the M.O. Valve Company staffs.

3963. THE LIFE OF TRANSMITTING VALVES, AND ITS ACCURATE PREDICTION FROM THE FILAMENT DIAMETER.—Bell & others. (In paper referred to in 3962, above.)

3964. CALCULATION OF THE TEMPERATURE RELATIONS IN INDIRECTLY HEATED VALVE CATHODES ["Ostar" Cathode of Ceramic Cylinder penetrated by Several Channels (parallel to Axis) enclosing the Spiral Filaments].—F. Chmelka. (*Elektrot. u. Masch:bau*, 14th & 21st Aug. 1938, Vol. 56, pp. 417–420 & 435–439.) The calculation is first carried out for the simple case of a single channel, and the solution for n channels is then derived by conformal representation.

3965. THE CORRELATION OF COLOUR TEMPERATURES BASED ON THE WIEN AND THE PLANCK RADIATION FORMULAS.—R. S. Estey. (*Journ. Opt. Soc. Am.*, Aug. 1938, Vol. 28, No. 8, pp. 293–295.)

3966. GASES AND METALS [Cantor Lectures].—C. J. Smithells. (*Journ. Roy. Soc. Arts*, 5th, 12th, & 19th Aug. 1938, Vol. 86, pp. 936–949, 951–964, & 971–983.) With illustrations from the writer's book of the same name (4118 of 1937).

3967. AN ENGINE FOR SMOOTHING SMALL TUNGSTEN WIRES.—R. P. Johnson, A. B. White, & R. B. Nelson. (*Review Scient. Instr.*, Aug. 1938, Vol. 9, No. 8, pp. 253–255.)

3968. PAPERS ON SECONDARY EMISSION.—(*See* under "Phototelegraphy & Television.")

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DIRECTIONAL WIRELESS

3969. RADIO DIRECTION-FINDING ON WAVELENGTHS BETWEEN 6 AND 10 METRES (FREQUENCIES 50 TO 30 Mc/s) [Experiments with Rotating Loop and Rotating Spaced-Aerial (Adcock) Types: Accuracy: Effects of Wires, Pipes, Aerials, Trees, and Buildings: Effect of Wave Polarisation: etc.].—R. L. Smith-Rose & H. G. Hopkins. (*Journ. I.E.E.*, July 1938, Vol. 83, No. 499, pp. 87–97.)

3970. THE MEASUREMENT OF THE LATERAL DEVIATION OF RADIO WAVES BY MEANS OF A SPACED-LOOP DIRECTION-FINDER [Description of Four-Fixed-Loop Equipment: Its Performance: Proof of Lateral Displacement of Amount depending on Range and Type of Reflected Waves (Deviations up to 50° for Dorchester—160 km): Effective Points of Reflection at Ionosphere may be 50–100 km out of Great-Circle Path: "Cones" of Rays: etc.].—R. H. Barfield & W. Ross. (*Journ. I.E.E.*, July 1938, Vol. 83, No. 499, pp. 98–110.)

3971. A SHORT-WAVE CATHODE-RAY DIRECTION-FINDING RECEIVER [Accuracy within about 2°, for Field Strength of 10 μV/m, with Typical Aerial System for Waveband 30–70 m: Later Model for Wavelengths down to 15 m, with Special Method of Lining-Up].—Staff of Radio Research Station. (*Wireless Engineer*, Aug. 1938, Vol. 15, No. 179, pp. 432–439.)

3972. SINGLE INDICATOR FOR BLIND LANDING SYSTEMS ["Air Track" System, as at Pittsburgh Airport: Two Movable Pointers at Right Angles when Aeroplane is on Correct Course].—F. W. Dunmore. (*Sci. News Letter*, 23rd July 1938, Vol. 34, No. 4, p. 57.) *See* also 3628 of September.

3973. THE DANGER OF STATIC TO AIRCRAFT [and Starr's American Tests with Projecting Rods].—H. N. Ebrall: Starr. (*Proc. I.R.E. Australia*, May 1938, Vol. 1, No. 4, pp. 102–104.)

3974. DIRECT-READING ALTIMETER FOR AVIATION [Advantages of Radioelectric over Supersonic Altimeters: Objections to Aerial-Capacity, Phase-Difference, and Pulse Methods: the Author's Micro-Wave System with Frequency Modulation, using Beat-Frequency Meter as Indicator: Applicable also to Marine Purposes, including Prevention of Collisions].—S. Matsuo. (*L'Onde Élec.*, July 1938, Vol. 17, No. 199, pp. 362–371.) *See* also 1002 of 1937, and for the "modulated frequency" principle applied to supersonic waves *see* 3272 of August.

3975. "PANORAMIC RECEPTION" SHOWS PROMISE IN RADIO NAVIGATION [Receiver swept periodically over Given Band of Frequencies (*e.g.* 30 Times per Sec. by Motor-Driven Condenser) giving C-R Oscillographic Indication of Relative Signal Strength and Frequency Separation of All Stations within Band: Various Methods of Application to Direction Finding].—M. Wallace. (*Electronics*, July 1938, Vol. 11, No. 7, pp. 36 and 38 . . 42.)

3976. RADIO AIDS TO NAVIGATION [Survey].—H. Boxall. (*Proc. I.R.E. Australia*, May 1938, Vol. 1, No. 4, pp. 91–101.)

3977. MARINE RADIO BEACONS [Comparison of Various Systems, leading to Choice of Omnidirectional Beacons (with D.F. Apparatus on Ship): Description of System for 100 Miles' Range, to give Utmost Continuity of Service].—O. O. Pulley. (*A.W.A. Tech. Review*, July 1938, Vol. 3, No. 5, pp. 253–268.) A World Radio Conference (Sydney) paper.

3978. SPECIAL MAPS FOR USE WITH LOOP DIRECTION FINDERS [halving the Number (12) of Distinct Operations to draw a Wireless Position Line].—J. M. Coburn. (*Journ. Aeron. Sci.*, April 1938, Vol. 5, No. 6, pp. 233–236.)

ACOUSTICS AND AUDIO-FREQUENCIES

3979. SENSITIVITY AT DIFFERENT FREQUENCIES OF A SPHERICAL MODEL OF A PRESSURE-GRADIENT MICROPHONE.—J. de Boer. (*Physica*, July 1938, Vol. 5, No. 7, pp. 545–552: in English.)

The motion of the ribbon is easily calculated if the wavelength of the sound is very small, or very great, compared with the microphone dimensions, but when the wavelength is comparable with those dimensions the calculation is more complicated. It can be executed exactly if the shape of the microphone is simple, for instance a sphere, when the ribbon can be represented approximately by a part of the surface of the sphere lying between two circles, parallel to and at a small distance from the equator: the two other parts of the sphere form the pole-pieces, between which the thin shell (disc) can move. The writer carries out this calculation, and confirms his results by experiment. He finds that the sensitivity of the spherical model is independent of the frequency for values of ka equal to or less than 1, and that the phase difference between the velocity of the thin disc and the pressure of the sound wave is zero for values of ka equal to or less than 2 ($k = 2\pi/\lambda$, a = sphere radius).

3980. EXPLORATION OF PRESSURE FIELD AROUND THE HUMAN HEAD DURING SPEECH.—Dunn & Farnsworth. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, p. 83: summary only.)

3981. RESISTANCE AND MODULATION MEASUREMENTS ON CARBON MICROPHONES [in connection with the Elucidation of the Mechanism], *and* SURFACE LAYERS ON CARBON AND GRAPHITE POWDERS.—E. Waetzmann, O. Gigling, Th. Schmidt. (*Akust. Zeitschr.*, July 1938, Vol. 3, No. 4, pp. 169–175: pp. 176–180.)

3982. VACUUM OVEN FOR THE INVESTIGATION OF CARBON SAMPLES.—T. Schmidt. (*Akust. Zeitschr.*, July 1938, Vol. 3, No. 4, pp. 181–182.)

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3983. A Method for the Investigation of Electrical Deaf Aids [giving an Objective Measurement of the Amplification].—V. Thorsen. (*Akust. Zeitschr.*, July 1938, Vol. 3, No. 4, pp. 218–224.) On similar lines to the author's method of calibrating a condenser microphone (4092 of 1936).

3984. Equipment for the Measurement of Loudspeaker Response [giving Rapid Visual Observation of Sound-Pressure Curve or a Permanent Graphic Record of Response: Simple and Inexpensive Design].—J. B. Rudd. (*A.W.A. Tech. Review*, April 1938, Vol. 3, No. 4, pp. 143–156.) A World Radio Convention (Sydney) paper.

3985. Graphs for Exponential Horn Design.—A. J. Sanial. (*RCA Review*, July 1938, Vol. 3, No. 1, pp. 97–102.)

3986. The Ground Loudspeaker ["Bodenlautsprecher": a New Loudspeaker for Open-Air Work, as first used at Breslau German Sports, 1938: Waterproof Design, embedded in Ground].—G. Duvigneau. (*Zeitschr. V.D.I.*, 6th Aug. 1938, Vol. 82, No. 32, pp. 935–936.)

3987. The Analysis of the Forced Vibration of [Stretched] Circular Membrane, Circular Plate [Clamped or Free], and Hollow Sphere.—M. Matudaira & T. Hayasaka. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 231–246.)

3988. The Heat Capacity of Rochelle Salt [Very Little Indication of Anomaly at Upper Curie Point].—Wilson, Hicks, & Hooley. (*Phys. Review*, 1st July 1938, Series 2, Vol. 54, No. 1, p. 87.)

3989. Optical Observation of the Debye Heat Waves in Crystals [Photographs: Wavelengths of Corresponding Acoustic Velocities].—C. V. Raman & C. S. Venkateswaran. (*Nature*, 6th Aug. 1938, Vol. 142, p. 250.)

3990. On the Beam Gain of a Sound Source.—Y. Kikuti & K. Fukusima. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 286–287.)

3991. Disturbance of Sound Waves produced by a Rigid Sphere.—H. Stenzel. (*Journ. Acoust. Soc. Am.*, July 1938, Vol. 10, No. 1, pp. 78–79.) Long summary of the German paper referred to in 2817 of July.

3992. Sound Reinforcement in Westminster Abbey [the Permanent P.A. System].—(*Wireless World*, 28th July 1938, Vol. 43, pp. 83–84.)

3993. Acoustical Insulation afforded by Double Partitions constructed from Dissimilar Components [Theory: Occurrence and Properties of Minimum with Increase of Separation between Components: Double Partitions best constructed from Similar Components].—J. E. R. Constable. (*Phil. Mag.*, Aug. 1938, Series 7, Vol. 26, No. 174, pp. 253–259.)

3994. Binaural Reproduction [with Earphone System: a New Phenomenon].—Robin. (*See* 3910.)

3995. The Physiological Conditions for the Correct Functioning of Automatic Contrast Expansion Devices.—Hildebrandt. (*See* 3911.)

3996. Researches on the Recording and Reproduction of Sound by the "B" Intensity Process.—F. Steube. (*Akust. Zeitschr.*, July 1938, Vol. 3, No. 4, pp. 197–215.)

"The 'B' process [in which the positive and negative half waves have separate sound tracks] applied to amplitude recording has already proved extremely successful in practice in America . . . but on the other hand very little has been published on the combination of intensity ["ladder-rung"] recording and the 'B' process. In the following paper investigations on this are described."

3997. "Akustische Rückkopplung und Rückwirkung" [Book Review].—W. Bürck. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 19, 1938, p. 248.) *See* 575 of February.

3998. Standard Speech-Input Assemblies.—J. P. Taylor. (*Communications*, July 1938, Vol 18, No. 7, pp. 15–18 and 24, 29 . . 34.)

3999. An Input Switching Console.—J. B. Epperson. (*Electronics*, June 1938, Vol. 11 No. 6, pp. 38–41 and 73.)

4000. Portable Repeaters [for Lines used in Outside Broadcasts: the PER/3 Repeater].—O. W. Barron. (*World-Radio*, 1st July 1938, Vol. 27, pp. 16–17.)

4001. "Niederfrequenzverstärker und Übertragungsanlagen" [2nd Edition: Book Review].—P. Hatschek & R. Wigand. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31 p. 844.)

4002. The [Audio-Frequency] Amplifier with Retroaction.—Bohnenstengel. (*See* 3919.)

4003. Discussions on "Modern Systems of Multi-Channel Telephony on Cables."—Angwin & Mack. (*Journ. I.E.E.*, Aug. 1938, Vol. 83, No. 500, pp. 216–227.) *See* 163 of January.

4004. Relation between the Non-Linear Distortion and the Cross-Talk on Multiplex Transmission.—S. Yonezawa & Y. Hirayama. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 215–230.)

4005. The Application of the Tone-Pitch Recorder in Mathematical, Phonetic, and Musical Problems.—M. Grützmacher & W. Lottermoser. (*Akust. Zeitschr.*, July 1938, Vol. 3, No. 4, pp. 183–196.) Together with some improvements on the original apparatus dealt with in 1488 of April.

4006. The Circuit Noise-Meter (Psophometer) and Its Applications.—H. R. Harbottle. (*Journ. I.E.E.*, Aug. 1938, Vol. 83, No. 500, pp. 261–274: Discussion pp. 275–288.)

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4007. An Objective Noise-Meter for the Measurement of Moderate and Loud, Steady and Impulsive Noises [and the Danger of Much Too Low Results for Impulsive Sounds from Noise Meters conforming with a Recently Proposed Specification: also, the Dangers of the "Simultaneous Listening" Aural Method, and the Advantages of an "Alternate Listening" Method].—A. H. Davis. (*Journ. I.E.E.*, Aug. 1938, Vol. 83, No. 500, pp. 249–260: Discussion pp. 275–288.)

4008. A Working Standard for Telephone Transmission [with Permanent-Magnet Moving-Coil Transmitter and Receiver].—L. C. Pocock. (*Elec. Communication*, July 1938, Vol. 17, No. 1, pp. 16–21.)

4009. Laboratory and Measuring Equipments [New Apparatus, including the Rider Chanalyst (for Rapid Servicing, tracing Passage of Signal through Entire Receiver) and the Shure Pistonphone (L.F. Generator giving Readily Calculable Sound Pressures)].—(*Communications*, July 1938, Vol. 18, No 7, pp. 9–10 and 36.)

4010. Feedback Oscillator [using Simultaneous Positive and Negative Feedback, to give Very Small Harmonic Content (particularly at Low Audio-Frequencies) with Minimum of Circuit Elements: also for Valve-Driven Tuning Forks, and for use in Seismic Frequency Range].—P. M. Honnell. (*Review Scient. Instr.*, Aug. 1938, Vol. 9, No. 8, p. 258.)

4011. "Tabelle zur Berechnung von Ausgangstransformatoren . . .", *and* "Tabellen zur Berechnung von Drosseln" [Tables for Calculation of Output Transformers and Smoothing Chokes: Book Reviews].—P. E. Klein. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, p. 844: p. 844.)

4012. On the Effective Attenuation (Betriebsdämpfung) of Electroacoustic Systems [Extension of Electrical Definition into Acoustics: Its Use as a Dimensionless Quantity for Comparison of Quality of Electroacoustic Instruments].—H. Nukiyama & K. Fukusima. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 284–285.)

4013. Proposal for a Practical Definition of Loudness.—K. W. Wagner. (*Hochf:tech. u. Elek:akus.*, July 1938, Vol. 52, No. 1, pp. 14–18.)

