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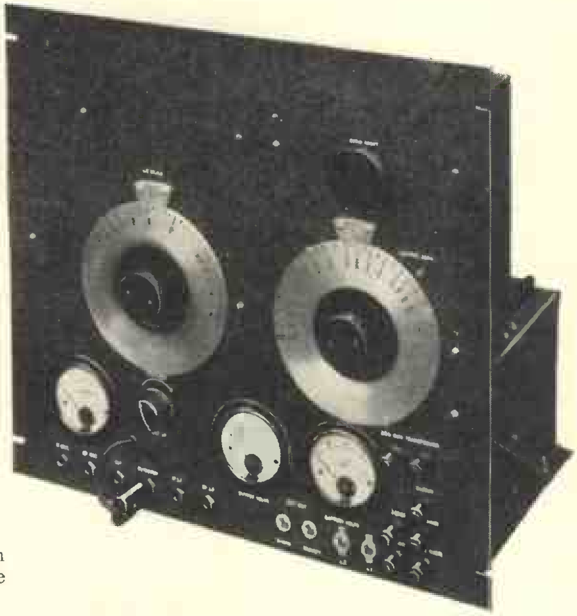

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THE
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VOL. XIII. MAY, 1936. No. 152

Editorial

Iron Cores for Radio Coils

ALTHOUGH it is now some years since it was shown that the cores made of finely divided iron, which had played such an important part in the development of telephone and telegraph transmission, could be used with advantage at radio frequencies, they seem to have made but little headway with the radio industry in this country. A German writer* has recently expressed surprise that whereas most improvements, such as valves with several grids, automatic volume control, and tuning indicators, have been rapidly adopted in all countries, the use of iron-cored coils in radio receivers has made such slow progress. One reason is undoubtedly the manufacturing difficulties. A large outlay would have to be incurred in development and special equipment and this would only be justified by a subsequent commensurate turn-over. It is not claimed that iron cores enable results to be obtained which are phenomenally better than can be obtained without them, but that the same or better results can be obtained with less weight, space and cost. The first two are technical matters which can be tried out in the laboratory, but the economic question is much more involved.

In the paper referred to figures are given showing that the coil in an oscillatory circuit is generally inferior to the condenser. This is only natural, however, for Nature has provided us with dielectrics in which there are practically no losses, but not with conductors devoid of resistance at ordinary temperatures. Even a cheap variable condenser with press-spahn dielectric has no greater losses than a carefully constructed wave-meter coil, whilst an ordinary radio coil has from 20 to 200 times the losses of a condenser with one of the new ceramic dielectrics. Further improvement in the oscillatory circuit should therefore be directed to the coil and not to the condenser.

In 1933 (*W.E.* p. 1) we showed that the permeability of iron powder cores was very dependent upon the space lost due to the insulation between the particles. It was shown that if the iron occupied 90 per cent. of the total space and the insulation 10 per cent., the effective permeability could not exceed 28, even if the iron itself had infinite permeability, and that it would still be about 20 if the permeability of the iron were only 50. As the space-factor is increased from 90 to 100 per cent. the effective permeability increases very rapidly if the iron itself has a high permeability, e.g., from 28 to infinity if the iron has infinite permeability. In a recent number of the *Bell Technical Journal* it was stated that by using special alloys such as permalloy the permeability of iron dust cores for telephone purposes had been raised to 75, and that it was to be increased still further by using molybdenum permalloy. For radio frequencies, however, it is necessary to use very fine powder for

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* Riepka, *E.T.Z.*, 27 Feb., 1936, p. 218.

which the space-factor will be low, and for which consequently the permeability of the iron itself will have little effect on the effective permeability. In this case it is probably more important to use an iron of high resistivity in order to reduce the eddy current losses in the particles.

The iron is obtained in the form of the fine powder either by deposition from the gaseous carbonyl or by grinding and winnowing. The mixture of iron powder and insulating material can be made into the necessary form in several ways. The best result is obtained by pressing into a mould ; in this way it is possible to approach the toughness of cast iron, with a specific weight of 5 and a permeability of 18. Difficult shapes can be made by squirting, but the specific gravity is then only about 4 and the permeability 7.

These materials are now being made by some of the leading German firms, e.g., " Sirufer " by Siemens and Halske* and " Draloperm " by the Steatit Magnesia Co.

The lower the losses in a tuned circuit the greater the importance of constancy in *L* and *C*, otherwise the increased selectivity is rendered useless. It is important, therefore, that the iron cores have a very low temperature coefficient of permeability and a fixity of position within the coils. For the pressed material the temperature coefficient is stated to be less than — 0.0001 per degree C. Specially shaped cores have been developed, fitting tightly into the coil former and carried on a central hollow bakelite bolt into which is screwed an adjustable iron core by which the inductance is finally adjusted. In another form the whole core is moved in and out of the coil which serves as the variable element of the tuned circuit. It is stated that in mass production the permeability is within ± 6 per cent. of the nominal value, but that this can be reduced to ± 1.5 per cent. for a 50 per cent. increase of price.

Experiments have shown that these cores can be used with advantage down to wavelengths of 10 metres.

Attempts to vary the inductance by varying the d.c. magnetisation of the cores have not proved very successful, since, as we have already seen, the effective permeability varies but slightly with large variations in the permeability of the iron employed, and would consequently be little affected by the d.c. magnetisation.

Coils with iron cores would appear to be specially suitable for receiving sets where space is a prime consideration, such as those intended for use in vehicles and aeroplanes. By their use compactness will be obtainable without sacrificing efficiency. G. W. O. H.

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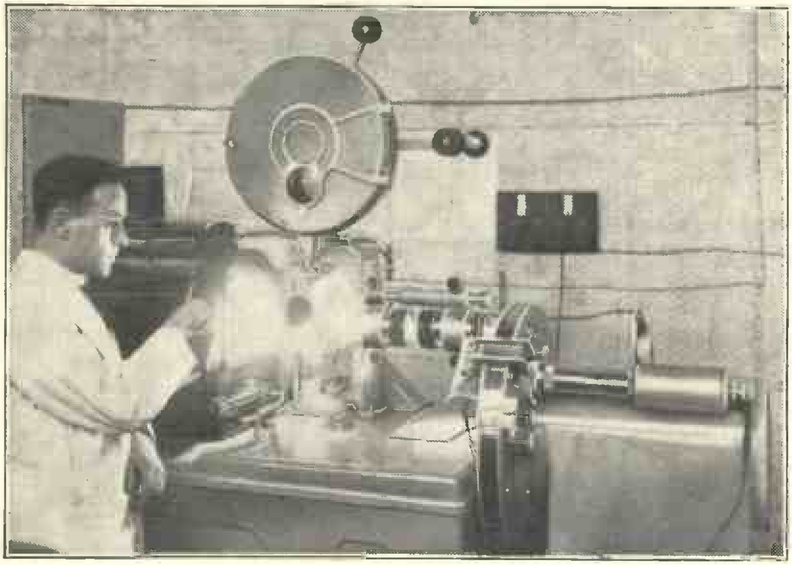
* This firm made over a million H-shaped cores of "Sirufer" in a year. See *Hochfrequenztechnik*, March, 1936, p. 100.



Baird Television

A recent photograph, showing the arc lamp, optical system and disc scanning unit for one of the disc scanners in use in the Baird television equipment which is being supplied to the British Broadcasting Corporation for installation at the new transmitter at Alexandra Palace.

Variable Selectivity and the I.F. Amplifier

Part III.*—The Amplifier as a Whole

By W. T. Cocking

ALTHOUGH the design of circuits for the attainment of variable selectivity has been dealt with in considerable detail in the two preceding parts of this article, the data given there is by no means sufficient to enable an amplifier having the desired characteristics to be built. The correct result will only be secured when steps are taken in design to ensure that the actual circuit constants have the same values as those employed in the calculations. This is obvious in the case of coils and condensers, but it is all too easy to underestimate the importance of the input and output impedances of the valves. These impedances are often thought to be so high with modern valves that they exercise a negligible effect upon the circuits to which they are connected. This is by no means the case, however, and the shape of a resonance curve can be very seriously altered by an unsuitable choice of valve; according to the circuit arrangement, a circuit capable of giving a curve with three equal peaks may in practice show only a single peak with two side " bumps " or may have two large peaks with an enormous trough between them.

In dealing with the variably-coupled circuits in Part I, it was assumed that the valves between which they would be connected would have infinite input and output impedances. In practice, this condition is approached by arranging for these impedances to be very high compared with the output and input impedances respectively of the circuit. It is particularly important to note that this course is the only one possible. At first sight, the obvious course is to modify the circuit equations to take into account the valve impedances, but this is not practicable because the valve impedances are not constants. Volume control, either manual or automatic, usually operates by changing the grid bias of the valves and this also changes both the input and output impedances. Consequently, if the circuit were designed for finite values of these impedances, the correct results would be secured only for a particular value of grid bias, and as this depends on signal strength, in the end, only for signals of a particular strength. It is clear, then, that as the impedances are variable, their effect can only be unimportant when their lowest values are very high compared with the circuit impedances.

When considering the coupling between the last I.F. valve and the detector in Part II, the valve impedances were taken into account. In this portion of the receiver the argument against this carries little weight. In the first place it is not usually permissible to vary the operating conditions of the last I.F. valve for volume control purposes, since it must be operated under conditions giving maximum undistorted output; its output impedance is, therefore, constant. Secondly, if the A.V.C. system maintains the detector input at a nearly constant level, the detector input impedance is nearly constant. Actually, with a diode detector, the input impedance is very nearly the same for all inputs exceeding a certain figure. It is clear, therefore, that in the case of this particular coupling it is perfectly justifiable, and advantageous, to take the valve impedances into account.

The output impedance of a valve can be represented by a capacity and a resistance in parallel. The capacity does not change to any appreciable degree with normal alterations in the operating conditions of the valve, and it need not be further considered since its effect can be exactly compensated by the tuning capacity in the I.F. transformer. The resistance is the anode A.C. resistance (R_a) of the valve and varies greatly with the operating conditions.

It was shown in Part I that a possible value for the dynamic resistance (R_D) of the kind of tuned circuit likely to be used is 0.54 MΩ;

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* MS. accepted by the Editor, March, 1936.

this is for coils of 2,000 μH. inductance at 465 kc/s. In practice, an inductance of about 1,500 μH. is more likely to be used, since it then seems easier to obtain the required value of Q, and R_D is at the somewhat lower figure of 0.41 MΩ. From the point of view of the effect of the valve resistance, however, it is not so much R_D that is important as the effective dynamic resistance of the primary in the presence of the secondary. The effect of the secondary tuned circuit is to decrease the effective primary dynamic resistance, but as the coupling is variable in this case it is hardly safe to rely on it, and it is wiser to choose the valve on the basis of the tuned circuit alone.

It seems probable that the effects of the valve will be negligible when $R_a \nless 10R_D$, so that R_a should have a minimum value of some 4 MΩ when $R_D = 0.41$ MΩ. The measured values of R_a for a number of typical H.F. pentodes are shown in Fig. 25, and it can be seen that only two of the four valves given have this value of R_a with a reasonably high value of mutual conductance. For $R_a = 4$ MΩ, the Ferranti VPT4B has $g = 1.7$ mA/V, and with the Brimar 9A1 $g = 1.65$ mA/V. The absurdity of the commonly believed statement that the A.C. resistance of an H.F. pentode is so high that it can be ignored is obvious from an inspection of the curves; thus for $g = 1.7$ mA/V the Marconi and Osram VMP4G has R_a=0.7 MΩ —only 70 per cent. higher than the dynamic resistance of the tuned circuit.