After discussing the necessity for defining the idea of "loudness" (§ I) and various proposals which have been put forward for the definition (§§ II, III), the writer proposes to give numerical expression to the sensation of loudness by a quantity proportional to the acoustic pressure p of the normal tone of 1000 c/s of equal loudness. He suggests "the value of $p/100p_0$, where p_0 is the acoustic pressure at the audibility threshold. The proposed definition gives a scale of loudness which corresponds approximately to the sensation felt, avoids all the vagueness and contradiction of the purely psychological loudness scales, stands in a very simple relation to the 'phon' scale of acoustic intensity, and gives convenient numbers for the most commonly occurring degrees of loudness." He proposes the name *Wien* for the unit of loudness.

4014. The Diffraction of Light by Supersonic Waves in Solids, *and* Supersonic Waves as an Optical Shutter.—Nath: Maercks. (*See* 4042 & 4043.)

PHOTOTELEGRAPHY AND TELEVISION

4015. A New Television System [for 400 Lines, 25 Frame Frequency: based on Loop Oscillograph, with the Usual Distortion due to Its Sinusoidal Movement corrected by Optical Means using Cylinder Lenses].—D. von Mihaly. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, p. 833: summary only.)

4016. Television in Colour covered by New Patent [Scene broken up into Three (Primary Colour) Images *before* Scanning: Only One Photocell Bank required].—R. Harding, Jr. (*Sci. News Letter*, 30th July 1938, Vol. 34, No. 5, p. 70.)

4017. Figure of Merit for Television Performance [Resolution probably the Property which is Most Indicative of Quality: Methods of Measurement—the "Tapered Wedge Chart," or (for More Rigorous Tests) the "Sectionalised Resolution Chart"].—A. V. Bedford. (*RCA Review*, July 1938, Vol. 3, No. 1, pp. 36–44.)

4018. Title of the Italian Journal *Televisione* extended to *Radio e Televisione* [Review published by the National Institute for Cultural Relations with Foreign Countries].

The issue for July 1938 of the journal dealt with in 1067 of March is No. 1 of the third volume and inaugurates the new title. It contains Pession's Brussels address (in French) on Guglielmo Marconi: a paper by Sacerdote on the Acoustics of Broadcasting Studios: a page containing curves showing the chromatic sensitivity of old and new models of iconoscope compared with that of the eye: an instalment of Castellani's survey of Electronic Analysers for Television (including the SAFAR "telepantoscope"—*see* also 2272 of 1936): and other articles, including the first part of a paper by L. Pajetta on a Valve Frequency Meter for the Direct Indication of High Frequencies, in which he discusses the condenser-charging or discharging types of frequency meter, particularly the bridge-circuit and diode varieties which are the best suited to high frequencies. All these papers except the first are in Italian.

4019. 25 Kilowatt Television Transmitter at Eiffel Tower goes into Operation.—(*Electronics*, July 1938, Vol. 11, No. 7, pp. 46 and 48.)

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4020. A NEW MECHANICAL FILM-SCANNER [for the New German Standards : as exhibited at the 1938 Berlin Show].—K. Thöm. (*Zeitschr. der Fernseh A.G.*, Aug. 1938, Vol. 1, No. 1, pp. 24–28.) General description : the scanning process with multiple spirals (six) : the spiral-hole disc and its perforations (accuracy of position ; shape and size) : optical image correction : shrinking of the film (allowable limits, etc.) : brightness equalisation.

4021. NOTES ON NEW TELEVISION STANDARDS [Theoretical and Experimental Investigations leading to Present German Standards].—R. F. Wild : von Oettingen, Urtel, & Weiss. (*Communications*, July 1938, Vol. 18, No. 7, pp. 5–8 and 34, 35.) Long summary of the German paper dealt with in 3678 of September.

4022. THE VOLTAGE STABILISATION OF MAINS-DRIVEN APPARATUS UNDER VARYING LOAD [*e.g.* Television Modulating Systems].—Bastelberger. (*See* 3766 of September.)

4023. AUTOMATIC FREQUENCY CONTROL FOR SYNCHRONISING-SIGNAL GENERATORS FOR ASSURING SYNCHRONISM WITH THE A.C. MAINS.—F. Below. (*Zeitschr. der Fernseh A.G.*, Aug. 1938, Vol. 1, No. 1, pp. 14–18.)

The wider band-width of both the picture and sound channels in television makes the use of "automatic tuning correction," as now employed in many large broadcast receivers, of little importance for reception, and in any case the exhaustive treatment by Kettel (1393 of April) makes any further discussion of it unnecessary. But at the transmitting end such a system is extremely useful where the synchronising pulses are generated electrically by frequency division (where they are generated mechanically by rotating discs the synchronisation is assured by the use of synchronous motors), and particularly so for interlaced scanning, where correctness of phase is so important.

A regulating voltage proportional to the difference in frequencies is not good enough for the automatic frequency control, since the electrical back-lash of a control system based on such a voltage would allow too much frequency variation. The regulating voltage must, therefore, alter with the phase position (Figs. 1 & 3). The frequency-adjusting arrangements may vary according to the nature of the "mother" generator (generating the basic frequency from which the synchronising pulse frequencies are derived). The simplest method is that taken from broadcast-receiver practice (Figs. 3–5 ; Fig. 6 shows a variation) : here the basic frequency is sinusoidal, which is good as regards stability but is not very favourable for the subsequent frequency-dividing processes. A second plan (Knick's) is that of the frequency-regulated Abraham-Bloch multivibrator (Fig. 7), working on a rectangular wave form ; this is very good for frequency division, but for frequency regulation it requires rather large voltages and is thus inclined to let the frame-change frequency wander, in phase, from the mains frequency.

A third plan (due to Farhentholz) is the use of a Strauss multivibrator (an ordinary h.f. triode oscillator whose transformer has a large number of grid-circuit turns, so that over-back-coupled oscillations occur which build up very quickly and are then broken off by the negative charge produced by the grid current at the condenser C (Fig. 8). This circuit, adapted to the present purpose by the addition of another grid (U_{reg}) also gives a rectangular wave form, but it requires more input, for its frequency regulation, than can be supplied by the phase-measuring valve unaided : an extra stage is necessary. It has, however, the great advantage that it is well adapted to give a simultaneous division of frequency.

4024. A GLANCE BACK [at the Work of the Fernseh Company from 1929 to 1937].—R. Möller & G. Schubert. (*Zeitschr. der Fernseh A.G.*, Aug. 1938, Vol. 1, No. 1, pp. 2–3.)

4025. THE WIRELESS LARGE-PROJECTION RECEIVER WITH 1.5 M² PICTURE SURFACE [as exhibited at the 1937 Berlin Show : with Particular Attention to the Circuits employed to give Good Brightness and Uniform Gradation (Influence of Time Constant of Image-Signal Detector Circuit on the Gradation) : etc.].—W. Dillenburger. (*Zeitschr. der Fernseh A.G.*, Aug. 1938, Vol. 1, No. 1, pp. 29–35.)

4026. THE SCOPHONY TELEVISION RECEIVER [Description of Optico-Mechanical System with Light Control based on Diffraction of Light by Supersonic Waves in Liquid].—H. W. Lee. (*Nature*, 9th July 1938, Vol. 142, pp. 59–62.)

4027. A LABORATORY TELEVISION RECEIVER.—D. G. Fink. (*Electronics*, July 1938, Vol. 11, No. 7, pp. 16–20.)

4028. RAY GENERATION IN TELEVISION TUBES FOR PROJECTION PURPOSES.—E. Schwartz, H. Strübig, & H. W. Paehr. (*Zeitschr. der Fernseh A.G.*, Aug. 1938, Vol. 1, No. 1, pp. 5–13.)

Authors' summary (the numbers refer to the sections) :—(1) The fundamental requirements of a ray-producing system are formulated in their thermionic-valve and electron-optical aspects. (2) The generating system, for large-picture projection, of the Fernseh A-G is described. (3) The various possible types of cathode are discussed, and preference given to the directly heated tungsten cathode. (4) The influence of the cathode emissivity on the merits of a generating system is investigated [by varying the cathode heating]. It is found that the steepness of slope of the modulation curve increases up to a certain limit [the table on p. 7 (and Fig. 3) shows that for the tungsten filament examined this maximum slope is reached at 2750° K, corresponding to a life of 150 hours : "thus it is never desirable to go below this length of life ; it may under certain circumstances be advisable to go down to it, since the life of a projection tube is not determined by the cathode only," for an ordinary screen loaded with an average of 8–10 watts shows a falling-off in efficiency (of as much as 30%) after about 100 hours. Fig. 3 shows also the curve of a good oxide-coated hairpin cathode. It is seen that this, normally heated, gives the same emission as

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the tungsten cathode "at 2750° K" (this is evidently a mistake; it should read 2640° K), with a life of 770 hours. Tests are now being carried out to see whether such a life is obtainable from an oxide cathode at 40 kv and over].

"(5) The directivity of the system is independent of the quality of the cathode [" the ray divergence increases as the positive control-field-strength in front of the cathode becomes greater. It thus increases with the emission current. But whereas its connection with the former factor is a simple one, in the second case the cathode quality is involved as a parameter "]. (6) If the position of the cathode with respect to the modulating diaphragm [at the front of the Wehnelt cylinder] is altered, the effects on the directivity and on the slope of the modulation characteristic are opposite in sense [pushing the cathode further into the diaphragm-opening flattens the modulation slope but improves the directive action]. A discussion of the current-density curves indicates that for any given modulation conditions there exists an optimum position of the modulating elements relative to the cathode. (7) A specimen picture obtained with the ray-generating system here described is given [441 lines, anode voltage 40 kv, height of original picture 9 cm, so that the line thickness was about 0.2 mm].

4029. DETERMINATION OF ELECTRON MOTION IN TWO-DIMENSIONAL ELECTROSTATIC FIELDS.—Kleynen. (*See* 3941.)

4030. THE SHORT MAGNETIC [Electron] LENS WITH THE SMALLEST APERTURE ERROR [Theory].—W. Glaser. (*Zeitschr. f. Physik*, No. 11/12, Vol. 109, 1938, pp. 700–721.)

A "short" lens is understood to denote one in which the effective magnetic field acts over a length of the axis short compared with the focal length of the lens; such a lens, corrected, would be of particular importance for television reception tubes. For papers dealing with the case of an infinitely weak field *see* Scherzer, 3545 of 1936 (for further work on lens errors *see* 4195 of 1936) and Rebsch & Schneider, 280 of January. In the present paper, simple formulae for the aperture error (eqns. 15–18) are deduced from first principles, *via* a similarity law for the paths of electrons moving in an electromagnetic field. Two paths are said to be *similar* when they have the same characteristic number, given by eqn. 7. The type of magnetic field giving the smallest aperture error is then found to be that shown in Fig. 3a; it is represented by eqns. 38, 39, or, for sufficiently large values of the characteristic number, by eqn. 45. The magnitude of the aperture error is characterised by the dimensionless number A (eqns. 47, 48). A second type of magnetic field (Fig. 3b) is also discussed; eqn. 57 gives its form for smallest aperture error, eqn. 65 the relation connecting the breadth of the field and the focal length of the lens (magnetic field Fig. 6, practically a cosine curve, eqn. 66). The equation representing the magnetic field in all space is also determined (eqn. 68). The aperture errors of some other fields are determined for comparison.

4031. LUMINESCENCE OF SOLIDS AT LOW TEMPERATURES [Tables of Compounds Fluorescent at Low Temperatures, and Low Temperature Spectra of Impurity Phosphors Activated by Manganese].—J. T. Randall. (*Nature*, 16th July 1938, Vol. 142, pp. 113–114.)

4032. PERSISTENT FLUORESCENCE IN THE GROUP OF NATURAL LIMESTONES.—M. Déribéré. (*Comptes Rendus*, 18th July 1938, Vol. 207, No. 3, pp. 222–223.)

4033. TELEVISION I.F. AMPLIFIERS: DESIGNING WIDE-BAND COUPLINGS [and a Comparison between Single- and Double-Circuit Coupling: Use of Capacitance Trimmers is Inadmissible: etc.].—W. T. Cocking. (*Wireless Engineer*, July 1938, Vol. 15, No. 178, pp. 358–362.)

4034. COEXISTENT THERMAL AND THERMIONIC FLUCTUATIONS IN COMPLEX NETWORKS [with Application to Wide-Band Photocell Amplifier].—Williams. (*See* 3872.)

4035. SWITCHING PROCESSES IN CIRCUITS WITH INDUCTANCE AND VARYING OHMIC RESISTANCE [*e.g.* where the Varying Resistance is the Switching Element itself—a Grid-Controlled Valve or a Spark at "Break": Analysis, and Application to Various Types of Valve].—H. Bähring. (*Zeitschr. der Fernseh A.G.*, Aug. 1938, Vol. 1, No. 1, pp. 18–23.)

Author's summary:—The results of this investigation, as applied to valves, can be summed up by the statement that for the straight-line part of the anode-current/anode-voltage characteristic only the a.c. resistance is of importance. This is particularly the case for the pentode in the region where the anode voltage is above the screen-grid voltage. For diodes and triodes with the anode-current/anode-voltage relation $i = k(u - U_v)^n$ the exponent n is the determining quantity for the switching process. For every maximum amplitude I_0, and for every ratio I_0/K [$i = K \cdot u^n$], there is a certain value of n for which the switching time is a minimum. These minima lie in the range $1 < n < 2$ when $I_0/K > 8$, and are still more marked if a bias $-U_g = U_v > 0$ is applied. For K and $I_0 < 1$ the switching-off time decreases with falling K and increasing n. The voltage rise occurring during the switching-off process is proportional to the a.c. resistance in the linear region of $i_a = f(u_a)$.

4036. TELEVISION *via* TELEPHONE CABLES [for Outside Broadcasts over One or Two Miles].—A. R. A. Rendall. (*World-Radio*, 12th & 19th Aug. 1938, Vol. 27, pp. 12–13 & p. 13.)

4037. ON THE FREEDOM FROM INTERFERENCE OF COAXIAL WIDE-BAND LINES WITH TUBULAR EXTERNAL CONDUCTOR [Survey and New Results].—E. Müller. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, pp. 815–818.)

Low-frequency power-current fields: high-frequency external fields (commercial and broadcasting stations): neighbouring coaxial lines: the measuring equipment. Author's summary:—"From the results of these investigations it is found that with single coaxial lines with a four-wire

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[or pair] circuit lying over it, a covering of metallised paper is a sufficient protection against interference, and that with several coaxial lines an additional screening sheath of iron tape is desirable. The same provision is to be recommended for single coaxial lines which have no accompanying four-wire circuit and which as a rule are provided with a thin lead sheath. In this way cables with single or multiple coaxial lines can be made satisfactorily free from interference."

4038. MEASUREMENT OF ATTENUATION IN H.F. CABLES IN THE METRE-WAVE RANGE.—A. Dahme. (*Hochf:tech. u. Elek:akus.*, July 1938, Vol. 52, No. 1, pp. 1–9.)

The method of measurement here described uses the principle of Baumann & Roosenstein (1931 Abstracts, p. 616) in which a resonance curve is obtained by altering the frequency of the emitter. In § III an attenuation formula is derived by applying the theory of long lines to a cable short-circuited at the end; eqns. 13 & 20 give formulae on which the method of measurement is based. Measurements on various cables are described; the results are given in detail and show good agreement with the value of attenuation derived theoretically from the cable dimensions and insulating arrangements.

4039. DISCUSSIONS ON "MODERN SYSTEMS OF MULTI-CHANNEL TELEPHONY ON CABLES."—Angwin & Mack. (*Journ. I.E.E.*, Aug. 1938, Vol. 83, No. 500, pp. 216–227.) *See* 163 of January.

4040. COAXIAL CABLES: THEIR USE AT HIGH FREQUENCIES, PARTICULARLY FOR TELEVISION.—R. Bélus. (*L'Onde Élec.*, July 1938, Vol. 17, No. 199, pp. 325–337: to be contd.)