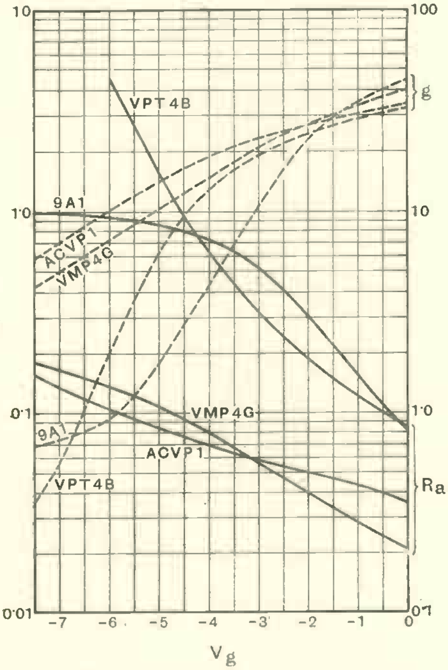


Fig. 25.—*The characteristics of four typical H.F. pentodes.*

The low A.C. resistance of certain pentodes must not be considered a fault, since it can sometimes be turned to good account. Thus, in the case of a pair of coupled circuits between the last I.F. valve and the detector (Part II), if the primary circuit has a dynamic resistance of 0.41 MΩ it must be shunted by a resistance of this value in order to obtain the correct resonance curve. When there is no A.V.C. circuit damping the primary, the correct results are most readily secured by selecting a valve having $R_a = 0.41$ MΩ, and reference to Fig. 25 shows that while the Brimar and Ferranti are both unsuitable, the Marconi and Osram VMP4G here comes into its own. At $-$ 2.1 volts grid bias it has $R_a = 0.41$ MΩ and $g = 2.65$ mA/V.

It is clear, therefore, that there are really two different classes of H.F. pentodes and that the right kind must be used in the right place if good results are to be secured. Neither class is intrinsically better than the other, but each is better than the other for certain applications. The impossibility of obtaining satisfactory results with tetrodes is evident, however, when it is remembered that such valves have resistances as low as 0.1–0.2 MΩ.

When choosing valves, the frequency-changer must not be overlooked, for the first I.F. tuned circuit is damped by the conversion resistance of this valve. The ordinary heptode is unsuitable, since most types have a resistance of the order of 0.3 MΩ; the octode and triode-pentodes are an improvement with a resistance of some 1 MΩ, but the triode-hexode seems better still. This valve is rated for a resistance of 2 MΩ, but it may be materially increased by operating it at a higher value of grid bias. The conversion conductance is naturally reduced, but so is the risk of overloading, and consequent grid current, in the grid circuit.

Turning now to the input impedance of a

valve, the matter is much more difficult. The impedance can be represented in three parts. The first is a capacity of fixed value, analogous to the output capacity, which need not be further considered since it can be absorbed by the trimmer. The second is also a capacity, the value of which depends on the nature and magnitude of the anode circuit load impedance as well as upon the valve characteristics, and the third is a resistance the sign and value of which depend on the same factors as the capacity. This capacity only becomes zero and this resistance only becomes infinite when the grid to anode valve capacity is zero—a condition which never obtains in practice—or under certain critical conditions of the anode load impedance.

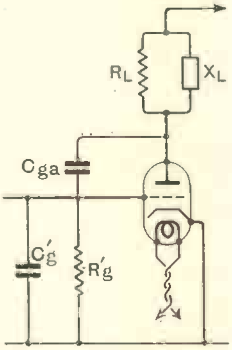


Fig. 26.—*The input impedance of a valve can be represented by a resistance R_g' in parallel with the reactance of a condenser C_g'.*

In general, the input resistance is more important than the capacity, and just like the output resistance, its value varies with the grid bias applied to the valve; unlike the output resistance, however, it is also a function of frequency. When the anode circuit load impedance is a tuned circuit, the input resistance varies rapidly for small changes in frequency and changes sign as the frequency passes through resonance. Thus any attempt at compensation is out of the question even if the operating conditions of the valve be kept constant, for any compensation could be correct only at one frequency and large variations within the side-band range of frequencies would still be found.

When the anode circuit load impedance of a valve is represented by a resistance and reactance in parallel, as in Fig. 26, the input resistance R_g' and capacity C_g', due to feedback through the grid-anode capacity C_{ga}, are given by

$$R_g' = X_{ga}\left\{\frac{G^2 + (S_L + S_{ga})^2}{g(S_L + S_{ga}) + GS_{ga}}\right\} \quad \ldots \quad (103)$$

$$C_g' = C_{ga}\left\{\frac{G(g+G) + S_L(S_L + S_{ga})}{G^2 + (S_L + S_{ga})^2}\right\} \quad \ldots \quad (104)$$

where

$$G = G_a + G_L = 1/R$$
$$G_a = 1/R_a$$
$$G_L = 1/R_L$$
$$S_L = 1/X_L$$
$$S_{ga} = \omega C_{ga} = 1/X_{ga}$$

In most practical cases $S_{ga} << S_L$ and $G << g$ then

$$R_g' \approx X_{ga}\left\{\frac{1 + X_L^2/R^2}{gX_L}\right\} = X_{ga}\left\{\frac{1 + R^2/X_L^2}{gR^2/X_L}\right\} \quad \ldots \quad \ldots \quad (105)$$

$$C_g' \approx C_{ga}\left\{1 + \frac{gR}{1 + R^2/X_L^2}\right\} \quad \ldots \quad \ldots \quad (106)$$

From equation (105) R_g' is a minimum when $R = \pm X_L$ and a maximum when $X_L = \infty$.

When the anode circuit load Z_L consists of a single tuned circuit as in Fig. 27, it is easily shown that

$$R_L = \omega^2 L_1^2/R_1 \quad \ldots \quad \ldots \quad (107)$$

and

$$jX_L = j\omega L_1/y \quad \ldots \quad \ldots \quad (108)$$

When the load is of the form of Fig. 28, however, the expressions are more complex. Using the nomenclature of Part II, where this circuit is treated in detail,

$$G_L = \frac{1}{a_1^2 R_a}\left[1 + \frac{a^2(1 + a_2^2)}{(1 + a_2^2)^2 + y^2Q^2}\right] \quad \ldots \quad (109)$$

$$jS_L = \frac{jyQ}{R_a}\left[1 - \frac{a^2}{(1 + a_2^2)^2 + y^2Q^2}\right] \quad \ldots \quad (110)$$

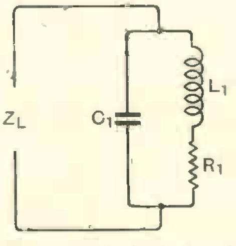


Fig. 27.—*A single tuned circuit imposes a load impedance Z_L on the valve.*

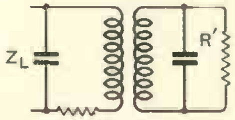


Fig. 28.—*When coupled circuits are used, the effect of the secondary on the load Z_L must be taken into account.*

In the case of the detector coupling, $a_1 = a_2 = a = 1$ (it is here assumed that $R_{AVC} = \infty$; *i.e.*, there is no A.V.C. circuit connected to the transformer primary) and the equations reduce to

$$G_L = \frac{1}{R_a}\left[1 + \frac{2}{4 + y^2Q^2}\right] \quad \ldots \quad (111)$$

$$jS_L = \frac{jyQ}{R_a}\left[1 - \frac{1}{4 + y^2Q^2}\right] \quad \ldots \quad (112)$$

The insertion of these values of G_L and jS_L in equation (105) gives

$$R_g' = X_{ga}\left[\frac{y^2Q^2 + (1 + R_D/R_a)^2}{gR_D yQ}\right] \quad \text{.. (113)}$$

for the case of a single tuned circuit as the anode load, and

$$R_g' = X_{ga}\left[\frac{16 + (3 + y^2Q^2)^2}{gR_a yQ(3 + y^2Q^2)}\right] \quad \text{.. (114)}$$

for the case of a pair of coupled circuits as described above.

It can be shown that the minimum values of R_g' occur for $yQ = 1 + R_D/R_a$ in the case of the single circuit and $yQ = 2.62$ in the special case of coupled circuits.

When $R_D = R_a$, the frequencies for which R_g' assumes its minimum positive and negative values fall well within the sideband range when operating at 465 kc/s, and the value of R_g' is of the order of 0.5 MΩ; in both cases when $g = 2.65$ mA/V, $C_{ga} = 0.0025$ μμF., $Q = 93.5$, and $R_D = 0.41$ MΩ. The minimum value of R_g' can only be increased by reducing C_{ga} or the amplification, this last being achieved either by reducing g or by employing a lower value of R_D. In the last stage of amplification, however, it is rarely permissible to do this, for the highest possible stage gain is required in order to reduce to a minimum the risk of distortion through overloading, for such distortion becomes very noticeable in practice. In the matter of C_{ga}, the designer is in the hands of the valve makers and the figure taken above seems to be the lowest generally obtainable; many valves, in fact, have a higher capacity.

It is, therefore, necessary to reckon that the last I.F. valve will have an input resistance which, within the sideband range of frequencies, will vary from infinity to as little as some ± 0.5 MΩ. If normal practice is to be followed the input circuit to this valve will consist of a pair of variably-coupled circuits, each having a dynamic resistance of 0.41 MΩ. It is clear, however, that as the input resistance of the valve may be of the same order as the dynamic resistance of the tuned grid circuit, the required performance will certainly not be obtained.

One solution to the difficulty is to adopt the Colebrook system of amplification, but using pentodes instead of triodes. This is an obvious and easy way out, but has the practical drawback of requiring four valves instead of two in a two-stage amplifier. While this may be no objection in some cases, it is in commercial apparatus where cost has to be studied.

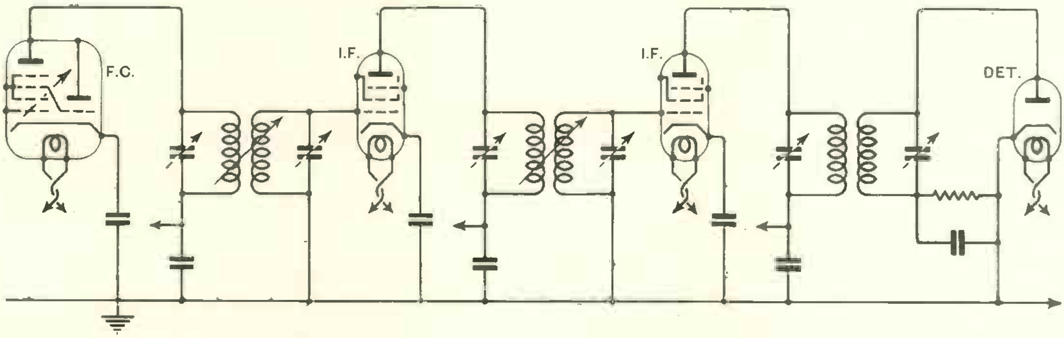


Fig. 29.—*With the conventional circuit arrangement, valves and pairs of tuned circuits alternate through the amplifier.*

There is, however, no reason why the conventional arrangement of alternating valves and pairs of tuned circuits should be adhered to. There is no inherent objection to the connection of all or most of the tuned circuits together and to making the amplifier substantially aperiodic; in other words, to the separation of the processes of selectivity and amplification. It is, of course, necessary to retain tuned circuits for the coupling between the last I.F. valve and the detector since high amplification must be obtained at this point. As compared with the normal arrangement of Fig. 29, this system would take the form shown in Fig. 30, where I.V.C. is an intervalve coupling of nature at present unspecified.

The first step is obviously to determine how two pairs of variably-coupled coils

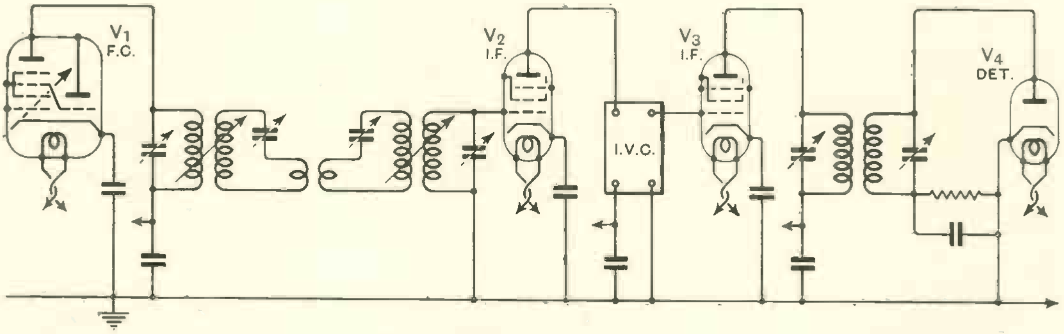


Fig. 30.—*In order to reduce the effects of the input impedance of the valves, the arrangement shown here can be adopted.*

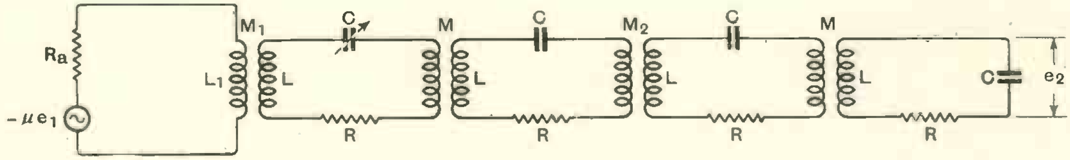


Fig. 31.—*The generalised circuit of four coupled tuned circuits each of total inductance L, capacity C, and resistance R.*

behave when coupled together instead of being separated by ideal valves. The relevant portion of Fig. 30, between V_1 and V_2, can be generalised as in Fig. 31, where there are four tuned circuits of total inductance L, capacity C, and resistance R coupled as shown. By the straightforward application of Kirchhoff's laws

$$\frac{e_2}{e_1} = \frac{\mu\omega^5 M^2 M_1 M_2 L}{R_a[Z^2(Z^2 + \omega^2M^2 + \omega^2M_2^2) + \omega^2M^2(Z^2 + \omega^2M^2)] + \omega^2M_1^2Z(Z^2 + \omega^2M^2 + \omega^2M_2^2)} \quad .. \quad (115)$$

When $\omega L_1 << R_a, \quad \omega L \approx 1/\omega C,$
and $Z = R + j\omega L - j/\omega C$

$$\frac{e_2}{e_1} \approx \frac{g a^2 a_1 a_2 \sqrt{R_D R_a}}{\sqrt{[\{(1 + a^2 - y^2Q^2)^2 + a_2^2 - y^2Q^2(4 + a_2^2) + a_1^2(1 + a^2 + a_2^2 - 3y^2Q^2)\}^2 + y^2Q^2\{2(2 + 2a^2 + a_2^2 - 2y^2Q^2) + a_1^2(3 + a^2 + a_2^2 - y^2Q^2)\}^2]}} \quad .. \quad (116)$$

where

$g = \mu/R_a \qquad a_2 = \omega M_2/R$
$a = \omega M/R \qquad R_D = \omega LQ = \omega^2L^2/R$
$a_1 = \omega M_1/\sqrt{RR_a} \qquad yQ \approx 2nQ/f$

Now in practice $\omega L_1 = \omega L = \omega M_1$, so that $a_1^2 = \omega^2L^2/RR_a = R_D/R_a$. Consequently, when $a_1^2 << 1$ the equation can be reduced to

$$\frac{e_2}{e_1} = \frac{gR_D a^2 a_2}{\sqrt{[\{(1 + a^2 - y^2Q^2)^2 + a_2^2 - y^2Q^2(4 + a_2^2)\}^2 4y^2Q^2\{2 + 2a^2 + a_2^2 - 2y^2Q^2\}^2]}} \quad .. \quad (117)$$

At resonance $y = 0$ and then

$$\frac{e_2}{e_1} = \frac{gR_D a^2 a_2}{(1 + a^2)^2 + a_2^2} \quad .. \quad (118)$$

By differentiating and equating to zero

$$(a^4)_{\text{opt.}} = 1 + a_2^2$$
$$(a_2)_{\text{opt.}} = 1 + a^2$$

and both conditions cannot be satisfied simultaneously.

Inspection of the equation shows that the *shape* of the resonance curve will only be that required when $a_2 = 0$—that is, it will then be the same as the square of that of a pair of coupled circuits. This value of a_2 cannot be used, however, for there would be no transfer of energy between the circuits. It is difficult to estimate the maximum value of a_2 which can be used with a negligible effect on the characteristics of the circuits, but for present purposes a good value for the coupling will be that adopted in Part II for a pair of loosely-coupled circuits approximating two single circuits in cascade. Therefore, let $a_2 = (a_2)_{\text{opt.}}/2$. The value of $(a_2)_{\text{opt.}}$ is variable for it depends on a; it will lead to fairly loose coupling, however, if it is taken at $a = 1$, and then $a_2 = 1$.

Under this condition, the amplification at resonance becomes

$$\frac{e_2}{e_1} = \frac{gR\,.\,a^2}{1 + (1 + a^2)^2} \quad \ldots \quad (119)$$

and $(a^4)_{\text{opt.}} = 2$

then $$\frac{e_2}{e_1} = \frac{gR_D}{2(1+\sqrt{2})} = 0.2075\, gR_D \ldots (120)$$

It will be shown later that with a suitable design of coil $R_D = 0.41\ M\Omega$ and a typical frequency-changer operating under suitable conditions for the avoidance of grid current and the attainment of a high value of R_a has a conversion conductance of about 0.3 mA/V. Using these values, $e_2/e_1 = 25.5$.

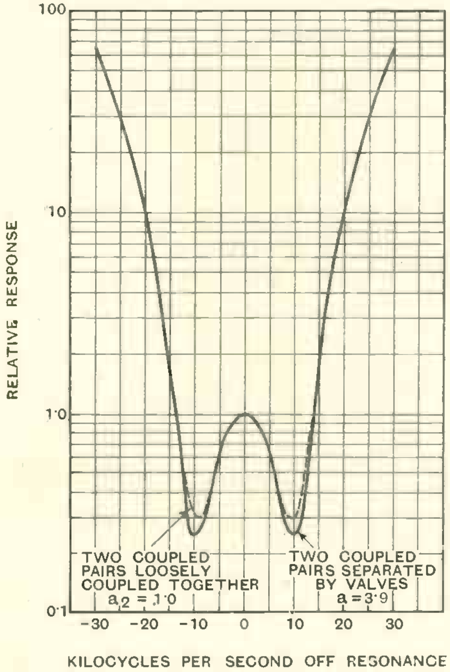


Fig. 32.—*The overall resonance curves of four tuned circuits having $a = 3.9$; the solid curve is for two pairs of circuits separated by ideal valves, while the dotted curve shows the results when the four circuits are coupled together with $a_2 = 1$.*

In order to make sure that the value selected for a_2 is satisfactory from the point of view of the shape of the resonance curve, the performance has been calculated and is shown in Figs. 32 and 33. The former shows the response obtained with four tuned circuits, the solid line representing the case of two identical transformers coupled by perfect valves and calculated from the data given in Part I for a coupling factor of 3.9. The dotted curve shows the results when the same two transformers are coupled together in the manner of the circuits between the first two valves of Fig. 30, the coupling factors a between the coils of each pair being 3.9, and that a_2 between the pairs themselves being 1. It is evident that the use of the circuits in this manner affects the response only in the neighbourhood of the peaks.

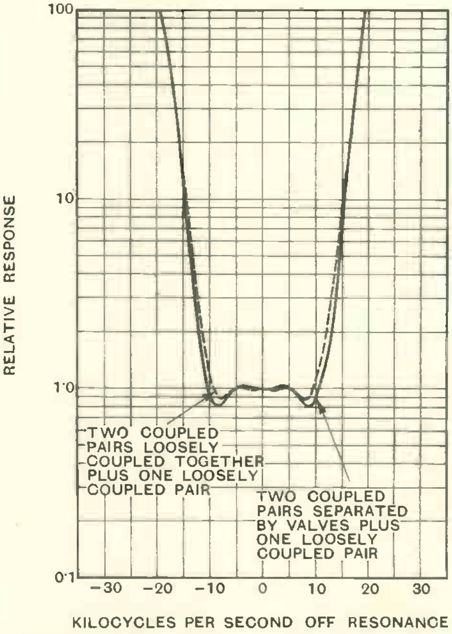


Fig. 33.—*The solid and dotted line curves show respectively the two different arrangements of Fig. 32 combined with a further pair of circuits having $a = 1$.*

In Fig. 33 are shown the results when the same two circuits are followed by a loosely-coupled pair of circuits having coils of $Q/2$ and $a = 1$, as discussed in Part II. As before, the solid line curve refers to the arrangement of Fig. 29, while the dotted line represents the circuit of Fig. 30. The curious result emerges that the performance is actually better with the latter connections and the reason is that the loosely-coupled pair of circuits of $Q/2$ is only an approximation to the correct arrangement for use with two variable-selectivity transformers separated by ideal valves. It is, however, a much closer approximation to the ideal in the case when the two transformers are themselves coupled together. It is clear, therefore, that no one need have qualms about using the system of Fig. 30 as far as the shape of the resonance curve is concerned.

It has been shown that this arrangement permits the correct pass-band to be obtained and with a gain of 25.5 times from the grid of the frequency-changer to the grid of the first I.F. valve. The next step is to calculate the gain in the last I.F. stage. It is desired to obtain as much amplification as possible in this stage, not only for the sake of the gain itself but to reduce to a minimum the risk of amplitude distortion. As explained in Part II the gain is dependent upon the dynamic resistance of the circuits and their coupling and the former are dependent upon the external damping imposed on the circuits. On the secondary, there is the damping of the detector and as this is of the order of 125,000 Ω for the usual diode detector, the constants of the secondary are fixed at $L_2 = 457.5\ \mu$H., $C_2 = 258\ \mu\mu$F., and $R_2 = 14.3\ \Omega$. Of this circuit alone $Q = 93.5$ and $R_D = 0.125$ MΩ, but when shunted by the detector, the effective Q is 46.75 and R_D becomes 62,500 Ω.