4041. THE USE OF POLYSTYROL (AS STYROFLEX) IN WIDE-BAND CABLES.—E. Fischer & F. H. Müller. (*E.T.Z.*, 11th Aug. 1938, Vol. 59, No. 32, pp. 858–859: summary only.)

4042. THE DIFFRACTION OF LIGHT BY SUPERSONIC WAVES IN SOLIDS [Theory of the Action as an Optical Diffraction Grating of Two Superposed Supersonic Waves, One formed by Longitudinal and the Other by Transverse Elastic Vibrations, passing in the Same Direction (a) through Liquids and (b) through Glass].—N. S. N. Nath. (*Proc. Camb. Phil. Soc.*, April 1938, Vol. 34, Part 2, pp. 213–223.) For previous work *see* 1944 of May.

4043. SUPERSONIC WAVES AS AN OPTICAL SHUTTER.—O. Maercks. (*Zeitschr. f. Physik*, No. 9/10, Vol. 109, 1938, pp. 598–605.)

For previous work on h.f. modulation of light by supersonic waves *see* 4119 of 1936 (and also 2523 of June). The attainable depth of modulation depends largely on the best possible realisation of a homogeneous standing wave; an arrangement (Fig. 2) is here described which uses the "schlieren" method for the adjustment of a homogeneous acoustic field and the best modulation. Fig. 3 shows how the depth of modulation depends on the homogeneity of the field. This modulation method may be used in the ultra-violet region; good constancy of frequency is attained by using a piezo-quartz crystal. Only a small amount of controlling energy is required and the time variation of the apparatus is small.

4044. ELECTRON MULTIPLIER DESIGN [and the Rubber-Membrane Method].—J. R. Pierce. (*Electronics*, July 1938, Vol. 11, No. 7, pp. 50 and 51: summary only.) *See* also 3689 of September, and Kleynen, 3941, above.

4045. THE SECONDARY EMISSION OF COMPOSITE SURFACES.—Khlebnikov & Korshunova. (*Tech. Phys. of USSR*, No. 5, Vol. 5, 1938, pp. 363–382: in English.) The Russian paper was dealt with in 3297 of August.

4046. METHOD OF TAKING FULL ADVANTAGE OF THE ALKALI PHOTOCELL WITH INERT-GAS FILLING, BY APPLICATION OF "SUPER-REGENERATIVE" PRINCIPLE.—Schäfer. (*See* 4201.)

4047. MEASUREMENTS ON SELENIUM PHOTO-ELEMENTS.—H. Schweickert. (*Zeitschr. f. Physik*, No. 5/6, Vol. 109, 1938, pp. 413–430.)

This investigation of the barrier layer in selenium photoelements deals first with the properties of the barrier layer in darkness and demonstrates the existence of the layer by resistance and capacity measurements. Fig. 1 shows the variation of resistance with applied voltage, Fig. 2a the selenium photoelement investigated, Fig. 2b the arrangement for capacity measurement. In § 3 the importance of the barrier layer for the performance of the photoelement is discussed, with an investigation (§ 3a) of the open-circuit voltage (Figs. 4–6) which indicates that the "flow" resistance (resistance in the current-passing direction) of the barrier layer is the factor responsible for the performance. Fig. 7 shows the power obtained from two photoelements with different "flow" resistances for various intensities of illumination. The temperature variation of the photocell is also shown to be due to the barrier layer (§ 3b, Fig. 8); the barrier-layer resistance is found (contrary to the belief of previous workers) to be independent of the illumination (§ 3c). The energy distribution of the photoelectrons (§ 3d) is shown in Fig. 9. Fig. 10 gives the results of experiments on the above points with three different cells, for red and blue light. The experimental results of Liandrat (*see* for example 826 & 3583 of 1935, and 1934 Abstracts, p. 624) could not be confirmed (§ 4) but the writer agrees with his theoretical explanations. The yield of quanta in the short-circuit current is determined (§ 5); it is greater than 0.5 but less than 1.0. The nature of the barrier layer is discussed in § 6; even small traces of mercury vapour have a deleterious effect on the action of the element and this seems to indicate that the layer consists of a non-conducting modification of selenium (amorphous or crystalline).

4048. THE EXPERIMENTAL DETERMINATION OF THE OPTICAL CONSTANTS OF METALS: THE METHODS AND RESULTS, *and* DETERMINATION OF OPTICAL CONSTANTS WITH THE AID OF AN OPTICAL PYROMETER.—J. B. Nathanson: A. G. Worthing. (*Journ. Opt. Soc. Am.*, Aug. 1938, Vol. 28, No. 8, pp. 300–310: pp. 311–312.)

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4049. The Latest Phototelegraphic Apparatus developed by E. Belin.—G. Gallarati. (*Televisione*, Rome, June 1938, Vol. 2, No. 6, pp. 305–312 : in Italian.)

4050. Photoradio Transmission of Pictures [Lecture to Photographic Society of America]. —H. Shore. (*RCA Review*, July 1938, Vol. 3, No. 1, pp. 45–62.)

MEASUREMENTS AND STANDARDS

4051. A Method of using Horizontally Polarised Waves for the Calibration of Short-Wave Field-Strength Measuring Sets by Radiation [with Experimental Proof that Simple Ray Theory holds for Horizontally (but Not for Vertically) Polarised Short Waves for practically All Heights of Transmitter and Receiver].—J. S. McPetrie. (*Journ. I.E.E.*, Aug. 1938, Vol. 83, No. 500, pp. 210–215.)

4052. Measurements of Attenuation in H.F. Cables in the Metre-Wave Range.—Dahme. (*See* 4038.)

4053. An Electronic Device for measuring Magnetic Fields [Special Cathode-Ray Tube for exploring Fields over Large Spaces]. —A. Rose. (*Electronics*, July 1938, Vol. 11, No. 7, pp. 21 and 53, 54.) *See* also 4140.

4054. An Impedance Meter [for Rapid and Accurate Measurements on Filters, Transformers, Loudspeakers, etc.].—A. W. Barber. (*Communications*, July 1938, Vol. 18, No. 7, pp. 23–24.)

4055. Laboratory and Measuring Equipments [New Apparatus, including the Rider Chanalyst (for Rapid Servicing, tracing Passage of Signal through Entire Receiver) and the Shure Pistonphone (L.F. Generator giving Readily Calculable Sound Pressures)].—(*Communications*, July 1938, Vol. 18, No. 7, pp. 9–10 and 36.)

4056. The Wobbly Oscillator [for Receiver Alignment, with C-R Oscillograph: Frequency Variation obtained by altering Permeability of Iron-Dust Core].—J. H. Reyner. (*Wireless World*, 11th Aug. 1938, Vol. 43, pp. 112–114.)

4057. A Rapid Oscillograph Method for testing Condensers [Capacitance & Leakage measured by Adjustment of Standard Variable Condenser, shunted by Variable High Resistance, to give Straight Line Trace on Screen of C-R Tube].—F. M. Bruce & J. A. Wilcken. (*BEAMA Journ.*, July 1938, Vol. 43, No. 13, pp. 7–8.)

4058. Galvanometer with Logarithmic Response [using Photoelectric Cell with Suitably Cut Illuminating Slit to produce Smaller Opposing Current through Galvanometer Coil].—Y. LeGrand. (*Comptes Rendus*, 4th July 1938, Vol. 207, No. 1, pp. 50–51.)

4059. A Thermionic Voltmeter with a Linear Law [for A.C. Mains: Direct-Reading, Range 0.1 to 1.0 Volt, Higher Voltages by Input-Divider Circuit: Frequency Error negligible to 1.5 Mc/s].—D. G. Reid. (*Journ. Scient. Instr.*, Aug. 1938, Vol. 15, No. 8, pp. 261–263.)

4060. Electron-Tube Vector-Meters.—L. I. Gutenmakher. (*Automatics & Telemechanics* [in Russian], No. 6, 1937, pp. 7–22.)

4061. "Electrical Standards for Research and Industry: Testing and Measuring Apparatus for Communication Engineering" [Book Review].—H. W. Sullivan, Ltd. (*Wireless Engineer*, Aug. 1938, Vol. 15, No. 179, p. 442.)

4062. New Investigations on the Direct-Reading Method of Frequency Measurement by Charging a Condenser.—H. A. Wahl. (*E.N.T.*, June 1938, Vol. 15, No. 6, pp. 171–182.)

Reference has been made to the principles of this method (Fecker, 3900 of 1936). The present work aims at increasing the accuracy and limits of measurement of the method and at explaining certain points. The fundamental circuit of the frequency meter is shown in Fig. 1; § I analyses the charging of the measuring condenser *via* the valves, § IA the conditions for a favourable charging characteristic (Fig. 2, variation of anode current with anode voltage) and the error due to variations of the charging time, § IB error curves of commercial valves (Fig. 3), § IC the practical determination of the charging characteristic (Fig. 4), § ID the variation with time of the condenser voltages and the charging currents (oscillograms Figs. 5, 6). In § II the control of the charging valves is discussed; this may be done (1) with a reversing valve (circuit Fig. 7) or (2) with a push-pull input circuit (Fig. 8). The lower and upper limits of frequency which can be measured are dealt with in § III; the lower limit is determined by the increasing vibration of the indicator consequent on insufficient smoothing of the charging impulses. Methods of decreasing this are given, including doubling the number of impulses per period by the circuit of Fig. 9. The actual upper limit (Fig. 12) is determined by effects due to the control circuit (Fig. 10, effective capacities at high frequencies), including additional shortening of the charging time and phase displacement between the charging current impulses. The effects due to harmonics are discussed in § IV; they cause changes in the charging time (§ IVA, Figs. 13, 14; Fig. 15, effect of the relative phases of the harmonics on the charging time). If the amplitude of the harmonics becomes so large that the oscillation passes the zero position more frequently than the normal number of times, the number of charging impulses may be increased and the measuring current may rise (§ IVB; Figs. 16–18); there may be a region in which no unique frequency measurement can be made (Fig. 19, measured value as a function of the "klirr" factor; Figs. 20, 21). For an arbitrary curve form (§ IVC) the method really measures the number of zero transits and is more likely to give true frequency readings if the

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measuring voltage crosses the zero line at a very steep angle. With modulated oscillations, the carrier frequency is measured correctly if the depth of modulation is small. A summary of the errors and a short comparison with other methods is given in § v.

4063. SCHEME WITH LOGOMETER FOR FREQUENCY MEASUREMENT IN NARROW BAND ABOUT 50 c/s [with Precision up to 0.02 c/s].—R. R. Kharchenko. (*Automatics & Telemechanics* [in Russian], No. 6, 1937, pp. 23–28.)

4064. A VALVE FREQUENCY METER FOR THE DIRECT INDICATION OF HIGH FREQUENCIES.—Pajetta. (*See* 4018.)

4065. METALLIC ELLIPSOID AS A [Micro-Wave] FREQUENCY STABILISER.—Morita & Hayashi. (*See* 3899.)

4066. THE NATURE AND APPLICATIONS OF PIEZO-ELECTRICITY [Survey].—E. C. Metschl. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, pp. 819–825.)

4067. A METHOD FOR DETERMINING THE ADIABATIC ELASTICITY MODULI OF CRYSTALS [from Supersonic Velocities of Propagation].—E. Baumgardt. (*Comptes Rendus*, 25th July 1938, Vol. 207, No. 4, pp. 273–274.)

4068. THE HEAT CAPACITY OF ROCHELLE SALT [Very Little Indication of Anomaly at Upper Curie Point].—Wilson, Hicks, & Hooley. (*Phys. Review*, 1st July 1938, Series 2, Vol. 54, No. 1, p. 87.)

4069. ELECTRO-MECHANICAL RESONANCE DECIPHERERS WITH A LATERAL OSCILLATING VIBRATION METER [and the Theory of Electrically-Driven Reeds and Tuning Forks].—N. A. Lifschitz. (*Automatics & Telemechanics* [in Russian], No. 6, 1937, pp. 29–58.)

4070. A NEW SELF-DRIVEN SCHULER CLOCK AND THE PERFORMANCES OF TWO SCHULER PENDULUMS, MAY/SEPTEMBER 1937 [Sudden Jumps occur about Every Six Days, also in Rugby Time Signals from Greenwich Shortt Clock: Possibly due to Earthquakes].—H. Gockel & M. Schuler. (*Zeitschr. f. Physik*, No. 7/8, Vol. 109, 1938, pp. 433–458.)

4071. THE WHEATSTONE BRIDGE WITH RESISTANCES DEPENDENT ON THEIR LOAD [Incandescent Lamps, Iron-Wire Barretters, Semiconductors, Glow-Discharge Lamps, etc: Applications and Advantages: Effects of Thermal Inertia: Bibliography].—G. Nidetzky. (*Elektrot. u. Masch:bau*, 19th & 26th June 1938, Vol. 56, Nos. 25 & 26, pp. 317–324 & 334–342.)

4072. CIRCLE DIAGRAM OF A.C. BRIDGE.—M. Monji. (*Electrot. Journ.*, Tokyo, Aug. 1938, Vol. 2, No. 8, pp. 195–196.)

4073. THE COMPARISON OF SERIES OF MEASURES WHEN THE STANDARD ERRORS ARE UNEQUAL.—H. Jeffreys. (*Proc. Roy. Soc.*, Series A, 7th July 1938, Vol. 167, No. 928, p. S 81: abstract only.)

4074. ABSOLUTE PERMITTIVITY [of a Dielectric Medium or Space: Note on Its Definition].—G.W.O.H. (*Wireless Engineer*, July 1938, Vol. 15, No. 178, p. 357.)

4075. SHOULD THE RATIONALISED M.K.S. SYSTEM OF UNITS BE ADOPTED?—G.W.O.H. (*Wireless Engineer*, Aug. 1938, Vol. 15, No. 179, pp. 411–413.)

SUBSIDIARY APPARATUS AND MATERIALS

4076. THE ELECTRON "RASTER" MICROSCOPE: THEORETICAL FOUNDATIONS.—M. von Ardenne. (*Zeitschr. f. Physik*, No. 9/10, Vol. 109, 1938, pp. 553–572.)

For the writer's work on the limits of the resolving power of the ordinary electron microscope see *Zeitschr. f. Physik*, 1938, Vol. 108, p. 338: a summary in English is referred to in 3739 of September. In this it is shown that the attainable resolving power is much diminished by the chromatic errors due to the different degrees of electron retardation produced in the object film and the foil beneath it. The "raster" microscope now described avoids this and thus permits the full resolving power to be applied to thicker object films and the observation of objects in air. The principle is that an extremely fine "electron probe" (exploring ray) produced by several electron-optical reducing stages (Figs. 1 & 2) is moved over the object surface in the manner of a television "raster"; the effects of the object elements on this ray are made to reproduce, in image form, the fine structure of the object. Fig. 3 illustrates the derivation of the object "raster." Fig. 4 gives three methods of illuminating the microscope, which can be done by all the known methods for the optical microscope. Fig. 5 shows the arrangement of the object for investigations (a) in a vacuum, and (b) in air.

In § B the limits of the resolving power of the "raster" microscope are discussed; errors may be caused by electron diffraction (Fig. 8), by space charge (Fig. 9, auxiliary curves for determining its effect, though this is not of practical importance), by the aperture width, by spatial electron scattering, and by disturbing magnetic fields; chromatic errors may occur, though these are unimportant. The effect of these errors is tabulated (Tables 2, 3). The limits of contrast control are discussed; it is found that the contrast can be artificially increased at the cost of intensity, which is not the case with the electron microscope. § C deals with questions of intensity and resolving power, including the intensity of the electron probe (Fig. 10). Fig. 11 gives the connection between the probe current strength which can be recorded and the limit of resolving power, due to aperture error alone, for various types of cathode emission. Various electron indicators and their limiting sensitivity are discussed; Fig. 12 gives a quantitative basis for the sensitivity of photographic electron indication. Illustrations are given of a "raster" micro-image

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of ZnO crystals (Fig. 13a) and an optical micro-image of the same crystals (Fig. 13b); Fig. 14 shows a microscopic photograph of part of the line " raster " of Fig. 13a with brightness modulations.

4077. THE PRESENT POSITION OF THE " SUPER-MICROSCOPE " [Übermikroskop: Name suggested to distinguish from Previous Electron-Microscopes for Investigation of Electron-Emitting Objects only].—von Borries & Ruska. (*Zeitschr. V.D.I.*, 6th Aug. 1938, Vol. 82, No. 32, pp. 937–941.)

4078. FURTHER PROGRESS IN THE DESIGN AND PERFORMANCE OF THE SUPER-MICROSCOPE, *and* SUPER-MICROSCOPE BACTERIA OBSERVATIONS.—von Borries & Ruska. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, p. 836: p. 836: summaries only, of papers in *Wiss. Veröff. Siemens-Werk*.)

4079. THE SIEMENS " SUPER-MICROSCOPE " [Magnetically Focused Electron-Microscope, with First Stage giving 75 Magnification and Second giving 400, *i.e.* Total Magnification of 30 000].—Siemens & Halske. (*Elektrot. u. Masch:bau*, 31st July 1938, Vol. 56, No. 31, pp. 398–400.)

4080. PERFORMANCE AND NEW APPLICATIONS OF THE " MAGNETIC ELECTRON-MICROSCOPE " [Resolving Power claimed to be Twice as Great as that of the von Borries & Ruska " Super - Microscope ": Photographs of Aerosols, Viruses, etc: Superiority over " Ultra-Microscope "].—Krause. (*E.T.Z.*, 11th Aug. 1938, Vol. 59, No. 32, pp. 851–853.) For the " super-microscope " *see* above.

4081. THE SHORT MAGNETIC ELECTRON LENS WITH THE SMALLEST APERTURE ERROR.—Glaser. (*See* 4030.)

4082. THE FORMATION OF ELECTRON-OPTICAL IMAGES OF CATHODES IN A GASEOUS DISCHARGE.—Mahl. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, p. 838: summary only.)

For cold objects the practical methods of setting free electrons are by the action of light or by the impact of positive ions or electrons. The writer examines the use of positive gaseous-discharge ions produced in the image-forming chamber itself. The free paths of the electrons must be greater than the distance from cathode to screen, to avoid scattering by the gas: the implications of this fact are considered. The ionisation can be increased (and with it the image brightness) without lightening the background, by lengthening the paths of the slow secondary electrons by means of a longitudinal magnetic field, which does not appreciably affect the image-electron paths: thus an auxiliary coil 12–15 cm from the cathode will multiply the discharge current by as much as 100 without spoiling the image by lightening the background.

4083. LOW-VOLTAGE ELECTRON DIFFRACTION TUBE [giving Photographic Records with Electrons of 2000 V Energy].—Darbyshire. (*Nature*, 30th July 1938, Vol. 142, p. 214.)

4084. NEW INTEGRATION OF THE EQUATIONS OF MOTION OF AN ELECTRIFIED PARTICLE IN SUPERPOSED ELECTRIC AND MAGNETIC FIELDS.—Boggio. (*Comptes Rendus*, 11th July 1938, Vol. 207, No. 2, pp. 134–136.)

4085. DETERMINATION OF ELECTRON MOTION IN TWO-DIMENSIONAL ELECTROSTATIC FIELDS.—Kleynen. (*See* 3941.)

4086. AN APPARATUS FOR DETERMINING THE TRANSMISSION OF SLOW ELECTRONS THROUGH THIN COLLODION FILMS [*e.g.* Windows of Geiger Counter used in determining Photo-electrons ejected by X-Rays].—Ference & Stephenson. (*Review Scient. Instr.*, Aug. 1938, Vol. 9, No. 8, pp. 246–248.)

4087. INVESTIGATING CATHODE-RAY TUBES WITH " CONTAX " PHOTOGRAPHY [Use of " Contax " Camera to measure the Three Possible Types of Distortion].—Görlich & Ploke. (*Photographie und Forschung*, July 1938, Vol. 2, No. 6, pp. 177–182: in English.)

4088. ON THE VOLTAGE STABILISATION OF HIGH-VOLTAGE EQUIPMENT [particularly Necessary for Electron-Diffraction Work and Electron-Microscopy: Existing Arrangements can give a Constancy within 0.1 per Thousand, however High the Voltage, provided that a Stabilising Device can be inserted in the Low-Voltage Circuit: Simple Modifications may increase Constancy by a further Order of Magnitude].—Bartel. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 19, 1938, pp. 235–237.)

4089. ELECTRONIC SWITCHING CIRCUITS [and the Generation of Voltage Impulses of Less than 1 Microsecond Duration].—Brown & Ryburn: Shumard. (*Elec. Engineering*, Aug. 1938, Vol. 57, No. 8, p. 360.) Prompted by Shumard's article (2945 of July).

4090. SWITCHING APPARATUS FOR THE RECORDING OF SHORT-TIME ELECTRICAL PROCESSES WITH THE LOOP OSCILLOGRAPH.—Neumann. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, pp. 835–836: summary only.)

4091. THE MECHANISM OF SYNCHRONISATION IN THE LINEAR TIME BASE [Theoretical Study of Thyratron Action].—G. F. H. Harker. (*Phil. Mag.*, Aug. 1938, Series 7, Vol. 26, No. 174, pp. 193–213.)

4092. CATHODE-RAY TUBE MONITOR [Miniature Hard-Vacuum Tube for Monitor Circuits or Portable Radio-Servicing Purposes].—General Electric Company. (*Journ. Scient. Instr.*, Aug. 1938, Vol. 15, No. 8, p. 281.)

4093. AN ELECTRONIC [C-R Tube] DEVICE FOR MEASURING MAGNETIC FIELDS.—Rose. (*See* 4053.)

4094. APPARATUS FOR RELAY TESTING [Simpler than Oscillograph Methods: Gaseous-Discharge Lamp driven by Synchronous Motor at 600 r.p.m. round Circular Scale reading in Milliseconds].—Mutschke. (*E.T.Z.*, 11th Aug. 1938, Vol. 59, No. 32, pp. 853–854.)

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4095. A Rapid Oscillograph Method for testing Condensers.—Bruce & Wilcken. (*See* 4057.)

4096. Luminescence of Solids at Low Temperatures.—Randall. (*See* 4031.)

4097. New Types of Fluorometer [using Standing Supersonic Wave as Light Interrupter].—O. Maercks. (*Zeitschr. f. Physik*, No. 11/12, Vol. 109, 1938, pp. 685–699.)

In the first type of fluorometer, using a standing supersonic wave as light interrupter (Fig. 1), the decay time is determined "by the change in intensity of the diffracted light for a second passage of light through the supersonic wave." This requires a variable optical path, which is not needed in the second type (Figs. 6, 9). This uses as an analyser "the image of a progressive supersonic wave, stroboscopically illuminated, which changes its position when the illumination takes place first with direct and then with fluorescent light. When the frequency of interruption is known, the change in position gives the decay times directly." Results of measurements are given from which the accuracy is found to be 0.2×10^{-9} sec.

4098. Persistent Fluorescent Materials in Gas-Discharge Lamps: Improvement of Luminous Output, Colour, and "Ripple" [Welligkeit] of the Light.—Andresen. (*Elektrot. u. Masch:bau*, 31st July 1938, Vol. 56, No. 31, pp. 403–404: summary only.) The "ripple factor" (amplitude ratio of fundamental brightness-fluctuation to steady flux) is a measure of the subjective value of flicker.

4099. Investigation of the Diffuse Fluorescence Spectrum of Rare-Earth Ions in Solution and in a Crystal.—Mukherji. (*Zeitschr. f. Physik*, No. 9/10, Vol. 109, 1938, pp. 573–585.)

4100. Distribution of Fluorescence Excitation of Bivalent Europium in Calcium Fluoride and of Bivalent Samarium in Calcium Sulphate [Wavelengths of Fluorescence Maxima].—Eckstein. (*Nature*, 6th Aug. 1938, Vol. 142, pp. 256–257.)

4101. The Fluorescence and Absorption of Pr^{+++} and Eu^{+++}: II—The Emission and Absorption Spectrum of Trivalent Europium.—Lange. (*Ann. der Physik*, Series 5, No. 4, Vol. 32, 1938, pp. 361–377.)

4102. A Vacuum Relay [Pirani Gauge in A.C. Control Circuit].—Miller. (*Journ. Scient. Instr.*, Aug. 1938, Vol. 15, No. 8, pp. 263–265.)

4103. Electro-Mechanical Vibration Device as a Time-Marker and Recording-Drum Drive [in Absence of Time-Controlled Mains, *e.g.* in Aircraft, or where Greatest Accuracy is required].—Krummow. (*Elektrot. u. Masch:bau*, 31st July 1938, Vol. 56, No. 31, p. 402: summary only.)

4104. Calculation of High-Frequency Multiple Accelerators [Electronic or Ionic, for Generation of High Voltages: with a View to reconciling the Conflicting Requirements of High Voltage Efficiency (demanding Small Accelerating Paths) and Small Capacity (demanding Long Paths)].—Schlosser. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 19, 1938, pp. 237–240.) *See*, for example, Wideröe, 1929 Abstracts, p. 169, and Sloan, 2063 of 1935.

4105. An Apparatus for Recording the Strength of Wireless Signals from a Morse Sender.—K. G. Budden. (*Proc. Camb. Phil. Soc.*, July 1938, Vol. 34, Part 3, pp. 470–473.)

This apparatus (circuit Fig. 1) uses a "slow-moving galvanometer of the 'thread-recorder' type," which makes an ink record on paper every 30 secs., fed from "a detector arrangement which provided a steady current proportional to the received signal amplitude and therefore independent of the speed of the Morse sending." The detector was of the "slide-back diode" type; the galvanometer zero was periodically recorded. A record is given (Fig. 2) taken on a wavelength of 15.15 km and showing a sudden increase of signal strength at a time corresponding to a Dellinger "fade-out."

4106. The Behaviour of Resistors at High Frequencies [Howe's Calculation of Effect of Distributed Capacity of Rod Type verified by Measurements up to 100 Mc/s].—Hartshorn: G.W.O.H. (*Wireless Engineer*, July 1938, Vol. 15, No. 178, pp. 363–368.) For Howe's calculations *see* 3694 & 4076, both of 1935.

4107. Direct-Voltage Distribution on the Surface of Insulators [Experiments].—Ziegler. (*Arch. f. Elektrot.*, 11th July 1938, Vol. 32, No. 7, pp. 419–433.)

4108. On the Theory of Electrical Breakdown [of Solid Insulators]: the Influence of Temperature: the Influence of Time on the Breakdown Voltage.—Böning. (*Bull. Assoc. suisse des Élec.*, No. 14, Vol. 29, 1938, pp. 368–373: pp. 373–376: both in German.)

In the first paper the influence of temperature on the dielectric rigidity, intensity of minimum field, and number of adsorbed ions is examined, in order to deduce the relation between the perforating voltage and the temperature. Measurements (quoted from other workers) on glass and ceramic materials, including Frequenta, show good agreement with the theory. In the second paper the writer deduces, from the same theory of the adsorption of ions at the internal limiting surfaces, a relation for the delay between the application of a voltage to an insulator, of given nature and thickness, and the moment when perforation occurs. Practical results in agreement with the theory are quoted.

4109. The Influence of High Electrical Voltage on Insulator Porcelain under Dynamic Bending Stresses.—Schmidt. (*E.T.Z.*, 7th July 1938, Vol. 59, No. 27, p. 727: summary of Jena Dissertation, 1937.)

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4110. Tests on Insulator Porcelain [including the Interaction of Mechanical and Electrical Stresses].—Schmidt: Schaudinn. (*Zeitschr. V.D.I.*, 6th Aug. 1938, Vol. 82, No. 32, p. 928.)

4111. Investigation of the Amorphous State: XII—Dielectric Relaxation in Amorphous Phenol-Phthalein.—Kuvshinski & Kobeko. (*Tech. Phys. of USSR*, No. 5, Vol. 5, 1938, pp. 401–409: in English.) The Russian paper was referred to in 3372 of August. "It is necessary to revise the molecular picture of dielectric phenomena developed by Debye for polar liquids."

4112. On Reducing the Specific Volume of Electrolytic Condensers.—Petrovski. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1938, pp. 50–52.)

It is suggested that if the aluminium anodes of an electrolytic condenser are treated by a substance in which aluminium does not dissolve uniformly, the effective surface of the plates will be increased and the capacity of the condenser thus raised. In this paper a report is presented on experiments in which the anode plates were first treated by an alkali (solution of NaOH) and then by an acid (solution of HCl). Various stages of this treatment and of subsequent forming of the anode plates are described, and the results obtained are discussed and shown in a number of tables. It appears that in this way it is possible to raise the capacity of a condenser from 6.6 μF to 35.0 μF. It is pointed out, however, that as a result of this treatment losses in the condenser are also considerably increased.

4113. On the Use of Ceresin for the Impregnation of Low Voltage D.C. Paper Condensers.—Walter & Inge. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1938, pp. 48–50.)

A number of cylindrical and flat paper condensers were impregnated, some with paraffin and some with ceresin; in both cases in a vacuum and by boiling out under atmospheric pressure. These condensers were then subjected to exhaustive tests which have shown that the ceresin-impregnated condensers (a) have a high thermal stability making them suitable for working under temperatures up to 60°C, (b) that their electrical properties are somewhat better than those of the paraffin-impregnated condensers, and (c) that the thermal stability of ceresin with respect to oxidisation is many times greater than that of paraffin. It is therefore suggested that ceresin should be used for the impregnation of condensers in preference to paraffin.

4114. Effect of Curve Form [of Voltage] on the Breakdown Voltage of Some Insulating Materials [Condenser Papers, Transformer Oils, etc: Probable Influence of Heat].—Gänger. (*Arch. f. Elektrot.*, 10th June 1938, Vol. 32, No. 6, pp. 401–404.)

4115. The Electrical Properties of Synthetic Insulating Materials as a Function of Temperature.—Pfestorf & Hetzel. (*E.T.Z.*, 18th Aug. 1938, Vol. 59, No. 33, pp. 875–879.)

Authors' summary:—The influence of temperature on the electrical properties of numerous synthetic materials, particularly condensation resins, is investigated, and it is shown that the values of these properties of such materials are dependent on the nature and duration of their pre-heat-treatment. A simple equipment is described by which the measurement of the dielectric properties of solid insulating materials, as a function of the temperature, can be carried out on numerous samples under the same conditions, so that a comparison of the various materials is possible. Nine tables give the dielectric loss factors and dielectric constants, at 50 and 800 c/s, as well as the specific conductivities, of a series of synthetic materials in the temperature range 20 to 80°C.

4116. The Permeability to Water of Synthetic Materials [including Styroflex, Buna S, Cellophane, etc: in connection with Substitution for Lead in Cable Sheaths].—Badum & Leilich. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, p. 838: summary only.)

4117. Tables of Type-Classified and Controlled Moulding Materials [for Insulating, etc: with Makers' Names and Addresses], *and* of Synthetic-Resin Materials. (*E.T.Z.*, 7th & 14th July 1938, Vol. 59, Nos. 27 & 28, pp. 734–739: pp. 761–762.)