Calculations previously made for the primary allowed for both the valve A.C. resistance and for the loading of an A.V.C. system. The latter imposes a considerable limitation on the gain obtainable, and since it is a variable load it introduces distortion, so that it is probably better to dispense with it and to utilise, either directly or indirectly, the D.C. output of the detector itself for A.V.C. purposes. The Q of the primary circuit alone must be 93.5 and it must be reduced to half this figure by the damping of the A.C. resistance of the valve. This will be obtained when the dynamic resistance equals the valve resistance. For a given mutual conductance, the stage gain will then be greatest with the valve of highest resistance. There is, however, a limit to the dynamic resistance easily obtainable with circuits of a given Q, and in the case of the coils used in the variably-coupled circuits this has been taken as 0.41 MΩ, which is obtained with a coil of 1,500 μH. inductance.

Taking this figure, the valve used must have an anode A.C. resistance of 0.41 MΩ and as high a mutual conductance as possible. Fig. 25 shows the measured characteristics of a number of typical modern valves. Of these valves only two can be adjusted to give the required resistance, the ACVP1 and the VMP4G, and the former has a mutual conductance of 3.15 mA/V, whereas the latter has $g = 2.65$ mA/V. The ACVP1 consequently appears the better valve, but further examination of the curves shows that it requires a grid bias of only -0.75 volt while the VMP4G needs -2.1 volts. With indirectly heated valves, grid current usually flows until the grid is more negative than 1–1.5 volts. If grid current is to be avoided, therefore, the ACVP1 cannot be operated under these conditions and it is necessary to use the VMP4G.

It is now possible to calculate the stage gain from the relevant equation of Part II, which is

$$\frac{e_2}{e_1} = \frac{gaa_1\sqrt{R_aR'}}{4 + a^2}$$

Now $\quad a = 1$

and $\quad a_1 = \omega L_1/\sqrt{RR_a} = \sqrt{R_{D1}/R_a} = 1$

$$\therefore \quad \frac{e_2}{e_1} = 0.2\, g\sqrt{R_aR'}$$

In this case, $g = 2.65$ mA/V, $R_a = 0.41$ MΩ, and $R' = 0.125$ MΩ, therefore $e_2/e_1 = 120$.

It was previously found that a gain of 25.5 times could be expected from the frequency-changer, so that apart from V_2 of Fig. 30, the gain is $25.5 \times 120 = 3{,}060$ times. The gain which must be obtained from V_2 depends on the total amplification required. If this be fixed at the reasonable figure of 150,000 times, then V_2 must amplify with its coupling $150{,}000/3{,}060 = 49$ times.

The characteristics required of this stage can now be laid down as follows :—

(1) It must amplify about 50 times.

(2) It must have an input resistance of not less than 4 MΩ at any frequency within the pass-band of the input circuit.

(3) The coupling to the next stage must be of such form that the input resistance of this stage exercises a negligible effect ; that

is, a variation of infinity to ± 0.5 MΩ within the sideband range of frequencies must not appreciably affect the coupling.

The problem now resolves itself into the design of a stage having as nearly as possible these characteristics.

Consider a simple impedance coupling of the type of Fig. 26; the amplification can be written

$$A = \frac{gR}{\sqrt{1 + R^2/X_L^2}} = \frac{gX_L}{\sqrt{1 + X_L^2/R^2}} \quad .. \quad (121)$$

The input resistance R_g' is given by equation (105) which may be written in the form

$$R_g' = X_{ga}\left[\frac{\sqrt{1 + X_L^2/R^2}}{A}\right] \quad .. \quad (122)$$

Obviously, for a given value of A, the greatest value of R_g' is secured when X_L/R is a maximum. This occurs when $X_L = \infty$; *i.e.*, at resonance with a parallel tuned circuit. The use of such a circuit may not prove impossible for very high amplification is not required ; it is consequently worth a trial. At resonance $X_L = \infty$, therefore, $A = gR = 50$ and if $g = 2.65$ mA/V, $R = 18{,}850$ Ω. Now $R = R_aR_D/(R_a + R_D)$, and if $R_a = 0.41$ MΩ, $R_D = 19{,}750$ Ω. With such a low value of R_D, the input resistance of the following valve will have only a small effect, changing the effective value of R_D by some ± 5 per cent. ; it can, therefore, be ignored.

It was shown earlier that the minimum value of R_g' occurs when

$$yQ = 2nQ/f = 1 + R_D/R_a = 1.0482$$
$$\therefore \quad Q = 0.5241\, f/n = 2.44 \times 10^5/n$$

The value of n for which R_g' is a minimum should be as great as possible. As the limits of the sideband range occur for $n = \pm 10{,}000$ c/s, let $n = \pm 20{,}000$ c/s. Then $Q = 12.2$.

$$\text{Now} \quad R_D = 19{,}750 = \omega LQ = 12.2\,\omega L$$
$$\therefore \quad L = 550\ \mu\text{H. at } 465 \text{ kc/s}$$
$$C = 1/\omega^2 L = 214\ \mu\mu\text{F.}$$

These values are ones which are readily obtainable in practice, and it remains to see whether the other conditions are fulfilled. The minimum value of R_g' at $n = \pm 20{,}000$ c/s is $R_g' = \pm 2X_{ga}/gR = \pm 5.47$ MΩ. At all frequencies nearer to resonance it is higher than this, and is very much higher within the pass-band.

The selectivity of a circuit of this nature can be calculated by

$$S = \sqrt{1 + y^2Q^2_T} \approx \sqrt{1 + y^2Q^2}$$
$$= 1.13 \text{ (1.04 db.) for } n = \pm 10{,}000 \text{ c/s.}$$

This is not a large amount and is probably tolerable. It could easily be reduced, however, by making Q smaller and L larger, and this would also increase R_g' without affecting the stage gain. Alternatively, L could be increased and Q reduced to obtain an increase in R_D and A without decreasing R_g'. The input resistance of the second valve would then begin to have an appreciable effect, however, and the small increase in gain which would be possible does not seem worth while.

The highest possible value of R_g' would obviously be secured with the circuit of lowest Q, and this in turn means the highest inductance. The limit to inductance is set by the stray capacities which are likely to total about 45 μμF. including the self-capacity of the coil. This means an inductance of 2,600 μH. If $R_D = \omega LQ = 19{,}750$ Ω, $Q = 2.6$. When R_g' is a minimum $yQ = 1.0482$, therefore, $y = 0.403$ and $n = \pm 93{,}500$ c/s and at this frequency $R_g' = \pm 5.47$ MΩ.

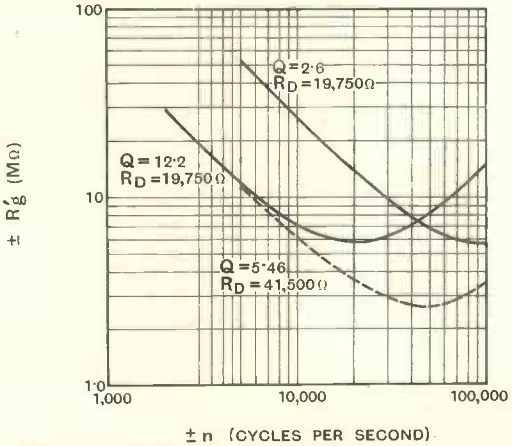


Fig. 34.—*The input resistance of a valve over the range of sideband frequencies is shown here for various constants in the intervalve coupling.*

The minimum value of R_g' is unaffected, but the value of R_g' in the pass-band is greatly increased since the frequency of the minimum is much further removed from resonance. Equation (113) enables the input resistance to be calculated and it is shown in Fig. 34 for the two cases just considered. Only positive values of n and R_g' are shown, since the negative values are numerically equal. It is easy to see that the input resistance of the valve should be truly negligible, since within the pass-band of $\pm$ 10,000 c/s it never falls below 25 MΩ. It would, in fact, be quite possible to obtain higher gain without the input resistance becoming too low.

For example, let $A = 100$. Then with the same valve as before, $R = 37{,}700\ \Omega$ and $R_D = 41{,}500\ \Omega$. If $L = 2{,}600\ \mu$H., $Q = 5.46$, and the input resistance is a minimum of $\pm$ 2.6 MΩ at about $\pm$ 50,000 c/s from resonance. As shown by the dotted curve of Fig. 34, within the pass-band the input resistance is always greater than $\pm$ 6 MΩ. It should, therefore, prove quite possible to employ these values, and the gain of 100 in this stage enables a total gain from the grid of the frequency-changer to the detector of 300,000 times to be obtained. This is probably as much as can be obtained with stability from the conventional circuit arrangement, so that the use of this scheme does not necessarily involve any loss of amplification for the same number of valves, and it does overcome the difficulties brought about by the input impedance of the valves. It is, of course, necessary to adopt sufficient screening and decoupling to avoid feed-back external to the valve, but the need for this should be no greater than with the more conventional arrangement.

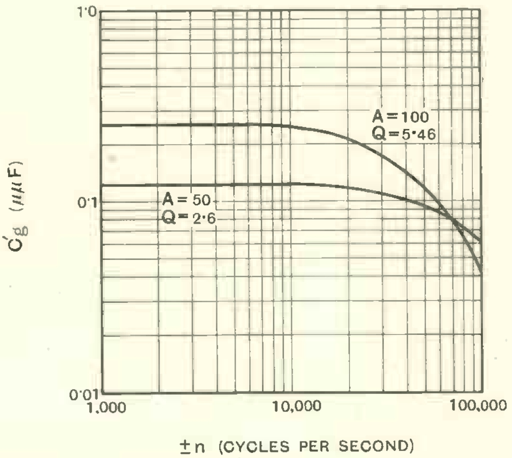


Fig. 35.—*The input capacity is substantially constant over the sideband range of frequencies.*

The variations of input capacity with frequency for the case of $A = 100$ are shown in Fig. 35, assuming $C_{ga} = 0.0025\ \mu\mu$F., and within the pass-band they are negligible—C_g' being nearly constant at 0.25 $\mu\mu$F. It must not be forgotten, however, that C_g' will fall as the amplification is reduced for volume control purposes. If the input circuit is not to be mistuned, therefore, the maximum value of C_g' must be very small compared with the tuning capacity. With an inductance of 1,500 μH., the capacity for resonance at 465 kc/s is 78.3 $\mu\mu$F., and the maximum variation of C_g' is rather less than 0.25 $\mu\mu$F. This means a change in resonance frequency of about 1 kc/s, which is rather great. It would be wiser, therefore, to reduce the effect by adopting the lower degree of amplification; that is, $A = 50$. The maximum value of C_g' is about halved, as shown in Fig. 35, and the mistuning effect is likely to be quite small.