4118. "Herstellung und Verarbeitung von Kunstharzpressmassen" [Manufacture and Working of Synthetic-Resin Moulding Materials (Practical Handbook), 2nd Edition: Book Review].—Brandenburger. (*E.T.Z.*, 11th Aug. 1938, Vol. 59, No. 32, p. 868.)

4119. Breakdown of Compressed Nitrogen under Impulse Voltage [in Uniform and Non-Uniform Fields].—Goldman. (*Tech. Phys. of USSR*, No. 5, Vol. 5, 1938, pp. 355–362: in English.) *See* 3383 of August.

4120. Reply to the Remarks of A. Jonescu on My Paper "Contributions to the Study of the Nature of the Oscillating Spark Discharge."—Purcaru. (*Zeitschr. f. Physik*, No. 5/6, Vol. 109, 1938, p. 431.) For Purcaru's paper *see* 966 of 1935.

4121. Generalisation of the Theory of Electrical Discharges.—Townsend & Gill. (*See* 4157.)

4122. Contribution to the Explanation of the Action of Hollow Cathodes [Decrease of Cathode Drop at Hollow Cathodes in Proportion to Their Curvature].—Lompe. (*Zeitschr. f. Physik*, No. 5/6, Vol. 109, 1938, pp. 310–311.)

4123. Cuprous Oxide and the Cuprous-Oxide Rectifier.—Nöldge. (*Physik. Zeitschr.*, 15th July 1938, Vol. 39, No. 14, pp. 546–559.)

Results of experiments on the preparation, conductivity, and rectification of cuprous-oxide rectifiers are here described. § 1—Preparation and growth of cuprous oxide: (a) oxidation of copper in the incandescent oven; (b) derivation of the equation for the growth of cuprous oxide; (c)

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explanation of the growth curves (Figs. 2, 4, 6). § II—Conductivity: resistance curves and explanation (Fig. 7). § III—Rectification: (a) effect of tempering after oxidation; (b) effect of superposition of opposite electrode. § IV—Destruction of rectification by pressure (Fig. 8): method of producing the best rectification effect. § V—Hysteresis: (a) occurrence of hysteresis (Fig. 9); (b) explanatory experiments:—(1) variation of time between charging and discharging; (2) the cuprous-oxide rectifier as a condenser; (3) investigation of frequency variation with a cathode-ray tube (Fig. 14). § VI—The barrier-layer rectification: "the rectification appears to depend on a cold electron discharge in the vacuum between Cu and Cu_2O, while the hysteresis is due to ion wandering." § VII—Literature references.

4124. THE CONDUCTIVITY LAW FOR SEMICONDUCTORS [Theory: Conductivity as Result of Internal Ionisation Effect: Two Different Laws for Large and Small "Separation" Work Functions (Abtrennungsarbeit)].—Möglich. (*Zeitschr. f. Physik*, No. 7/8, Vol. 109, 1938, pp. 503–509.)

4125. FILMS ON FRESHLY ABRADED COPPER SURFACES [Measurements of Thickness: Combination of Copper with Oxygen dissolved in Benzene or Water].—Campbell & Thomas. (*Nature*, 6th Aug. 1938, Vol. 142, pp. 253–254.)

4126. SUPERCONDUCTING THIN FILMS [Lead & Tin condensed on Glass show Properties reminiscent of Superconductive Alloys].—A. Shalnikov. (*Nature*, 9th July 1938, Vol. 142, p. 74.)

4127. PAPERS ON THE THEORY OF ADSORPTION, FILM EVAPORATION, ETC.—Chang, Wang, Bosworth, Cernuschi, Roberts. (*Proc. Camb. Phil. Soc.*, April & July, 1938, Vol. 34, Parts 2 & 3, pp. 224–237, etc.)

4128. MAGNETIC PERMEABILITY, AT HIGH FREQUENCIES, OF THIN FILMS OF IRON.—Procopiu. (*See* 3860.)

4129. MAGNETIC DISCONTINUITIES PRODUCED BY THE VARIATION OF THE CIRCULAR MAGNETISM OF A FERROMAGNETIC SUBSTANCE.—Procopiu. (*Rev. Gén. de l'Élec.*, 30th July 1938, Vol. 44, No. 5, p. 154: summary only.)

4130. MODERN IRON-CORED COILS [Recent German Developments, including Cores adjustable within Narrow Limits for Trimming].—(*Wireless World*, 4th Aug. 1938, Vol. 43, pp. 90–92.)

4131. THE BEST SHAPE OF IRON CORE FOR INDUCTANCE COIL [for Minimum Volume with Given Loss Factor at Given Frequency: for "Toroidal Type, Core Type, and New Shielded Shell Type": Superiority of the Shielded Shell].—Nakai. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 289–290.)

4132. MAGNETIC CONTRIBUTION [to Properties of Complex Hydroxide] OF THE CONSTITUENTS OF FERRIC HYDROXIDE EVOLVED IN AN ALKALINE MEDIUM.—Chevallier & Mathieu. (*Comptes Rendus*, 4th July 1938, Vol. 207, No. 1, pp. 58–61.)

4133. PROPERTIES OF FERROMAGNETIC SUBSTANCES IN POWDERS [Dependence of Coercive Force on Granule Size: Amendment of Ferromagnetic Theory is Necessary: Applications of the New Results].—Gottschalk: Sappa. (*La Ricerca Scient.*, 15th/30th June 1938, Series 2, 9th Year, Vol. 1, No. 11/12, pp. 639–640: in English.) A letter prompted by Sappa's paper (1622 of April). For Gottschalk's previous work *see* 2786 of 1935.

4134. THERMOMAGNETIC ANOMALY SHOWN AT ORDINARY TEMPERATURES BY MICROCRYSTALLINE FERROMAGNETIC SUBSTANCES.—Michel & Gallissot. (*Comptes Rendus*, 11th July 1938, Vol. 207, No. 2, pp. 140–142.)

4135. "MECHANISMUS DER KOERZITIVKRAFTERHÖHUNG . . ." [the Mechanism of the Raising of the Coercive Force in Two Ternary Alloys, Fe-Co-Mo and Fe-Ni-Al].—Snoek. (At Patent Office Library, London: Cat. No. 78 731: 20 pp.)

4136. COOLING OF PERMANENT MAGNET ALLOYS IN A CONSTANT MAGNETIC FIELD [gives Increased Remanence and BH_{max}].—Oliver & Shedden. (*Nature*, 30th July 1938, Vol. 142, p. 209.)

For similar work showing increases in maximum permeability on cooling high-permeability alloys *see* Dillinger & Bozorth, 738 of 1936.

4137. CONTRIBUTION TO THE STUDY OF PERMANENT MAGNETS AND THEIR PRACTICAL APPLICATIONS.—Venco. (*L'Elettrotec.*, 25th June 1938, Vol. 25, No. 12, pp. 410–412.) For previous work *see* 4316 of 1937.

4138. AN A.C. DYNAMO WITH A FLAT CHARACTERISTIC FOR BICYCLE ILLUMINATION [with 8-Pole Magnet of Small Dimensions made possible by "Ticonal" Magnet Steel].—Hazeu & Kiek. (*Philips Tech. Review*, March 1938, Vol. 3, No. 3, pp. 87–90.)

4139. RELAXATION METHODS APPLIED TO ENGINEERING PROBLEMS: III—PROBLEMS INVOLVING TWO INDEPENDENT VARIABLES [including Magnetic Induction in a Field containing Iron].—Christopherson & Southwell. (*Proc. Roy. Soc.*, Series A, 7th July 1938, Vol. 167, No. 928, p. S83: abstract only.)

4140. A MAGNETIC FIELD METER [suitable for Absolute Measurements of Large and Inhomogeneous Fields].—Cole. (*Review Scient. Instr.*, July 1938, Vol. 9, No. 7, pp. 215–217.) On same principle as Kohaut's apparatus (3536 of 1937). *See* also 4053.

4141. ON THE PHASE OF THE MAGNETIC FIELD.—Niessen. (*See* 3859.)

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4110. Tests on Insulator Porcelain [including the Interaction of Mechanical and Electrical Stresses].—Schmidt: Schaudinn. (*Zeitschr. V.D.I.*, 6th Aug. 1938, Vol. 82, No. 32, p. 928.)

4111. Investigation of the Amorphous State: XII—Dielectric Relaxation in Amorphous Phenol-Phthalein.—Kuvshinski & Kobeko. (*Tech. Phys. of USSR*, No. 5, Vol. 5, 1938, pp. 401–409: in English.) The Russian paper was referred to in 3372 of August. "It is necessary to revise the molecular picture of dielectric phenomena developed by Debye for polar liquids."

4112. On Reducing the Specific Volume of Electrolytic Condensers.—Petrovski. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1938, pp. 50–52.)

It is suggested that if the aluminium anodes of an electrolytic condenser are treated by a substance in which aluminium does not dissolve uniformly, the effective surface of the plates will be increased and the capacity of the condenser thus raised. In this paper a report is presented on experiments in which the anode plates were first treated by an alkali (solution of NaOH) and then by an acid (solution of HCl). Various stages of this treatment and of subsequent forming of the anode plates are described, and the results obtained are discussed and shown in a number of tables. It appears that in this way it is possible to raise the capacity of a condenser from 6.6 μF to 35.0 μF. It is pointed out, however, that as a result of this treatment losses in the condenser are also considerably increased.

4113. On the Use of Ceresin for the Impregnation of Low Voltage D.C. Paper Condensers.—Walter & Inge. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1938, pp. 48–50.)

A number of cylindrical and flat paper condensers were impregnated, some with paraffin and some with ceresin; in both cases in a vacuum and by boiling out under atmospheric pressure. These condensers were then subjected to exhaustive tests which have shown that the ceresin-impregnated condensers (a) have a high thermal stability making them suitable for working under temperatures up to 60°C, (b) that their electrical properties are somewhat better than those of the paraffin-impregnated condensers, and (c) that the thermal stability of ceresin with respect to oxidisation is many times greater than that of paraffin. It is therefore suggested that ceresin should be used for the impregnation of condensers in preference to paraffin.

4114. Effect of Curve Form [of Voltage] on the Breakdown Voltage of Some Insulating Materials [Condenser Papers, Transformer Oils, etc: Probable Influence of Heat].—Gänger. (*Arch. f. Elektrot.*, 10th June 1938, Vol. 32, No. 6, pp. 401–404.)

4115. The Electrical Properties of Synthetic Insulating Materials as a Function of Temperature.—Pfestorf & Hetzel. (*E.T.Z.*, 18th Aug. 1938, Vol. 59, No. 33, pp. 875–879.)

Authors' summary:—The influence of temperature on the electrical properties of numerous synthetic materials, particularly condensation resins, is investigated, and it is shown that the values of these properties of such materials are dependent on the nature and duration of their pre-heat-treatment. A simple equipment is described by which the measurement of the dielectric properties of solid insulating materials, as a function of the temperature, can be carried out on numerous samples under the same conditions, so that a comparison of the various materials is possible. Nine tables give the dielectric loss factors and dielectric constants, at 50 and 800 c/s, as well as the specific conductivities, of a series of synthetic materials in the temperature range 20 to 80°C.

4116. The Permeability to Water of Synthetic Materials [including Styroflex, Buna S, Cellophane, etc: in connection with Substitution for Lead in Cable Sheaths].—Badum & Leilich. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, p. 838: summary only.)

4117. Tables of Type-Classified and Controlled Moulding Materials [for Insulating, etc: with Makers' Names and Addresses], *and* of Synthetic-Resin Materials. (*E.T.Z.*, 7th & 14th July 1938, Vol. 59, Nos. 27 & 28, pp. 734–739: pp. 761–762.)

4118. "Herstellung und Verarbeitung von Kunstharzpressmassen" [Manufacture and Working of Synthetic-Resin Moulding Materials (Practical Handbook), 2nd Edition: Book Review].—Brandenburger. (*E.T.Z.*, 11th Aug. 1938, Vol. 59, No. 32, p. 868.)

4119. Breakdown of Compressed Nitrogen under Impulse Voltage [in Uniform and Non-Uniform Fields].—Goldman. (*Tech. Phys. of USSR*, No. 5, Vol. 5, 1938, pp. 355–362: in English.) *See* 3383 of August.

4120. Reply to the Remarks of A. Jonescu on My Paper "Contributions to the Study of the Nature of the Oscillating Spark Discharge."—Purcaru. (*Zeitschr. f. Physik*, No. 5/6, Vol. 109, 1938, p. 431.) For Purcaru's paper *see* 966 of 1935.

4121. Generalisation of the Theory of Electrical Discharges.—Townsend & Gill. (*See* 4157.)

4122. Contribution to the Explanation of the Action of Hollow Cathodes [Decrease of Cathode Drop at Hollow Cathodes in Proportion to Their Curvature].—Lompe. (*Zeitschr. f. Physik*, No. 5/6, Vol. 109, 1938, pp. 310–311.)

4123. Cuprous Oxide and the Cuprous-Oxide Rectifier.—Nöldge. (*Physik. Zeitschr.*, 15th July 1938, Vol. 39, No. 14, pp. 546–559.)

Results of experiments on the preparation, conductivity, and rectification of cuprous-oxide rectifiers are here described. § 1—Preparation and growth of cuprous oxide: (a) oxidation of copper in the incandescent oven; (b) derivation of the equation for the growth of cuprous oxide; (c)

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explanation of the growth curves (Figs. 2, 4, 6). § II—Conductivity: resistance curves and explanation (Fig. 7). § III—Rectification: (a) effect of tempering after oxidation; (b) effect of superposition of opposite electrode. § IV—Destruction of rectification by pressure (Fig. 8): method of producing the best rectification effect. § V—Hysteresis: (a) occurrence of hysteresis (Fig. 9); (b) explanatory experiments:—(1) variation of time between charging and discharging; (2) the cuprous-oxide rectifier as a condenser; (3) investigation of frequency variation with a cathode-ray tube (Fig. 14). § VI—The barrier-layer rectification: "the rectification appears to depend on a cold electron discharge in the vacuum between Cu and Cu_2O, while the hysteresis is due to ion wandering." § VII—Literature references.

4124. THE CONDUCTIVITY LAW FOR SEMICONDUCTORS [Theory: Conductivity as Result of Internal Ionisation Effect: Two Different Laws for Large and Small "Separation" Work Functions (Abtrennungsarbeit)].—Möglich. (*Zeitschr. f. Physik*, No. 7/8, Vol. 109, 1938, pp. 503–509.)

4125. FILMS ON FRESHLY ABRADED COPPER SURFACES [Measurements of Thickness: Combination of Copper with Oxygen dissolved in Benzene or Water].—Campbell & Thomas. (*Nature*, 6th Aug. 1938, Vol. 142, pp. 253–254.)

4126. SUPERCONDUCTING THIN FILMS [Lead & Tin condensed on Glass show Properties reminiscent of Superconductive Alloys].—A. Shalnikov. (*Nature*, 9th July 1938, Vol. 142, p. 74.)

4127. PAPERS ON THE THEORY OF ADSORPTION, FILM EVAPORATION, ETC.—Chang, Wang, Bosworth, Cernuschi, Roberts. (*Proc. Camb. Phil. Soc.*, April & July, 1938, Vol. 34, Parts 2 & 3, pp. 224–237, etc.)

4128. MAGNETIC PERMEABILITY, AT HIGH FREQUENCIES, OF THIN FILMS OF IRON.—Procopiu. (*See* 3860.)

4129. MAGNETIC DISCONTINUITIES PRODUCED BY THE VARIATION OF THE CIRCULAR MAGNETISM OF A FERROMAGNETIC SUBSTANCE.—Procopiu. (*Rev. Gén. de l'Élec.*, 30th July 1938, Vol. 44, No. 5, p. 154: summary only.)

4130. MODERN IRON-CORED COILS [Recent German Developments, including Cores adjustable within Narrow Limits for Trimming].—(*Wireless World*, 4th Aug. 1938, Vol. 43, pp. 90–92.)

4131. THE BEST SHAPE OF IRON CORE FOR INDUCTANCE COIL [for Minimum Volume with Given Loss Factor at Given Frequency: for "Toroidal Type, Core Type, and New Shielded Shell Type": Superiority of the Shielded Shell].—Nakai. (*Nippon Elec. Comm. Eng.*, June 1938, No. 11, pp. 289–290.)

4132. MAGNETIC CONTRIBUTION [to Properties of Complex Hydroxide] OF THE CONSTITUENTS OF FERRIC HYDROXIDE EVOLVED IN AN ALKALINE MEDIUM.—Chevallier & Mathieu. (*Comptes Rendus*, 4th July 1938, Vol. 207, No. 1, pp. 58–61.)

4133. PROPERTIES OF FERROMAGNETIC SUBSTANCES IN POWDERS [Dependence of Coercive Force on Granule Size: Amendment of Ferromagnetic Theory is Necessary: Applications of the New Results].—Gottschalk: Sappa. (*La Ricerca Scient.*, 15th/30th June 1938, Series 2, 9th Year, Vol. 1, No. 11/12, pp. 639–640: in English.) A letter prompted by Sappa's paper (1622 of April). For Gottschalk's previous work *see* 2786 of 1935.

4134. THERMOMAGNETIC ANOMALY SHOWN AT ORDINARY TEMPERATURES BY MICROCRYSTALLINE FERROMAGNETIC SUBSTANCES.—Michel & Gallissot. (*Comptes Rendus*, 11th July 1938, Vol. 207, No. 2, pp. 140–142.)

4135. "MECHANISMUS DER KOERZITIVKRAFTERHÖHUNG . . ." [the Mechanism of the Raising of the Coercive Force in Two Ternary Alloys, Fe-Co-Mo and Fe-Ni-Al].—Snoek. (At Patent Office Library, London: Cat. No. 78 731: 20 pp.)

4136. COOLING OF PERMANENT MAGNET ALLOYS IN A CONSTANT MAGNETIC FIELD [gives Increased Remanence and BH_{max}].—Oliver & Shedden. (*Nature*, 30th July 1938, Vol. 142, p. 209.)

For similar work showing increases in maximum permeability on cooling high-permeability alloys *see* Dillinger & Bozorth, 738 of 1936.

4137. CONTRIBUTION TO THE STUDY OF PERMANENT MAGNETS AND THEIR PRACTICAL APPLICATIONS.—Venco. (*L'Elettrotec.*, 25th June 1938, Vol. 25, No. 12, pp. 410–412.) For previous work *see* 4316 of 1937.

4138. AN A.C. DYNAMO WITH A FLAT CHARACTERISTIC FOR BICYCLE ILLUMINATION [with 8-Pole Magnet of Small Dimensions made possible by "Ticonal" Magnet Steel].—Hazeu & Kiek. (*Philips Tech. Review*, March 1938, Vol. 3, No. 3, pp. 87–90.)

4139. RELAXATION METHODS APPLIED TO ENGINEERING PROBLEMS: III—PROBLEMS INVOLVING TWO INDEPENDENT VARIABLES [including Magnetic Induction in a Field containing Iron].—Christopherson & Southwell. (*Proc. Roy. Soc.*, Series A, 7th July 1938, Vol. 167, No. 928, p. S 83: abstract only.)

4140. A MAGNETIC FIELD METER [suitable for Absolute Measurements of Large and Inhomogeneous Fields].—Cole. (*Review Scient. Instr.*, July 1938, Vol. 9, No. 7, pp. 215–217.) On same principle as Kohaut's apparatus (3536 of 1937). *See* also 4053.

4141. ON THE PHASE OF THE MAGNETIC FIELD.—Niessen. (*See* 3859.)

www.americanradiohistory.com

4142. Papers on Circuits containing Iron-Cored Reactors.—(*See* under "Properties of Circuits.")

4143. "German Tables for Calculation of Output Transformers and Smoothing Chokes" [Book Reviews].—Klein. (*See* 4011.)

STATIONS, DESIGN AND OPERATION

4144. Experiments with Micro-Waves around 4.8 cm [received on a Two-Split Magnetron with Super-Regeneration: Metallised Glass Reflectors at Transmitting & Receiving Ends (Gain at Receiver 700: "Quarter-Value Width"—Square of Field Strength reduced to a Quarter—2.6°: No Subsidiary Maxima): Good Communication over 15 km with 0.1–0.01 Watt, Not Disturbed by Atmospheric Conditions which limited Sight to 100 Metres: etc.].—Esau & Ahrens. (*Elektrot. u. Masch:bau*, 7th Aug. 1938, Vol. 56, No. 32, p. 415: summary only.) From a *Luftfahrtforschung* paper.

4145. Passive Relays ["Refractors"] for Metre and Decimetre Waves.—Loeb. (*L'Onde Élec.*, July 1938, Vol. 17, No. 199, pp. 338–361.)

Author's summary:—"Metre and decimetre waves have hitherto been employed only where no material obstacle lies in the way between transmitter and receiver, or where natural diffraction does not produce a complete extinction of the radiation. The present study has for its object the description of a new method of re-transmission allowing communication to be established in cases where the presence of material obstacles limits the range of the transmissions. The principle is as follows: a system of conductors exposed to an incident radiation becomes the seat of a current and consequently forms a secondary emitter which re-radiates energy. If these conductors are placed at a point from which both transmitter and receiver can be seen, communication can be established. In this way a relay for ultra-short waves is obtained; but this relay will contain no active element (valve, source of current, etc.), so that we will call it a 'passive relay' or 'refractor.' The calculations here given are intended to determine as accurately as possible the field produced at a distance by a system of conductors composing a passive relay, and to compare this field with that resulting from natural diffraction."

In the numerical example applying the theoretical results, a transmitter is radiating towards the edge of an obstacle 10 km away: the receiving point is 1 km beyond this edge, at an angle α to the extension of the straight line path to the edge. The width of the reflector system at the transmitter is taken as 10 m, that of the passive relay as 30 m (with a height of 5 m). The gain given by the passive relay is then calculated to be from 21 db ($\alpha = \pi/2$) to 13 db ($\alpha = \pi/6$) for a one-metre wave, while for a half-metre wave the corresponding figures are 30 db and 22 db. "Even if these extreme figures cannot be attained in practice, the gain given by the passive relays may be considerable."

4146. A Quantitative Study of Asymmetric-Sideband Broadcasting [primarily developed (and successfully used) for Carrier-Current Wire Broadcasting, but with Advantages for Ordinary Broadcasting].—P. P. Eckersley. (*Journ. I.E.E.*, July 1938, Vol. 83, No. 499, pp. 36–71: Discussion pp. 71–75.) Supplementing the earlier paper outlining the principles of the system (83 of 1936).

4147. Common-Wave Wire Broadcasting [Theoretical Examination and Practical Results on a 6-Station Experimental System in Berlin].—Vilbig. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, pp. 829–830: summary only.)

4148. A Practical Wired Radio System [Wire Broadcasting].—Wiessner. (*Electronics*, July 1938, Vol. 11, No. 7, p. 46.) For the full German paper *see* 2121 of May: *see* also 3408 of August.

4149. An International Broadcasting System [Cooperative Operation of Short-Wave Stations of NBC, General Electric, and Westinghouse: a Representative Day's Programme of W3XAL's European and Latin-American Beam Services: etc.].—Guy. (*RCA Review*, July 1938, Vol. 3, No. 1, pp. 20–35.)

4150. Australian Radio Communication Services.—Hooke. (*A.W.A. Tech. Review*, July 1938, Vol. 3, No. 5, pp. 229–251.)

4151. "Atlas des Weltfernsprechnetzes" [World's Telephone Network: Book Review].—Craemer. (*E.T.Z.*, 11th Aug. 1938, Vol. 59, No. 32, p. 867.)

4152. The International Telecommunication Conferences of Cairo, 1938.—Jolliffe. (*RCA Review*, July 1938, Vol. 3, No. 1, pp. 11–19.)

4153. Balloon Antenna explores New Location for WBZ.—(*Electronics*, July 1938, Vol. 11, No. 7, p. 36.)

4154. Ship-to-Shore Harbour Telephone Equipment.—Martin. (*RCA Review*, July 1938, Vol. 3, No. 1, pp. 63–66.)

4155. Forest Service develops Two-Way [Short-Wave] Radio for Fire-Fighting Vehicles [with Efficient Transmitter/Aerial and Aerial/Receiver Matching Unit].—(*Journ. Franklin Inst.*, July 1938, Vol. 226, No. 1, pp. 130–131: short note only.)

4156. Communication Equipment for Vehicles [Fleets of Small Mobile Units such as Cars, Trucks, and Launches].—Builder & Gilchrist. (*A.W.A. Tech. Review*, July 1938, Vol. 3, No. 5, pp. 269–282.)

www.americanradiohistory.com

GENERAL PHYSICAL ARTICLES

4157. GENERALISATION OF THE THEORY OF ELECTRICAL DISCHARGES [Extension of Previous Theory: Conditions under which the Electric Forces required to maintain the Discharges may be effected by a Magnetic Force: Calculation of Mean Energy of Electrons moving under Oscillatory Force: Theory tested by Measurements of Electric Force required to start Discharge in Dry Air under Various Conditions].—Townsend & Gill. (*Phil. Mag.*, Aug. 1938, Series 7, Vol. 26, No. 174, pp. 290–311.)

4158. VISCOSITY OF AIR AND THE ELECTRONIC CHARGE [Three Most Recent Measurements of Viscosity make Millikan's Value of *e* agree exactly with X-Ray Measurements].—Robinson: Banerjea & Pattanaik. (*Nature*, 23rd July 1938, Vol. 142, pp. 159–160.)

4159. THE DIMENSIONLESS CONSTANTS OF PHYSICS.—Haas. (*Proc. Nat. Acad. Sci.*, July 1938, Vol. 24, No. 7, pp. 274–276.)

4160. SOME REMARKS ON THE CALCULATION OF THE POLARISABILITY OF A MOLECULE [Wave-Mechanical Discussion of Silberstein's Theory].—Biedermann. (*Physica*, Aug. 1938, Vol. 5, No. 8, pp. 689–692: in English.)

4161. SYMMETRICAL PROPERTIES OF THE MAGNETIC FIELD [General Considerations], AND REMARKS ON A NOTE BY BRYLIŃSKI.—Bryliński: Cotton. (*Comptes Rendus*, 11th & 25th July 1938, Vol. 207, Nos. 2 & 4, pp. 136–138 & 270–271.)

4162. MAXWELL'S EQUATIONS IN TERMS OF THE FLUX-CUTTING CONCEPT.—G.W.O.H: Drysdale. (*Wireless Engineer*, July 1938, Vol. 15, No. 178, pp. 355–357.) Editorial prompted by Drysdale's article (2124 of May).

4163. CONTROVERSIES IN ELECTROMAGNETISM: II—POLARITY AND PERMEABILITY—THE LAW OF ELECTROMAGNETIC INDUCTION—PHYSICAL LINES OF INDUCTION.—Cramp. (*Electrician*, 5th Aug. 1938, Vol. 121, pp. 151–153.)

4164. LIGHT SIGNALS SENT AROUND A CLOSED PATH [" Sagnac Experiment "].—Ives. (*Journ. Opt. Soc. Am.*, Aug. 1938, Vol. 28, No. 8, pp. 296–299.)

MISCELLANEOUS

4165. EXPOSITION OF THE HEAVISIDE OPERATIONAL CALCULUS AND ITS EMPLOYMENT FOR THE INVESTIGATION OF TRANSIENT PROCESSES IN LINES: WITH SOME NEW RESULTS AND A BIBLIOGRAPHY.—Ekelöf. (In the long thesis referred to in 1793 of May).

4166. THE DEVELOPMENT OF THE SOLUTION OF THE TELEGRAPH EQUATION IN BESSEL FUNCTIONS.—Korn. (*Proc. Lond. Math. Soc.*, Series 2, 22nd Aug. 1938, Vol. 44, Part 5, pp. 352–362: in German.)

4167. " TABLES OF FUNCTIONS, WITH FORMULAE AND CURVES: FUNKTIONENTAFELN MIT FORMELN UND KURVEN " [3rd Edition: Book Review].—Jahnke & Emde. (*Electrician*, 12th Aug. 1938, Vol. 121, p. 182.) In English and German concurrently.

4168. ON BIPARTITIONAL FUNCTIONS [which supply Solutions of Combinatorial Problems and have Applications in Applied Statistics].—Sukhatme. (*Phil. Trans. Roy. Soc. Lond.*, Series A, 10th June 1938, Vol. 237, No. 780, pp. 375–409.)

4169. APPLICATION OF STATISTICAL METHODS TO MANUFACTURING PROBLEMS.—Shewhart. (*Journ. Franklin Inst.*, Aug. 1938, Vol. 226, No. 2, pp. 163–186.)

4170. THE COMPARISON OF SERIES OF MEASURES WHEN THE STANDARD ERRORS ARE UNEQUAL.—Jeffreys. (*Proc. Roy. Soc.*, Series A, 7th July 1938, Vol. 167, No. 928, p. S 81: abstract only.)

4171. RELAXATION METHODS APPLIED TO ENGINEERING PROBLEMS: III—PROBLEMS INVOLVING TWO INDEPENDENT VARIABLES.—Christopherson & Southwell. (*Proc. Roy. Soc.*, Series A, 7th July 1938, Vol. 167, No. 928, p. S 83: abstract only.)

4172. " BEITRAG ZUR NOMOGRAPHIE " [2nd Edition: Book Review].—Balogh. (*E.T.Z.*, 11th Aug. 1938, Vol. 59, No. 32, p. 868.)

4173. HOW MANY MILES? [with d'Ocagne Nomogram for obtaining Great Circle Distances].—Thomas. (*Wireless World*, 11th Aug. 1938, Vol. 43, pp. 120–121.)

4174. AN ELECTRO-MECHANICAL METHOD FOR SOLVING [High-Degree Algebraic] EQUATIONS [giving Real and Complex Roots: Experimental Model for Real Roots].—Schooley. (*RCA Review*, July 1938, Vol. 3, No. 1, pp. 86–96.) For a " practically identical " method independently developed *see* Hart & Travis, 1658 of April.

4175. THE CATHODE-RAY-TUBE POLAROGRAPH [for taking the Current/Potential Curves of a Dropping-Mercury Electrode in Electrochemical Analysis: Polarograms viewed continuously and require No Photographing or Recording].—Müller & others. (*Indust. & Eng. Chemistry*, 15th June 1938, Analytical Edition Vol. 10, No. 6, pp. 339–341.)

4176. CATHODE-RAY TUBE APPLICATIONS.—Batcher. (*Electronics*, June 1938, Vol. 11, No. 6, p. 69.) Notice of an article in *Instruments*.

4177. THE STUDY OF SMALL MECHANICAL MOVEMENTS WITH THE DUDDELL OSCILLOGRAPH.—Townsend. (*P.O. Elec. Eng. Journ.*, July 1938, Vol. 31, Part 2, pp. 112–116.) For another method, using string galvanometers, *see* 1225 of March (Hill).