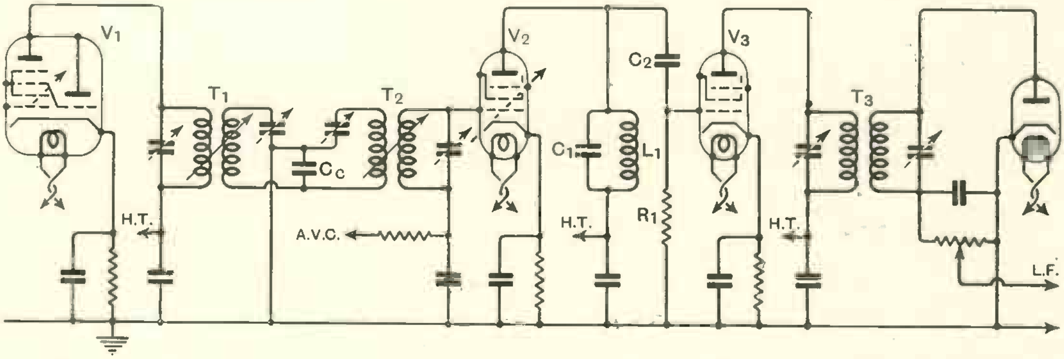
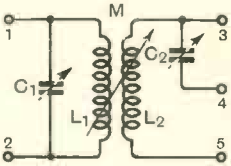


Fig. 36.—*The suggested circuit diagram of a receiver complying with the requirements discussed in this article.*

A receiver built on these lines would take the form shown in Fig. 36. The only point not definitely settled in the foregoing is the value of the coil inductances. In Parts I and II, a value of 2,000 μH. was assumed, but while this is quite possible a lower inductance of the order of 1,500 μH. is preferable, although it means slightly less amplification, for it seems easier to obtain coils of the requisite efficiency with the lower inductance. If 1,500 μH. is decided on, then the constants of the three transformers of Fig. 36 would be as given in Table I for T_1 and T_2, and as in Table II for T_3; Table III gives the data for a single-circuit suitable for use with a variable-coupled pair to form a three-stage filter as described in Part I.

TABLE I



$L_1 = L_2 = 1{,}500\ \mu\text{H}.$
$C_1 = C_2 = 78.3\ \mu\mu\text{F}.^*$
$Q_1 = Q_2 = 93.5$
$R_{D1} = R_{D2} = 0.41\ M\Omega$
$R_1 = R_2 = 46.9\ \Omega$
$a = \omega M/R = 0.5 - 3.9$
$M = 7.5 - 58.5\ \mu\text{H}.$

* For resonance and including stray capacities.

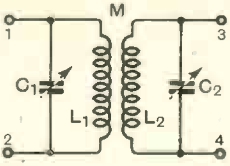
The coupling condenser C_c is readily calculated, for the coupling factor

$$a = X_c/R = 1$$

$$\therefore \quad C_c = 1/\omega R = 0.0073\ \mu\text{F}. \qquad \ldots (123)$$

In the coupling between V_2 and V_3, $L_1 = 2{,}600\ \mu\text{H}.$ and $C_1 = 45\ \mu\mu\text{F}.$ This figure includes the self-capacity of the coil and the input and output capacities of the valves, so that in many cases a condenser will be unnecessary, L_1 being wound to resonate with the stray capacities. In design it is not important to build the coil of a definite Q, for as long as $Q > 2.6$ it can be adjusted to the desired figure by the correct choice of R_1 provided that C_2 is large enough. With an X41 valve for V_1 and VMP4G types for V_2 and V_3, the arrangement of Fig. 36 should give a total gain of 150,000 times and almost ideal variable-selectivity characteristics.

TABLE II



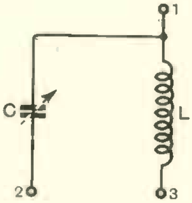
$L_1 = 1.500\ \mu\text{H}.$
$C_1 = 78.3\ \mu\mu\text{F}.$
$Q_1 = 93.5$
$R_{D1} = 0.41\ M\Omega$
$R_1 = 46.9\ \Omega$
$a^2 = \omega^2 M^2/R_1 R_2 = 1$

$L_2 = 457.5\ \mu\text{H}.$
$C_2 = 256.5\ \mu\mu\text{F}.$
$Q_2 = 93.5$
$R_{D2} = 0.125\ M\Omega$
$R_2 = 14.3\ \Omega$
$M = 8.86\ \mu\text{H}.$

If higher selectivity is required than can be obtained with six circuits, then nine must be used with an additional I.F. valve. As this extra valve need give only a very small degree of amplification to make up for the losses of the extra circuits, it should prove possible to use the arrangement of Fig. 37 without difficulties arising from the input impedance of the valves. The additional valve must, of course, have a high A.C. resistance, and the VPT4B should be suitable.

Before concluding, it may be as well to comment on the construction of the transformers. When the coupling between two circuits is fixed and sub-optimum, as in the case of the coupling to the detector, the exact nature of the coupling is not important as long as it is reactive. Mutual inductance, common inductance, common capacity and "top-end" capacity, or a combination of any, will give the same results provided that the mutual reactance has the same value in all cases. Naturally, mutual inductance coupling will be the method normally used, but special precautions to avoid capacity coupling due to the proximity of the components are unnecessary, since their effect can be allowed for by a slight alteration in the value of mutual inductance.

TABLE III



$L = 1{,}500\ \mu\text{H}.$
$C = 78.3\ \mu\mu\text{F}.^*$
$Q = 93.5$
$R_D = 0.41\ M\Omega$
$R = 46.9\ \Omega$

* For resonance and including stray capacities.

This is by no means the case with a variably-coupled transformer, however, and here it is essential for the coupling to be as nearly as possible due to the mutual inductance alone. All other forms of coupling cause the peaks in the response curve to open out unevenly about the resonance frequency. Thus with both forms of capacity coupling and with common inductance coupling, one peak is always at the resonance frequency and the other to one side. It is only with pure mutual inductance coupling that the two peaks occur symmetrically on either side of the resonance frequency.

It naturally follows that in the construction of transformers containing variably-coupled coils, great care must be taken to avoid stray capacity coupling. Connecting leads for the

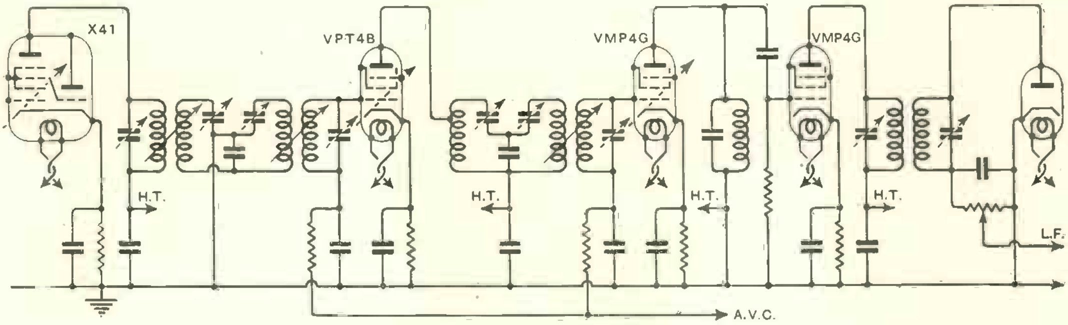


Fig. 37.—*When very high selectivity is needed, an extra valve and three more tuned circuits must be added to the arrangement of Fig. 37.*

primary circuit must be screened from those for the secondary, unless they are brought out at opposite ends of the screening can, and the same applies to the trimming condensers. Moreover, the inductance and self-capacity of the moving coil must not be changed by its normal movement. In the writer's experience these requirements are most easily filled by using small lattice-wound coils mounted coaxially and arranging for one to slide nearer to or further away from the other. The trimmers are best mounted at opposite ends of the can and it is usually possible to take advantage of the metal supports for the coil assembly to provide screening between the leading-out wires.

A good mechanical design is important, and need be little, if any, more expensive than a bad construction with sloppy bearings. In the long run, it will certainly be the cheaper, for unless the workmanship is good, continual repair will be required. It must be remembered that the selectivity control is one which is used nearly as much as the tuning control and probably much more than the wavechange switch. It must, therefore, be just as good mechanically.

Another point of the greatest importance is the method of connecting to the moving coil. This should be a straightforward mechanical problem and ought not to need mention here. Judging by variable-selectivity transformers which the writer has seen commercially produced, however, little attention is paid to the point. It is usual to find copper-braid with soldered joints employed for the connections. The heat of soldering hardens the copper at the ends and as most of the flexing of the connections occurs immediately adjacent to the hardened portion, the connections naturally break after a short time—usually after a few weeks' ordinary use. Sometimes ordinary Litz wire is used, and although this stands up rather better than copper braid, it lasts only a little longer.

The best method which the writer has found is that used in America by Hammarlund, and illustrated by the sketch of Fig. 38. The moving coil is supported by a small platform *A* which moves with it. A second fixed platform *B* is beneath it and carries the trimmer on its under side. Two flat springs *C* anchored to the platforms form the connections, and as long as no movement is permitted in the portions *D* immediately adjacent to the fixing points there is very little risk of breakage. The method is one which lends itself to the easy avoidance of most of the mechanical pitfalls of variable-selectivity transformer construction and should give an indefinite life to the transformer.

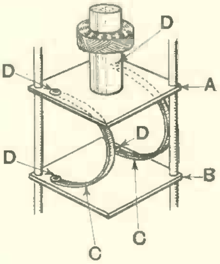


Fig. 38.—*This sketch shows a very reliable method of making contact with the moving coil of a variable-selectivity transformer.*

The Effect of Stray Capacities to Ground in Substitution Measurements*

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

ONE of the factors which plays an important part in practically all measurements of reactance and resistance is the effect of the unavoidable stray impedances to earth which the various components employed in making the measurements may have. This is particularly true at radio frequencies where these impedances may have comparatively low values which would result in errors of appreciable magnitude. Where a bridge method of measurement can be employed, these errors are generally avoided by arranging the bridge so that the stray impedances fall either across the corners of the bridge or across those arms where they have least effect. Where a substitution method is used, however, it is usually impossible to dispose the stray impedances so that no error is obtained and consequently it is necessary to be able to estimate the errors involved in making a given measurement. In the following, formulae are derived which enable these errors to be calculated so that the best conditions of test can be employed.

General Considerations

Measurements by substitution can be made either with the indicating instrument included in the testing circuit or with the meter external to this circuit. To begin with we shall confine our investigations to the former condition, in which case the measurement is usually carried out in the way shown in Fig. 1.

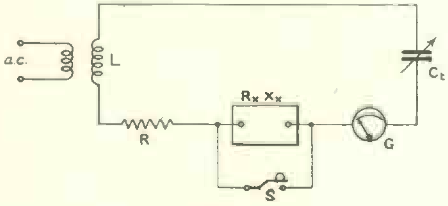


Fig. 1.

The source of A.C. supply is coupled to a coil L; the coil under test which has resistance R_x and reactance X_x is short-circuited by the switch S, and the circuit is tuned by the condenser C_t, the reading in the thermo-ammeter G being noted. R_xX_x is then inserted, the circuit is retuned to resonance and the resistance R is adjusted in order to obtain the same current. From the changes in C_t and in R are calculated the reactance and the resistance of the unknown, respectively.

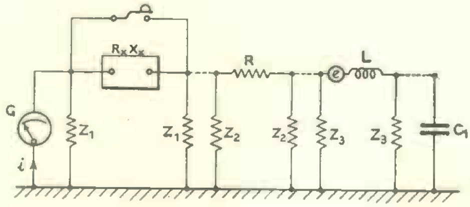


Fig. 2.

In practice, however, the meter and the condenser always have stray impedances to ground and the other components usually have stray impedances to ground as well so that the actual circuit takes the form indicated in Fig. 2. In this diagram it is assumed that the self capacitances of the various components can be ignored, that the stray impedances to ground of each component can be represented by an equal impedance attached to each end, and that the usual practice of grounding the meter and the condenser is adopted. The induced voltage e is introduced in series with L.