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4178. THE FRENCH RAILWAYS' USE OF THE PIEZO-QUARTZ METHOD FOR THE MEASUREMENT OF FORCES [including Data on Accuracy, Sensitivity, Temperature Dependence, etc., of the Method].—(*E.T.Z.*, 30th June 1938, Vol. 59, No. 26, p. 700: summary only.)

4179. A PORTABLE APPARATUS FOR MEASURING VIBRATION IN FRESH CONCRETE [with Electro-Magnetic Pick-Up Unit and Integrating or Differentiating Circuit-Amplifier-Oscillograph System].—Pigman, Hornibrook, & Rogers. (*Journ. of Res. of Nat. Bur. of Stds.*, May 1938, Vol. 20, No. 5, pp. 707–721.)

4180. THE ZEISS-IKON BALLISTIC PIEZOELECTRIC INDICATOR AND ITS APPLICATIONS [Czecho-Slovak Army Results].—Kadlec. (*Génie Civil*, 6th Aug. 1938, Vol. 113, No. 6, pp. 133–134: summary only.)

4181. THE NATURE AND APPLICATIONS OF PIEZO-ELECTRICITY [Survey].—Metschl. (*E.T.Z.*, 4th Aug. 1938, Vol. 59, No. 31, pp. 819–825.)

4182. ON CERTAIN CALCULATIONS IN MAGNETIC DEFECTOSCOPY. — Jaanus [Janus]. (*Tech. Phys. of USSR.*, No. 4, Vol. 5, 1938, pp. 298–308: in English.) The Russian paper was referred to in 3066 of July.

4183. MAGNETIC METHODS OF TESTING MATERIALS. —Schirp. (*Metallurgist* [Supp. to *Engineer*], 24th June 1938, pp. 129–131: summary only.)

4184. THYRATRON CONTROL OF D.C. MOTORS, *and* ELECTRONIC SPEED CONTROL OF MOTORS.—Garman: Alexanderson & others. (*Elec. Engineering*, June 1938, Vol. 57, No. 6, pp. 335–342: pp. 343–354.)

4185. THYRATRON REACTOR LIGHTING CONTROL [for Theatres, etc.].—Schneider. (*Elec. Engineering*, June 1938, Vol. 57, No. 6, pp. 328–334.)

4186. SURFACE HARDENING [of Steel Parts such as Piston Pins, Tappet Shafts, etc.]—A NEW JOB FOR TRANSMITTING TUBES.—Babat & Losinsky. (*Electronics*, June 1938, Vol. 11, No. 6, pp. 44–46.) A description of Russian work.

4187. ELECTRONIC SALES AIDS [including Microphone Operation and Hand-Capacity Remote Control].—Ephraim. (*Electronics*, June 1938, Vol. 11, No. 6, pp. 24–25 and 77 . . 79.)

4188. RADIO NURSE [" Guardian Ear " plugged into Mains in Night Nursery, and Reproducer Unit].—Zenith Radio Corporation. (*Scient. American*, June 1938, Vol. 158, No. 6, p. 349.)

4189. " ENGINEERING ELECTRONICS " [Book Review].—Fink. (*Television*, July 1938, Vol. 11, No. 125, pp. 408 and 420.)

4190. ELECTRONIC REGULATOR FOR THE STABILISATION OF SYNCHRONOUS HIGH-POWER TURBO-GENERATORS RUNNING IN PARALLEL [Russian Development].—(*E.T.Z.*, 18th Aug. 1938, Vol. 59, No. 33, p. 883: long summary only.)

4191. THE FUNDAMENTAL PRINCIPLES IN THE CONSTRUCTION OF " SMALL-CURRENT " APPARATUS.—Wögerbauer. (*Elektrot. u. Masch:bau*, 8th May 1938, Vol. 56, No. 19, pp. 245–250.)

4192. THE PESTARINI " METADYNE " D.C. MACHINE AS CONVERTOR, MOTOR, AND GENERATOR.—Trettin: Pestarini. (*E.T.Z.*, 14th April 1938, Vol. 59, No. 15, pp. 396–397.)

4193. HOW TO RECONDITION FLOODED ELECTRIC EQUIPMENT.—Rea. (*Gen. Elec. Review*, June & July 1938, Vol. 41, Nos. 6 & 7, pp. 265–268 & 330–335: to be contd.)

4194. AMERICAN RADIO-PROSPECTING SET [" Treasure Locator ": Portable Equipment with Transmitting and Receiving Loops at Ends of Carrier Rods and at Right Angles to each other].—(*Funktech. Monatshefte*, July 1938, No. 7, p. 218.)

4195. THE ELECTRICAL IGNITION OF MIXTURES OF ETHER VAPOUR, AIR, AND OXYGEN, *and* THE RISK OF EXPLOSION DUE TO ELECTRIFICATION IN OPERATING THEATRES OF HOSPITALS.—Thornton: Rayner. (*Journ. I.E.E.*, Aug. 1938, Vol. 83, No. 500, pp. 145–155: pp. 156–161: Discussions pp. 161–170.)

4196. DISCUSSION ON " THE RÔLE OF ELECTROTECHNICS IN THE ANALYSIS AND INTERPRETATION OF THE FUNCTIONING OF THE NERVOUS SYSTEM."—Monnier. (*Rev. Gén. de l'Élec.*, 25th June 1938, Vol. 43, No. 26, pp. 830–831.) *See* 3979 of 1937.

4197. THE ELECTROCARDIOGRAPH [and the Use of the " Electric Heart "].—Polyanski. (*Izvestiya Elektroprom. Slab. Toka*, No. 4, 1938, pp. 53–59.)

A semi-portable cardiograph (using an amplifier) developed in the USSR is described and the accuracy of cardiographs in general is discussed. The distortion introduced by condensers protecting the sensitive galvanometers is considered in detail, and a description is given of an " electric heart " developed by the author. The object of this device is to produce currents similar to those obtained in cardiograph measurements and thus to provide means for testing the accuracy of cardiographs. The paper is concluded by a report on tests with this device and a further discussion of the accuracy of cardiographs.

4198. THE THEORY OF ELECTROSMOTIC CIRCULATION IN VARYING FIELDS [for Laminar and Cylindrical Cells].—White. (*Phil. Mag.*, July 1938, Series 7, Vol. 26, No. 173, pp. 49–65.)

4199. SMALLPOX VIRUS PARTICLES VIEWED BY IMPROVED ELECTRON MICROSCOPE [2000 Diameters' Magnification].—Krause. (*Sci. News Letter*, 30th July 1938, Vol. 34, No. 5, p. 73.) For references to the " supermicroscope " and other new electron microscopes *see* under " Subsidiary Apparatus & Materials."

www.americanradiohistory.com

4200. Optical Telephony using "Skin Effect" on Surface of Lamp Filament.—Mostiller. (*Electrician*, 12th Aug. 1938, Vol. 121, p. 175: paragraph only.)

4201. On Carrier-Frequency Differential Circuits for Photoelectric Receivers [for Guard-Ray, Optical Remote Control, Optical Signalling, and Other Purposes].—Schäfer. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 19, 1938, pp. 217–232.)

"While the modern types of photoelectric converters, in combination with suitable indicating instruments and amplifiers, are satisfactory for the most varied kinds of scientific investigations, they fail as a general rule in communication technique with its special demands on freedom from interference, on simplicity, and on reliability under adverse conditions. Apart from the simplest signalling devices such as guard-ray apparatus, for communication over distances of the order of kilometres the fluctuating absorption in the atmosphere makes it desirable to use those detectors which are still effectively sensitive in the infra-red region. As is seen in Table 1, where the most important photoelectric converters [alkali cells, vacuum and with inert-gas fillings; cuprous-oxide and selenium barrier-layer cells, anterior-wall and posterior-wall types; thallofide cells; thermopiles; bolometers] are tabulated with their characteristic properties, it is difficult to combine this latter property with that of a high sensitivity." For signalling purposes, high-sensitivity moving-coil or moving-iron instruments are inadmissible, and valve amplification is therefore essential, but since conditions are not suitable for d.c. amplification, some form of modulation is necessary. Modulation at the transmitter, as used in infra-red telephony and telegraphy, has its special advantages but is not applicable to integrating receivers, for which receiving-end modulation is essential. "The purpose of the present work is to seek out, from among the detectors given in the table, those which are specially suitable for signalling purposes (other than telephony), and to determine the optimum working conditions," the line adopted being to find amplification arrangements (giving receiving-end modulation) which will allow robust indicators or relays to take the place of sensitive instruments; the period of functioning of the whole receiving system must be small enough to allow slow telegraphy; the amplifier must be proof against electrical disturbances of all kinds; the equipment must be suitable for battery or mains supply; and, finally, an increased sensitivity of at least two degrees of magnitude is aimed at.

"It is found that the barrier-layer cell, the bolometer, and the inert-gas alkali cell are specially suitable for the purpose. While the use of a barrier-layer cell with a constant polarising voltage has already been investigated thoroughly, data on the behaviour of the cell under the influence of a modulated alternating current are absent from the literature. The fundamental facts and possible improvements were therefore examined. A simple consideration shows further that the feeding of a bolometer bridge with a.c. offers quite unusually favourable prospects: although the attainable sensitivity remains far behind that of the alkali cell for visible light, the plan offers entirely new possibilities for signalling in the middle infra-red region.

"In the last main section [D, p. 226 onwards] an entirely new type of circuit for inert-gas alkali cells is disclosed, which furnishes a qualitative photo-relay of astonishing properties. By the application of the super-regenerative principle to this cell, its output can be increased by several orders of magnitude, while great simplicity and reliability is preserved" [the enormously increased electron current produced by the introduction of an inert gas into a vacuum alkali cell has hitherto never been made full use of, because when the condition of glow discharge is approached too closely, a small fluctuation of voltage or temperature, or too strong an illumination, produces a self maintained discharge from which the cell cannot return of its own accord to its normal condition. It is this difficulty that the writer overcomes by application of the super-regenerative principle, which here takes the form of replacing the usual constant "extracting" voltage by an a.c. or wave-form voltage whose peaks reach to the glow-discharge limit or slightly exceed it. Theoretically a rectangular wave form would be desirable, but its full advantage would only be derived at one particular brightness of illumination; a sinusoidal wave is therefore as effective. If a high-frequency is chosen, the residual ionisation becomes serious, the re-striking voltage is well under the static striking voltage, and the relay becomes difficult to adjust. A low frequency, such as that of the commercial mains, is therefore desirable, with the result that the installation enters the fully mains-driven class. A list of 26 literature references completes the paper].

4202. What's New in Radio: a Review of Components and Accessories recently announced by Manufacturers.—(*Electronics*, June 1938, Vol. 11, No. 6, pp. 16–19 and 74 . . 76.)

4203. Novelties of Radio-Electricity at the XVth Wireless Salon at the Paris Fair.—Adam. (*Génie Civil*, 18th June 1938, Vol. 112, No. 25, pp. 518–521.)

4204. IRE Convention, 1938 [with Short Summaries of Many Papers].—(*Communications*, July 1938, Vol. 18, No. 7, pp. 11–14 and 36: *Electronics*, July 1938, Vol. 11, No. 7, pp. 8–15 and 33, 34.)

4205. Proceedings of the World Radio Convention, Sydney, 1938 [including Addresses and Summaries of Papers].—(*Proc. I.R.E. Australia*, May 1938, Vol. 1, No. 4, pp. 82–90 and 101.)

4206. The American System of Broadcasting and Its Function in the Preservation of Democracy.—Sarnoff. (*RCA Review*, July 1938, Vol. 3, No. 1, pp. 3–10.)

4207. The Italian Journal *Radio e Televisione*. —(*See* 4018.)

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Some Recent Patents

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

486 038.—Arrangement of loud-speakers, vertically spaced on a common supporting pole, for radiating speech or music at a high level of power.

Telefunken Co. • *Convention date (Germany) 4th July,* 1936.

486 095.—High-powered public-address system in which distortion due to phase-displacement of the different sound-frequencies is prevented.

Telefunken Co. Convention dates (Germany) 17th February, 18th March, and 6th August, 1936.

486 290.—Preventing undesired feed-back or "singing" between the microphone and loud-speaker of a public address system.

Radio Corporation of America. Convention date (U.S.A.) 28th November, 1936.

486 870.—Low-frequency amplifier with provision for volume contraction or expansion by means of an A.V.C. bias which varies logarithmically so as to conform with the response of the human ear to loudness.

Telefunken Co. Convention date (Germany) 10th December, 1935.

AERIALS AND AERIAL SYSTEMS

487 282.—Transmission line for feeding a number of transmitting aerials with energy of different frequencies without giving rise to undesirable interaction.

Marconi's W.T. Co. (assignees of P. S. Carter). Convention date (U.S.A.) 30th June, 1936.

489 174.—Strain-insulator for a short-wave aerial, the insulator being made hollow to house a loading coil or condenser.

The Gramophone Co. and L. A. Chapman (addition to 444 494). *Application date 20th January,* 1937.

DIRECTIONAL WIRELESS

485 682.—Directive aerial unit consisting of a rhombic arrangement of four wires, coupled at one corner to the transmitter or receiver, and at the opposite corner to a terminating impedance.

Standard Telephones and Cables (assignees of E. Bruce). Convention date (U.S.A.) 11th January, 1936.

485 764.—Wireless direction-finder in which the bearing of a distant transmitting beacon is indicated by a flashing line on the screen of a cathode-ray tube.

J. P. Jeffcock. Application date 26th November, 1936.

486 084.—Method of mounting a frame aerial, for direction-finding, inside the cabin of an all-metal aeroplane.

V. I. Bashenoff. Application date 25th November, 1936.

486 576.—Direction-finder utilising one or more frame aerials mounted in a stream-lined casing, particularly for aircraft.

E. J. Hefele (divided from 482 717). *Convention date (U.S.A.) 2nd October,* 1935.

486 652.—Mechanical keying system for directional transmitters used to produce a navigational course for aeroplanes by means of overlapping beams.

C. Lorenz Akt. Convention date (Germany) 28th November, 1936.

487 048.—Switching arrangement for the radio-goniometer coils of a direction-finder designed to allow both the "sense" and "bearing" indications to be shown coincidently.

J. P. Jeffcock. Application date 14th November, 1936.

487 446.—Radio-navigational beam transmitter in which radiation along the equi-signal line is more pronounced than usual.

C. Lorenz Akt. Convention date (Germany) 21st March, 1936.

487 485.—Directional system comprising a main aerial and a reflector with "phasing" elements designed to prevent back-radiation when the working wavelength is changed.

Standard Telephones and Cables (assignees of A. Alford). Convention date (U.S.A.) 31st December, 1936.

RECEIVING CIRCUITS AND APPARATUS

(See also under Television.)

485 713.—Method of controlling the selectivity of a band-pass filter circuit in a wireless receiver so as to ensure uniform amplification of all the accepted frequencies.

N. V. Philips' Lamp Co. Convention date (Holland) 29th June, 1936.

485 737.—Valve amplifier in which the output is maintained substantially constant, irrespective of variations in the load impedance.

N. V. Philips' Lamp Co. Convention date (Germany) 16th December, 1936.

485 854.—Wireless receiver in which negative feed-back is utilised to give automatic volume control and also some degree of automatic selectivity.

Standard Telephones and Cables; D. H. Black; and W. Lawrence. Application date 25th September, 1936.

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485 890.—Push-button tuning in which one or other of two broadcast programmes is selected by a switch which changes the frequency of the local oscillator in a superhet receiver.

E. K. Cole and A. W. Martin. Application date 17th February, 1937.

485 995.—Negative feed-back circuit for a wide-band amplifier with a transformer-coupled load.

Telefon Akt. L. M. Ericsson. Convention date (Sweden) 3rd December, 1936.

486 372.—Automatic volume control system in which the regulation is practically non-existent for very weak signals but effective for all signals above a certain datum line.

Standard Telephones and Cables. Convention date (France) 19th September, 1936.

486 557.—Means for preventing frequency "drift" in the local-oscillator of a superhet receiver.

Marconi's W.T. Co (assignees of B. Trevor and R. W. George). Convention date (U.S.A.) 6th December, 1935.

486 570.—Automatic volume control utilising a network having a divided input and output circuit, particularly applicable to amplifying valves of the "beam" type (divided from No. 469 895).

Marconi's W.T. Co. and J. D. Brailsford. Application date 8th December, 1936.

486 793.—Amplifier in which negative back-coupling is applied to prevent non-linear distortion and in which "phase rotation" due to undesired capacities is eliminated.

Siemens and Halske Akt. Convention date (Germany) 12th December, 1935.

486 889.—Tuning scale for an all-wave set designed to give sufficient room for the various short-wave stations to be marked by name.

Marconi's W.T. Co.; N. M. Rust; and N. Levin. Application date 11th December, 1936.

487 125.—Wireless cabinet with sliding panel which hides the tuning controls and station-indicator from view once they have been adjusted to a given setting.

Telefunken Co. Convention date (Germany) 3rd November, 1936.

487 170.—Automatic tuning system in which the necessary control voltage is obtained by vectorially adding the oscillations produced by the signal in a pair of coupled circuits.

E. K. Cole. Convention date (Sweden) 17th January, 1936.

487 687.—Tuning system in which any desired station is selected by means of "finger holds" provided on a rotating dial, the initial setting being corrected by automatic fine tuning.

Marconi's W.T. Co. Convention date (U.S.A.) 23rd December, 1935.

488 158.—System of automatic tuning in which a rectifier bridge is used to derive the fine-adjustment control voltage.

Marconi's W.T. Co. (assignees of G. Guanella and M. Lattman) (addition to 472 739 and 478 775). Convention date (Switzerland) 11th July, 1937.

488 413.—Resistance-capacity coupling for valve amplifiers in which the usual "charging" period is reduced to a minimum.

R. Elmqvist. Convention date (Germany) 10th March, 1937.

488 717.—Step-by-step system of remote tuning control for a superhet receiver, in which use is made of harmonic frequencies produced by the local-oscillator valve.

Murphy Radio and D. N. Truscott. Application date 13th January, 1937.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception.

485 653.—Television receiver in which the synchronising impulses are separated from the picture signals in a demodulator, the output from which is connected directly to the time-base unit.

W. E. Benham. Application date 21st October, 1936.

486 041.—Time-base circuit for television scanning in which an "electron beam" valve is used for generating saw-toothed oscillations.

Marconi's W.T. Co.; D. L. Plaistowe; and D. J. Fewings. Application date 30th November, 1936.

486 048.—Electron-multiplier for "seeing through fog" by converting an infra-red image into a visible one.

Farnsworth Television Inc. Convention date (U.S.A.) 24th February, 1936.

485 989.—Generating circuit for the synchronising impulses radiated by a television transmitter.

Philco Radio and Television Corporation (divided from Patent No. 485 924). Convention date (U.S.A.) 23rd November, 1935.

485 990.—Wide-band amplifier giving uniform gain down to "zero" for use in television.

Philco Radio and Television Corporation (divided from Patent No. 485 924). Convention date (U.S.A.) 23rd November, 1935.

485 991.—Producing line and frame synchronising impulses, with wave-fronts of different slope, for use in television.

Philco Radio and Television Corporation (divided from Patent No. 485 924). Convention date (U.S.A.) 23rd November, 1935.

485 999.—"Light-chopper" method of generating the synchronising impulses radiated by a television transmitter.

Philco Radio and Television Corporation (divided from Patent No. 485 924). Convention date (U.S.A.) 23rd November, 1935.

486 017.—Frequency-dividing circuit for deriving scanning frequencies in television.

Baird Television and G. R. Tingley. Application date 27th November, 1936.

486 204.—Electron-optical arrangement designed to prevent "astigmatic" effects, when focusing an electron stream on to the fluorescent screen of a light-sensitive discharge tube.

V. Zeitline; A. Zeitline; and V. Kliatchko. Convention date (France) 5th May, 1936.

486 373.—Construction of screen for reproducing a televised picture by incandescence instead of fluorescence.

Farnsworth Television Inc. Convention date (U.S.A.) 18th August, 1936.

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486 377.—Television transmitter in which the high-light value of a poorly-lighted scene is automatically regulated to that of a brilliantly-lit scene.

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

486 467.—Deflecting system for the electron stream of a cathode-ray television receiver, designed to increase the flexibility of control and to prevent picture distortion.

Philco Radio and Television Corporation. Convention date (U.S.A.) 25th February, 1936.

486 528.—Time-base circuit in which the long limb of the saw-toothed oscillation is generated by a steady voltage, whilst the "flyback" limb is controlled by a "free" oscillation.

Telefunken Co. Convention date (Germany) 3rd December, 1935.

486 548.—Method of manufacturing a photo-electric electrode of the mosaic-cell type, as used in television, by depositing the sensitive metal upon a backing plate through a wire-gauze or similar meshwork.

W. E. Williams. Application date 7th December, 1936.

486 604.—Television technique applied to increase the verisimilitude of the performance of a "mechanical man."

F. von Okolicsanyi. Convention date (Germany) 12th December, 1935.

486 666.—Wireless transmitter or receiver, particularly for aeroplanes and motor-cars, built up of unitary components to give a compact assembly and to facilitate replacement and repair.

Standard Telephones and Cables; W. Bond; and G. Davies. Application date 8th December, 1936.

486 750.—Method of making visible an image illuminated by invisible rays, or of intensifying an image illuminated by visible light, by using secondary emission in a discharge tube of the cathode-ray type.

Radio-Akt. D. S. Loewe. Convention date (Germany) 16th October, 1935.

486 787.—Image dissector tube in which the scene to be televised is projected on to a photo-electric surface forming the plane lower surface of a cup-shaped cathode.

Farnsworth Television Inc. Convention date (U.S.A.) 31st December, 1935.

486 896.—Television transmitters in which the normal exposure of the mosaic-cell electrode to the light from the image is shortened, in order to prevent "blurring."

Radio-Akt. D. S. Loewe. Convention date (Germany) 12th December, 1935.

486 915.—Use of a separately-heated electrode to increase secondary emission, and therefore the picture brilliance, in a cathode-ray television receiver.

Radio-Akt. D. S. Loewe. Convention date (Germany) 16th October, 1935.

487 240.—Automatically controlling or limiting wide fluctuations in the average light intensity of a televised scene.

Radio-Akt. D. S. Loewe. Convention date (Germany) 16th December, 1935.

487 242.—Combined resistance-capacity coupling and filter network for eliminating the effect of "ripple" in the mains voltage supplied to a television amplifier.

Radio-Akt. D. S. Loewe. Convention date (Germany) 17th December, 1935.

487 998.—Cathode-ray tube containing a permanent steel-alloy magnet for concentrating the electron stream.

N. V. Philips' Lamp Co. Convention date (Germany) 30th October, 1936.

488 031.—Electromagnetic scanning control and time-base circuit for a cathode-ray tube.

The British Thomson-Houston Co. and K. J. R. Wilkinson. Application date 29th December, 1936.

488 655.—Arrangement for cutting-off the H.T. supply to a cathode-ray tube unless the electron stream is being driven by the scanning voltages, thereby preventing any risk of burning-out the fluorescent screen.

E. W. Bull. Application date 10th December, 1936.

489 199.—Image-dissector for generating television signals in which the unabsorbed part of a scanning stream of electrons is reflected along a reverse path and further utilised.

P. T. Farnsworth. Application date 11th May, 1937.

489 282.—Method of making a "mosaic-cell" screen as used for television transmitters.

Baird Television; V. A. Jones; and T. C. Nuttall. Application date 22nd January, 1937.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television.)

485 806.—Ultra-short-wave signalling system in which the output from a magnetron or similar oscillator is subjected to frequency modulation.

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

486 244.—Preventing power-losses in a short-wave oscillator of the split-anode magnetron type.

The M-O. Valve Co. and E. C. S. Megaw. Application date 1st April, 1937.

486 358.—Push-pull arrangement of diodes for modulating a carrier wave and suppressing the carrier frequency.

Allgemeine Elektricitäts Ges. Convention date (Germany) 8th June, 1936.

486 448.—Thermionic generating system in which a number of oscillators are coupled together and controlled to produce a frequency selected by means of tuning dials.

Standard Telephones and Cables and B. B. Jacobsen. Application date 2nd December, 1936.

486 840.—Electrode arrangement and assembly for a high-powered amplifier designed to prevent losses due to inter-electrode capacity couplings.

Standard Telephones and Cables (assignees of V. L. Ronci and J. W. West). Convention date (U.S.A.) 5th December, 1936.

488 094.—Short-wave oscillation-generator in which auxiliary electrodes in the path of the main discharge stream serve to increase the power output.

Telefunken Co. Convention date (Germany) 30th November, 1935.

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488 605.—Means for expanding or contracting the normal period of time required for the transmission of wireless, television or other electric signals.

F. C. P. Henroteau. Application date 27th January, 1938.

488 817.—Short-wave oscillation-generator in which energy is abstracted from the electron stream as it passes through coaxial electrodes (connected to a resonant circuit) inserted between the cathode and a target-electrode.

Marconi's W.T. Co. (assignees of G. A. Morton). Convention date (U.S.A.) 24th December, 1936.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

485 672.—Electron multiplier in which the primary electrons are made to follow a helical path so that they strike against the target electrode at an acute angle.

Marconi's W.T. Co. (assignees of E. G. Linder). Convention date (U.S.A.) 30th November, 1935.

485 685.—Electrode assembly and construction of an electron discharge tube.

C. Lorenz Akt. Convention date (Germany) 16th January, 1936.

485 798.—Pentode valve with variable-pitch suppressor grid designed to keep the dynamic characteristic of the valve symmetrical above and below the working point.

N. V. Philips' Lamp Co. Convention date (Holland) 25th March, 1936.

486 020.—Electron multiplier in which a graded biasing voltage is applied to the electrodes for varying the strength and direction of the electric control fields.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 28th December, 1935.

486 338.—Supporting and centering the cathode in a split-anode magnetron valve used for generating centimetre waves.

The M-O. Valve Co. and E. C. S. Megaw. Application date 23rd February, 1937.

486 437.—Electron multiplier in which at least one of the secondary-emission cathodes consists of a metallic foil through which the high-velocity primary electrons can enter a space between two "target" electrodes.

Fernseh Akt. Convention date (Germany) 2nd December, 1935.

486 795.—Electron multiplier in which the "target" electrodes are in strip form and are set edgeways to the main electron stream so as to obstruct it as little as possible.

V. Zeitline; A. Zeitline; and V. Kliatchko. Convention date (France) 8th February, 1936.

486 888.—Electron multiplier in which the primary and "target" cathodes are arranged at equal intervals around the peripheries of concentric cylinders.

Marconi's W.T. Co. and G. B. Banks. Application date 11th December, 1936.

487 899.—Method of preparing the primary and secondary emission electrodes for an electron-multiplier.

The General Electric Co.; C. H. Simms; and L. R. G. Treloar. Application date 3rd February, 1937.

488 558.—Method of making and sealing an all-metal thermionic valve.

Radio-Akt D. S. Loewe. Convention date (Germany) 9th January, 1936.

488 873.—Construction and coating of oxide-coated cathodes for thermionic valves.

The M-O. Valve Co.; M. Benjamin; and R. O. Jenkins. Application date 1st February, 1937.

SUBSIDIARY APPARATUS AND MATERIALS

485 867.—Stabilising the operation of a frequency-reducing circuit containing an impedance element with a non-linear characteristic.

Associated Electric Laboratories Inc. Convention date (U.S.A.) 14th January, 1936.

485 891.—Automatic alarm system in which the relay operating the buzzer signal is in the plate circuit of a valve, the voltage across the relay windings being used to bias the grid of the valve.

Telephone Manufacturing Co. and L. H. Paddle. Application date 4th March, 1937.

485 904.—Cathode-ray tube arranged to generate a sharp impulse at the exact moment when an alternating potential passes through the zero point.

Radio-Akt D. S. Loewe. Convention date (Germany) 23rd August, 1935.

486 065.—Transformer and detector unit for measuring radio-frequency currents.

Siemens and Halske Akt. Convention date (Germany) 26th June, 1936.

486 140.—Mounting and construction of small high-frequency transformers wound with Litz wire and with movable iron cores for permeability tuning.

E. K. Cole and G. Bradfield. Application date 23rd January, 1937.

486 655.—Microphone designed to prevent extraneous "noises" due to the wind, when used out-of-doors.

Marconi's W.T. Co. (assignees of W. D. Phelps). Convention date (U.S.A.) 14th January, 1937.

486 801.—"Dual" loud speaker in which the membrane for the low frequencies is of concavo-convex shape, and the driving coil has the same diameter as the convex part.

J. Furstenzeller. Application date 29th January, 1937.

486 829.—Dry-contact rectifier with a "blocking layer" which is produced in part by the chemical conversion of substances present in the selenium electrode.

N. V. Philips' Lamp Co. Convention date (Germany) 13th August, 1936.

488 564.—Method of mounting a piezo-electric crystal oscillator so as to absorb parasitic vibrations.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 30th January, 1936.

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THE

WIRELESS ENGINEER

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Editorial

Reflection and Absorption of Electromagnetic Waves by Dielectric Strata

WHEN an electromagnetic wave impinges on a sheet of dielectric material some of the energy is usually reflected, some absorbed and some transmitted into the space beyond. If anyone were asked what would be the result of backing the dielectric with a metal reflecting sheet, thus preventing the transmission of waves beyond the sheet, they would almost certainly reply that the reflected wave would thereby be strengthened. That this is not necessarily the case is shown in a recently published paper.* In a given case in which the dielectric was a sheet of asbestos cement (a semi-conducting dielectric), 1 cm thick, the wavelength 13.5 cm, and the angle of incidence and reflection 20° to the normal, the intensity of the reflected wave was reduced to 1/7th of its former value when a metal reflector was placed on the back of the sheet.

To obtain an idea of the conditions which can cause the reflected wave to be reduced to a very small value when the reflector is in position, we may consider the case of the normal incidence of a plane wave and adopt the device which we introduced many years ago† of picturing fictitious transmission lines which in no way interfere with or modify the wave but enable one to use the ordinary transmission line formulae. In Fig. 1 is shown in section the vertical slab of semi-conducting dielectric with a metal sheet on the right-hand face. If plane waves are travelling from left to right they will not be modified by the horizontal conductors which we imagine to be present, and, if the waves are polarised with the electric field vertical, the conductors can be pictured as wide horizontal strips of perfectly conducting material. Such a transmission line between parallel strips lends itself to very simple calculation. We assume that they are 1 cm apart and we need only consider 1 cm perpendicular to the paper, so that we fix our attention upon the energy travelling horizontally along a column 1 cm square, through space with a relative permittivity of unity and zero conductivity until we come to the slab of material of permittivity κ and

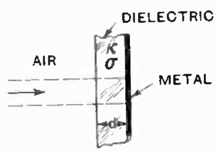

Fig. 1.

* Dällenbach and Kleinsteuber, *Hochfrequenztechnik*, May, 1938, p. 152.

† *Electrician*, 71, p. 965, 1913; also Dec. 26, 1913. *Journal Inst. of Elec. Eng.*, 54, p. 473, 1916.

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