From Fig. 2, an expression for e/i can be obtained in terms of all the impedances shown, but the resulting equations are too cumbersome for conclusions of any practical value to be drawn. It is possible, however, by making the assumptions outlined below, to simplify the equations considerably and at

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

the same time to give results approximating very closely to those obtained in practice. In the first place, at radio frequencies the stray impedances are mainly capacitive so that Z_1, Z_2, Z_3 can be represented by condensers which will not differ very greatly in value if the normal precautions to keep the circuit components at a reasonable distance from grounded objects are taken. This was tested by measuring the stray capacitances to ground of a number of resistances and coils, and it was found that all the values obtained fell between 8 and 12 $\mu\mu$F. It will therefore be assumed that each component has a capacitance to ground equal to C so that Fig. 2 can be redrawn to give Fig. 3.

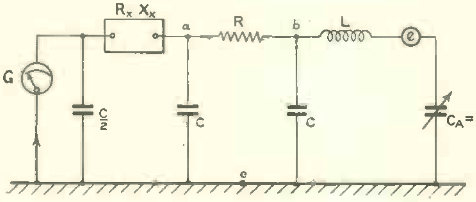

Fig. 3.

Unfortunately, even the circuit of Fig. 3 does not lend itself to analysis until a further assumption is made. We have seen that C can be expected to have a value of the order of 10 $\mu\mu$F, which means that, except for measurements at very high frequencies or of rather high resistances, the stray impedance to ground can be ignored when it is shunted by R, by the meter or by these two resistances in series. These assumptions enable Fig. 3 to be simplified to give the arrangement of Fig. 4 from which the evaluation of e/i presents no difficulty. In Fig. 4 the delta network *abc* of Fig. 3 has been transformed into a simplified star network.

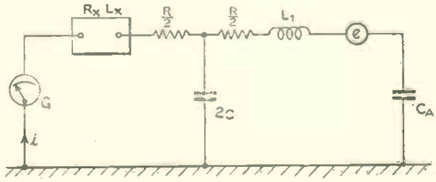

Fig. 4.

When the unknown is short-circuited, Fig. 3 reduces to Fig. 5 where, in order to obtain the same resonance current i, the condenser and resistance are reset to have the values C_2 and R_0 respectively.

Now, the components R, L and R_xX_x can be arranged in six different ways in the series circuit so that Fig. 3 represents only one of the six possible arrangements tabulated in Column 2 of Fig. 6. Columns 3 and 4 of Fig. 6 show, respectively, the simplified circuits corresponding to Figs. 4 and 5, *i.e.*, when the assumption that the magnitude of the stray impedance to ground is large compared with R and the meter resistance is employed.

Below, each of these arrangements is analysed separately, and the errors introduced by the stray capacitances in the evaluation of the unknown resistance and reactance (for convenience assumed to be inductive) is determined. Since the algebra involved is quite straightforward, only sufficient detail to make the successive steps clear is given. The following symbols are employed :—

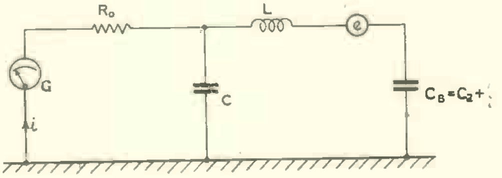

Fig. 5.

L_1 and R_1 = Inductance and resistance of pick-up coil
L_x and R_x = Inductance and resistance of unknown coil
e = e.m.f. introduced in series with pick-up coil
$2R_0$ = Resistance of variable before unknown coil is in circuit.
$2R$ = Resistance of variable when unknown coil is in circuit.
r = Resistance of meter.
i = Meter current at resonance.
$C/2$ = Stray capacitance to ground attached to the terminals of each component.
C_1 = Value of tuning condenser when unknown is in circuit.
C_2 = Value of tuning condenser when unknown is short-circuited.

Case I

When the unknown is short-circuited, the impedance of the series circuit, after assuming $1 >> 2\omega^2 R_0 C C_B$, is given by

$$Z_B = R_1 + r + \frac{2R_0 C_B^2}{(C+C_B)^2} + j\left\{\omega L_1 - \frac{1}{\omega(C+C_B)}\right\}$$

At resonance $\omega L_1 = \dfrac{1}{\omega(C+C_B)}$ .. (1)

Therefore $\dfrac{e}{i} = R_1 + r + \dfrac{2R_0 C_B^2}{(C+C_B)^2} = R_1 + r + 2R_0(1 - \omega^2 L_1 C)^2$ .. (2)

When the unknown is introduced, we have after assuming $1 >> 2\omega C(R + R_x)$, that

$$Z_A = R + R_1 + r + \frac{(R+R_x)}{\left\{1 - 2\omega C\left(\omega L_x - \dfrac{1}{\omega C_A}\right)\right\}^2} + j\left\{\omega L_1 + \frac{\omega L_x - \dfrac{1}{\omega C_A}}{1 - 2\omega C\left(\omega L_x - \dfrac{1}{\omega C_A}\right)}\right\}$$

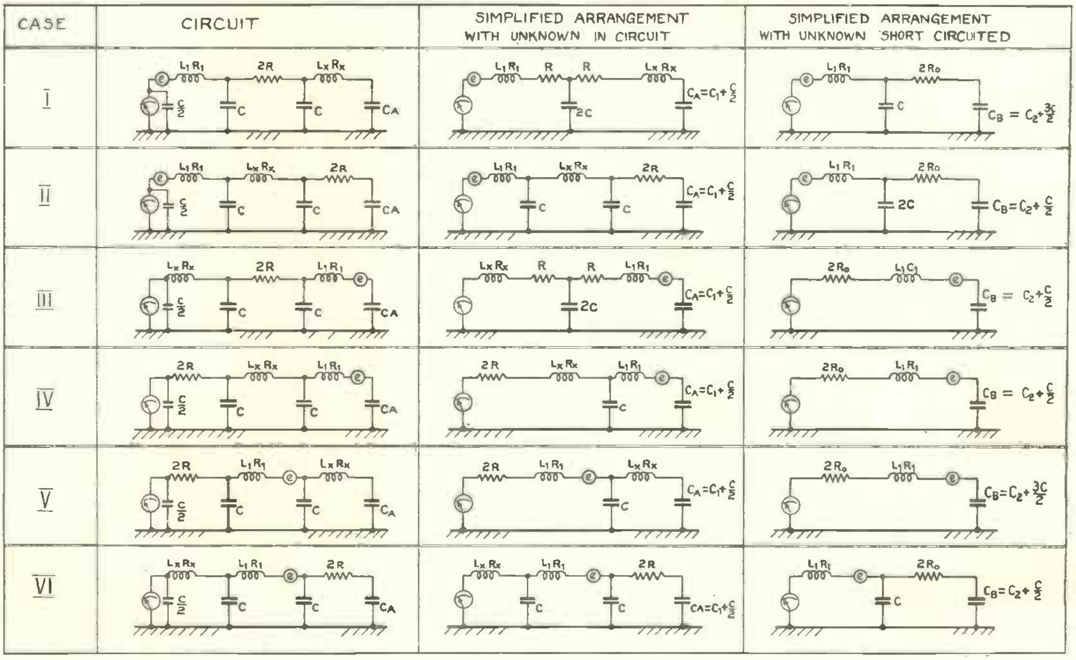

Fig. 6.

At resonance

$$\omega L_x - \frac{1}{\omega C_A} = \frac{-\omega L_1}{1 - 2\omega^2 L_1 C} = -\omega L_1(1 + 2\omega^2 L_1 C + \ldots\ldots) \quad .. \quad (3)$$

and $\dfrac{e}{i} = R + R_1 + r + (R+R_x)(1 - 2\omega^2 L_1 C)^2$

$$= 2R + R_1 + r + R_x(1 - 2\omega^2 L_1 C)^2 - 4\omega^2 L_1 C R + 4\omega^4 L_1^2 C^2 R \quad .. \quad (4)$$

Equating (2) and (4), we derive

$$\frac{R_x}{2(R_0 - R)}(1 - 2\omega^2 L_1 C)^2 = 1 - 2\omega^2 L_1 C - \omega^4 L_1^2 C^2 \frac{2R - R_0}{R_0 - R} \quad .. \quad (5)$$

Expanding $(1 - 2\omega^2 L_1 C)^{-2}$ by the Binomial Theorem and ignoring all terms involving higher powers of C than the second enables equation (5) to be further simplified to give

$$\frac{R_x}{2(R_0 - R)} = 1 + 2\omega^2 L_1 C\left\{1 + \omega^2 L_1 C\frac{5R_0 - 6R}{2(R_0 - R)}\right\} \quad .. \quad .. \quad (6)$$

Now, except at very high frequencies or when the circuit conditions are such that $\omega^2 L_1 C$ cannot be made small, the second order term can be neglected, and we have then from equation (6) that the value of R_x obtained from the readings $2R_0$ and $2R$ is less than the true value by an amount $2\omega^2 L_1 C$. Consequently, for the cases usually encountered in practice, the error involved in measuring the resistance of the coil is $-200\ \omega^2 L_1 C$ per cent., the minus sign indicating that the measured value is less than the true value.

From (1) and (3) we obtain

$$\omega L_x - \frac{1}{\omega C_A} = -\frac{(1 + 2\omega^2 L_1 C)}{(C + C_B)}$$
$$= -\frac{1}{\omega(C + C_B)} - \frac{2C}{\omega(C + C_B)^2}$$

i.e. $$\omega^2 L_x = \frac{1}{C_A} - \frac{1}{C_B(1 + C/C_B)} - \frac{2C}{C_B^2(1 + C/C_B)^2}$$
$$= \frac{1}{C_A} - \frac{1}{C_B} - \frac{C}{C_B^2} + \text{terms in } C^2\text{, etc.}$$

Now $C_A = C_1 + C/2$ and $C_B = C_2 + 3C/2$, so that

$$\omega^2 L_x = \frac{1}{C_1}\left(1 - \frac{C}{2C_1}\right) - \frac{1}{C_2}\left(1 - \frac{3C}{2C_2}\right) - \frac{C}{C_2^2}\left(1 - \frac{3C}{C_2}\right) + \ldots$$
$$= \left(\frac{1}{C_1} - \frac{1}{C_2}\right) - \left(\frac{C}{2C_1^2} - \frac{C}{2C_2^2}\right)$$

+ terms involving higher powers of C,

or $$\frac{\omega^2 L_x}{\left(\frac{1}{C_1} - \frac{1}{C_2}\right)} = 1 - C/2\,(1/C_1 + 1/C_2),$$

which shows that the measured inductance exceeds the true value by $\frac{C}{2}\left(\frac{1}{C_1} + \frac{1}{C_2}\right)$, therefore the error produced is $50\,C\left(\frac{1}{C_1} + \frac{1}{C_2}\right)$ per cent.

Case II

When the unknown is short-circuited, we have at resonance, after assuming $1 >> 4\omega^2 R_0 C C_B$, that

$$\omega L_1 = \frac{1}{\omega(2C + C_B)} \quad \ldots \quad \ldots \quad (7)$$

and $$\frac{e}{i} = R_1 + r + \frac{2R_0 C_B^2}{(2C + C_B^2)} = R_1 + r + 2R_0(1 - 2\omega^2 L_1 C)^2 \quad \ldots \quad (8)$$

When the unknown is in circuit, we obtain at resonance, after assuming

$1 >> 2\omega^2 R C C_A$ and $1 >> \omega C\left\{R_x + \frac{2RC_A^2}{(C + C_A)^2}\right\}$,

$$L_x - \frac{1}{\omega^3(C + C_A)} = -\frac{L_1}{(1 - \omega^2 L_1 C)} \quad \ldots \quad (9)$$
$$= -L_1(1 + \omega^2 L_1 C + \ldots.) \quad \ldots \quad (9a)$$

and $$\frac{e}{i} = R_1 + r + \frac{R_x + \frac{2RC_A^2}{(C + C_A)^2}}{\left[1 - \omega^2 C\left\{L_x - \frac{1}{\omega^2(C + C_A)}\right\}\right]^2} \quad \ldots \quad (10)$$

From (9) and (10)

$$\begin{aligned} e/i &= R_1 + r + \{R_x + 2RC_A^2(C + C_A)^{-2}\}(1 - \omega^2 L_1 C)^2 \\ &= R_1 + r + R_x(1 - \omega^2 L_1 C)^2 + 2R - 8R\omega^2 L_1 C \\ &\quad - 4R\omega^2 L_x C + 8R\omega^4 L_1^2 C^2 + 2R\omega^4 L_x^2 C^2 \\ &\quad + 12R\omega^2 L_1 L_x C^2 + \text{terms involving higher powers of } C \quad \ldots \quad \ldots \quad \ldots \quad (11) \end{aligned}$$

By equating (8) and (11) we obtain

$$\frac{R_x(1 - 2\omega^2 L_1 C + \omega^4 L_1^2 C^2)}{2(R_0 - R)} = 1 - 4\omega^2 L_1 C + \frac{2R}{R_0 - R}\omega^2 L_x C + 4\omega^4 L_1^2 C^2 - \frac{R}{R_0 - R}\omega^4 L_x^2 C^2 - \frac{6R}{R_0 - R}\omega^4 L_1 L_x C^2 \quad (12)$$

When the terms involving higher power of C than the second are ignored, equation (12) can be simplified to give

$$\frac{R_x}{2(R_0 - R)} = 1 - \omega^2 L_1 C(2 + \omega^2 L_1 C) + \frac{R}{R_0 - R}\omega^2 L_x C\{2 - \omega^2 C(2L_1 + L_x)\},$$

which shows that, for small values of $\omega^2 L_1 C$ and $\omega^2 L_x C$, the error involved in measuring the resistance is given by

$$200\ \omega^2 C\left(L_1 - \frac{R}{R_0 - R} L_x\right) \text{ per cent.}$$

From equations (7) and (9a), we obtain

$$L_x - \frac{1}{\omega^2(C + C_A)} = -\frac{1}{\omega^2(2C + C_B)} - \frac{C}{\omega^2(2C + C_B)^2}$$

i.e., $\omega^2 L_x$

$$= \frac{1}{(C+C_A)} - \frac{1}{(2C+C_B)} - \frac{C}{C_B^2}\left(1 - \frac{4C}{C_B}\right) + \dots$$

$$= \frac{1}{C_1}\left(1 - \frac{3C}{2C_1}\right) - \frac{1}{C_2}\left(1 - \frac{5C}{2C_2}\right) - \frac{C}{C_2^2}$$

$$+ \text{ terms in higher powers of } C.$$

$$= \left(\frac{1}{C_1} - \frac{1}{C_2}\right) - \frac{3C}{2}\left(\frac{1}{C_1^2} - \frac{1}{C_2^2}\right)$$

Therefore $\dfrac{\omega^2 L_x}{\left(\dfrac{1}{C_1} - \dfrac{1}{C_2}\right)} = 1 - \dfrac{3C}{2}\left(\dfrac{1}{C_1} + \dfrac{1}{C_2}\right)$

giving an error of $150C\left(\dfrac{1}{C_1} + \dfrac{1}{C_2}\right)$ per cent. in the evaluation of the inductance.

Case III

When the unknown is shorted, we have at resonance

$$\omega L_1 = \frac{1}{\omega C_B} \quad \dots \quad \dots \quad (13)$$

and $\dfrac{e}{i} = R_1 + r + 2R_0 \quad \dots \quad \dots \quad (14)$

When the unknown is in circuit, we obtain at resonance, after assuming

$$1 >> 2\omega C(R + r + R_x),$$

$$\omega L_x = -\left(\omega L_1 - \frac{1}{\omega C_A}\right)(1 - 2\omega^2 L_x C) \quad (15)$$

and $\dfrac{e}{i} = (R + R)(1 - 2\omega^2 L_x C) + \dfrac{R + r + R_x}{(1 - 2\omega^2 L_x C)} \quad \dots \quad \dots \quad (16)$

Equating (14) and (16) gives finally

$$\frac{R_x}{2(R_0 - R)} = 1 - \omega^2 L_x C\left(\frac{2R_0 - 2R + r - R_1}{R_0 - R} + 2\omega^2 L_x C \frac{R_1 + R}{R_0 - R}\right),$$

so that, for small values of $\omega^2 L_x C$, the error obtained in measuring the resistance is given by

$$100\ \omega^2 L_x C \frac{2R_0 - 2R + r - R_1}{R_0 - R} \text{ per cent.}$$

From (13) and (15) we obtain

$$\omega L_x = \left(\frac{1}{\omega C_A} - \frac{1}{\omega C_B}\right)(1 - 2\omega^2 L_x C)$$

Therefore $\omega^2 L_x$

$$= \left\{\left(\frac{1}{C_1} - \frac{1}{C_2}\right) - \frac{C}{2}\left(\frac{1}{C_1^2} - \frac{1}{C_2^2}\right)\right\}(1 - 2\omega^2 L_x C)$$

or

$$\frac{\omega^2 L_x}{\left(\dfrac{1}{C_1} - \dfrac{1}{C_2}\right)} = \left\{1 - \frac{C}{2}\left(\frac{1}{C_1} + \frac{1}{C_2}\right)\right\}(1 - 2\omega^2 L_x C)$$

$$= \frac{1 - \dfrac{C}{2}\left(\dfrac{1}{C_1} + \dfrac{1}{C_2}\right)}{1 + 2C\left(\dfrac{1}{C_1} - \dfrac{1}{C_2}\right)\left\{1 - \dfrac{C}{2}\left(\dfrac{1}{C_1} + \dfrac{1}{C_2}\right)\right\}}$$

$$= \left\{1 - \frac{C}{2}\left(\frac{1}{C_1} + \frac{1}{C_2}\right)\right\}\left[1 - 2C\left(\frac{1}{C_1} - \frac{1}{C_2}\right)\left\{1 - \frac{C}{2}\left(\frac{1}{C_1} + \frac{1}{C_2}\right)\right\}\right] + \dots$$

$$= 1 - \frac{C}{2}\left(\frac{1}{C_1} + \frac{1}{C_2}\right) - 2C\left(\frac{1}{C_1} - \frac{1}{C_2}\right)$$

$+$ terms involving higher powers of C.

Therefore the error obtained in measuring the inductance is

$$50C\left\{\left(\frac{1}{C_1} + \frac{1}{C_2}\right) + 4\left(\frac{1}{C_1} - \frac{1}{C_2}\right)\right\} \text{ per cent.}$$

Case IV

With the unknown shorted, we have at resonance

$$\omega L_1 = 1/\omega C_B \quad \dots \quad \dots \quad \dots \quad (17)$$

and $\dfrac{e}{i} = R_1 + 2R_0 + r \quad \dots \quad \dots \quad (18)$

when the unknown is in circuit, we have, after assuming $1 >> 2\omega C(2R + r + R_x)$, that at resonance

$$\omega L_x = -\left(\omega L_1 - \frac{1}{\omega C_A}\right)(1 - \omega^2 L_x C) \quad (19)$$

and $\dfrac{e}{i} = R_1(1 - \omega^2 L_x C) + \dfrac{2R + r + R_x}{(1 - \omega^2 L_x C)} \quad (20)$

Equating (18) and (20), we obtain finally

$$\frac{R_x}{2(R_0 - R)} = 1 - \omega^2 L_x C\left\{\frac{2R_0 + r - R_1}{2(R_0 - R)} + \omega^2 L_x C \frac{R_1}{2(R_0 - R)}\right\},$$

so that, for small values of $\omega^2 L_x C$, the error involved in measuring the resistance is given by $50\ \omega^2 L_x C\ \dfrac{2R_0 + r - R_1}{R_0 - R}$ per cent.

From (17) and (19) we derive

$$\omega^2 L_x\left(1 - \omega^2 L_1 C + \frac{C}{C_A}\right) = \frac{1}{C_A} - \frac{1}{C_B}$$

Therefore $$\omega^2 L_x = \frac{\dfrac{1}{C_A} - \dfrac{1}{C_B}}{1 + C\left(\dfrac{1}{C_A} - \dfrac{1}{C_B}\right)}$$

$$= \left(\frac{1}{C_A} - \frac{1}{C_B}\right)\left\{1 - C\left(\frac{1}{C_A} - \frac{1}{C_B}\right)\right\} + \ldots$$

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

+ terms involving higher powers of C.

or $$\frac{\omega^2 L_x}{\left(\dfrac{1}{C_1} - \dfrac{1}{C_2}\right)} = 1 - \frac{C}{2}\left(\frac{1}{C_1} + \frac{1}{C_2}\right) - C\left(\frac{1}{C_1} - \frac{1}{C_2}\right).$$

Therefore the error produced in measuring the inductance is

$$50C\left\{\left(\frac{1}{C_1} + \frac{1}{C_2}\right) + 2\left(\frac{1}{C_1} - \frac{1}{C_2}\right)\right\} \text{ per cent.}$$

Case V

When the unknown is short-circuited, we have at resonance

$$\omega L_1 = \frac{1}{\omega C_B} \quad \ldots \quad \ldots \quad \ldots \quad (21)$$

$$\text{and} \quad \frac{e}{i} = R_1 + 2R_0 + r \quad \ldots \quad (22)$$

When the unknown is in circuit, we have at resonance, after assuming $1 >> \omega C R_x$, that

$$\omega L_x - \frac{1}{\omega C_A} = \frac{-\omega L_1}{1 - \omega^2 L_1 C} \quad \ldots \quad (23)$$

and

$$\frac{e}{i} = 2R + R_1 + r + \frac{R_x}{\left\{1 - \omega C\left(\omega L_x - \dfrac{1}{\omega C_A}\right)\right\}^2}$$

$$= 2R + R_1 + r + R_x(1 - \omega^2 L_1 C)^2 \quad \ldots \quad (24)$$

Equating (22) and (24) gives

$$\frac{R_x}{2(R_0 - R)} = \frac{1}{(1 - \omega^2 L_1 C)^2}$$

$$= 1 + \omega^2 L_1 C(2 + 3\omega^2 L_1 C).$$

For small values of $\omega^2 L_1 C$ the error involved in measuring the resistance is therefore $-200\ \omega^2 L_1 C$ per cent.

From (21) and (23) we obtain

$$\omega L_x - \frac{1}{\omega C_A} = -\omega L_1(1 + \omega^2 L_1 C)$$

$$= -\frac{1}{\omega C_B} - \frac{C}{\omega C_B^2}$$

or $$\omega^2 L_x = \frac{1}{C_A} - \frac{1}{C_B} - \frac{C}{C_B^2}$$

$$= \left(\frac{1}{C_1} - \frac{1}{C_2}\right) - \frac{C}{2}\left(\frac{1}{C_1^2} - \frac{1}{C_2^2}\right)$$

+ terms involving higher powers of C.

Therefore $$\frac{\omega^2 L_x}{(1/C_1 - 1/C_2)} = 1 - \frac{C}{2}\left(\frac{1}{C_1} + \frac{1}{C_1}\right),$$

and the error obtained in measuring the inductance is given by $50C\left(\dfrac{1}{C_1} + \dfrac{1}{C_2}\right)$ per cent.

Case VI

When the unknown is short-circuited, we have, as in Case I

$$\omega L_1 = \frac{1}{\omega(C + C_B)} \quad \ldots \quad \ldots \quad (25)$$

$$\text{and} \quad \frac{e}{i} = R_1 + r + 2R_0(1 - \omega^2 L_1 C)^2 \quad \ldots \quad (26)$$

When the unknown is in circuit, we have at resonance, after assuming

$1 >> 2\omega^2 R C C_A$ and $1 >> \omega C(r + R_x)$, that

$$\omega L_x = -\left\{\omega L_1 - \frac{1}{\omega(C + C_A)}\right\}(1 - \omega^2 L_x C) \quad (27)$$

and

$$\frac{e}{i} = \left\{R_1 + \frac{2RC_A^2}{(C + C_A)^2}\right\}(1 - \omega^2 L_x C) + \frac{r + R_x}{(1 - \omega^2 L_x C)}$$

$$= R_1(1 - \omega^2 L_x C) + \frac{2R}{(1 - \omega^2 L_x C)}(1 - 2\omega^2 L_1 C$$
$$- 4\omega^2 L_x C + \omega^4 L_1^2 C^2 + 4\omega^4 L_x^2 C^2$$
$$+ 6\omega^4 L_1 L_x C^2) + \frac{(r + R_x)}{1 - \omega^2 L_x C}$$

+ terms involving higher powers of C .. (28)

Equating (26) and (28) we obtain

$$R_x + r + 2R(1 - 2\omega^2 L_1 C - 4\omega^2 L_x C$$
$$+ \omega^4 L_1^2 C^2 + 4\omega^4 L_x^2 C^2 + 6\omega^4 L_1 L_x C^2)$$
$$= r(1 - \omega^2 L_x C) + 2R_0(1 - \omega^2 L_x C)$$
$$(1 - \omega^2 L_1 C)^2 + R_1 \omega^2 L_x C(1 - \omega^2 L_x C) \quad \ldots (29)$$

By ignoring all terms containing powers of C higher than the second, equation (29) can be simplified to give

$$\frac{R_x}{2(R_0 - R)} = 1 - \omega^2 L_1 C(2 - \omega^2 L_1 C)$$
$$- \frac{\omega^2 L_x C}{2(R_0 - R)} [(2R_0 - 8R + r - R_1)$$
$$+ \omega^2 C\{L_x(8R + R_1) - 4L_1(R_0 - 3R)\}]$$

Therefore, for small values of $\omega^3 L_1 C$ and $\omega^3 L_x C$, the error involved in measuring the resistance is

$$100\,\omega^2 C\left\{2L_1 + L_x \frac{2R_0 - 8R + r - R_1}{2(R_0 - R)}\right\}$$

per cent.

From (25) and (27) we obtain

$$\frac{\omega^2 L_x}{1 - \omega^2 L_x C} = \frac{1}{(C + C_A)} - \frac{1}{(C + C_B)} = \frac{1}{C_A}$$
$$- \frac{1}{C_B} - C\left(\frac{1}{C_A{}^2} - \frac{1}{C_B{}^2}\right) + \ldots .$$
$$= \left(\frac{1}{C_1} - \frac{1}{C_2}\right) - \frac{3C}{2}\left(\frac{1}{C_1{}^2} - \frac{1}{C_2{}^2}\right)$$
$$+ \text{ terms in } C^2\text{, etc.}$$

or

$$\frac{\omega^2 L_x}{\left(\frac{1}{C_1} - \frac{1}{C_2}\right)}$$
$$= \frac{1 - \frac{3C}{2}\left(\frac{1}{C_1} + \frac{1}{C_2}\right)}{1 + C\left(\frac{1}{C_1} - \frac{1}{C_2}\right)\left\{1 - \frac{3C}{2}\left(\frac{1}{C_1} + \frac{1}{C_2}\right)\right\}}$$
$$= 1 - \frac{3C}{2}\left(\frac{1}{C_1} + \frac{1}{C_2}\right) - C\left(\frac{1}{C_1} - \frac{1}{C_2}\right)$$
$$+ \text{ terms involving higher powers of } C.$$

Therefore the error involved in measuring the inductance is

$$50C\left\{3\left(\frac{1}{C_1} + \frac{1}{C_2}\right) + 2\left(\frac{1}{C_1} - \frac{1}{C_2}\right)\right\} \text{ per cent.}$$

Conditions when Meter is External to the Testing Circuit

When the meter is external, the measurement is usually made in the way indicated by Fig. 7.

The pick-up coil L_1 is coupled to the tuned circuit of an oscillating valve V and, with switch S closed, C_1 is adjusted until a resonance indication is obtained in the plate current meter M. S is then opened, C_1 is readjusted to resonance and resistance R is varied to obtain the same deflection in M. From the changes in C_1 and R, L_x and R_x are calculated as in the case of Fig. 1.

The analysis of the arrangement shown in Fig. 7 is very similar to that of Fig. 1, the only difference being that the meter resistance r is now zero and the resonance current i with which we are concerned always flows through the coil L_1. Consequently, when the unknown is short-circuited, all the equations derived for Fig. 6 hold for the corresponding arrangements of Fig. 7, when we write $r = 0$. When the unknown is in circuit, the equations obtained when $r = 0$ for cases I, II and V of Fig. 6 (i.e., when the meter is in series with L_1) will apply to the corresponding cases of Fig. 7. The equations for the cases corresponding to III, IV and VI will be slightly modified in the way shown below, the letter "*a*" being employed to indicate the difference between the two arrangements.

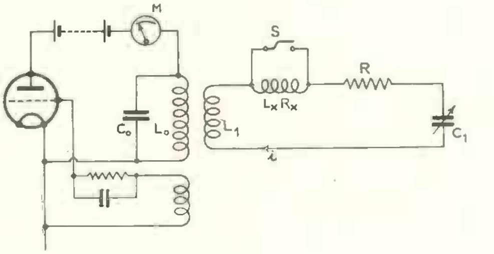

Fig. 7.

Case IIIa

At resonance, after assuming $1 >> 2\omega C(R + R_x)$, we have

$$\omega L_x = -\left(\omega L_1 - \frac{1}{\omega C_A}\right)(1 - 2\omega^2 L_x C) \quad .. (30)$$

and $$\frac{e}{i} = R + R_1 + \frac{R + R_x}{(1 - 2\omega^2 L_x C)^2} \quad .. (31)$$

Equating (31) and (14) after putting $r = 0$, we derive finally

$$\frac{R_x}{2(R_0 - R)} = 1 - 2\left(\frac{2R_0 - R}{R_0 - R}\right)\omega^2 L_x C(1 - \omega^2 L_x C)$$

so that, for small values of $\omega^2 L_x C_1$, the error involved in measuring the resistance is $200\,\omega^2 L_x C\left(\frac{2R_0 - R}{R_0 - R}\right)$ per cent.

Since equations (15) and (30) are identical, the error involved in measuring the inductance is the same as for Case III.

Case IVa

At resonance, after assuming $1 >> \omega C(2R + R_x)$, we have

$$\omega L_x = -\left(\omega L_1 - \frac{1}{\omega C_A}\right)(1 - \omega^2 L_x C)$$

and $$\frac{e}{i} = R_1 + \frac{2R + R_x}{(1 - \omega^2 L_x C)^2} \quad \ldots \quad (32)$$

Equating (32) and (18) after putting $r = 0$, we obtain finally

$$\frac{R_x}{2(R_0 - R)} = 1 - \frac{R_0}{R_0 - R}\omega^2 L_x C(2 - \omega^2 L_x C)$$

Therefore, for small values of $\omega^2 L_x C$, the error involved in measuring the resistance is $200\, \omega^2 L_x C\left(\frac{R_0}{R_0 - R}\right)$ per cent. For the inductance the error is the same as in Case IV.

Case VIa

At resonance, we have, after assuming $1 >> 2\omega^2 RCC_A$ and $1 >> \omega CR_x$, that

$$\omega L_x = -\left\{\omega L_1 - \frac{1}{(C + C_A)}\right\}(1 - \omega^2 L_x C)$$

and $$\frac{e}{i} = R_1 + \frac{2RC_A{}^2}{(C + C_A)^2} + \frac{R_x}{(1 - \omega^2 L_x C)^2}$$

$$= R_1 + \frac{2R}{(1 - \omega^2 L_x C)^2}(1 - 2\omega^2 L_1 C - 4\omega^2 L_x C + \omega^4 L_1{}^2 C^2 + 4\omega^4 L_x{}^2 C^2 + 6\omega^4 L_1 L_x C^2) + \frac{R_x}{(1 - \omega^2 L_x C)^2} + \text{terms}$$

involving higher powers of C .. (33)

Equating (33) and (26) after putting $r = 0$, and ignoring all terms involving powers of C higher than the second, gives finally

$$\frac{R_x}{2(R_0 - R)} = 1 - \omega^2 L_1 C(2 - \omega^2 L_1 C) - \frac{\omega^2 L_x C}{R_0 - R}[(2R_0 - 4R) - \omega^2 C\{L_1(4R_0 - 6R) + L_x(R_0 - 4R)\}]$$

TABLE I

Case	Error in Resistance Measurement — per cent.	Error in Inductance Measurement — per cent.	Assumptions.
I	$-200\,\omega^2 L_1 C$	$50\,C\left(\frac{1}{C_1} + \frac{1}{C_2}\right)$	$1 >> 2\omega^2 R_0 CC_B$ $1 >> 2\omega C(R + R_x)$
II	$200\,\omega^2 C\left(L_1 - \frac{R}{R_0 - R} \cdot L_x\right)$	$150\,C\left(\frac{1}{C_1} + \frac{1}{C_2}\right)$	$1 >> 4\omega^2 R_0 CC_B$ $1 >> 2\omega^2 RCC_A$ $1 >> \omega C\{R_x + 2RC^2_A(C + C_A)^{-2}\}$
III	$100\,\omega^2 L_x C\,\frac{2R_0 - 2R + r - R_1}{R_0 - R}$	$50C\left\{\left(\frac{1}{C_1} + \frac{1}{C_2}\right) + 4\left(\frac{1}{C_1} - \frac{1}{C_2}\right)\right\}$	$1 >> 2\omega C(R + R_x + r)$
IIIa	$200\,\omega^2 L_x C \cdot \frac{2R_0 - R}{R_0 - R}$		
IV	$50\omega^2 L_x C \cdot \frac{2R_0 + r - R_1}{R_0 - R}$	$50C\left\{\left(\frac{1}{C_1} + \frac{1}{C_2}\right) + 2\left(\frac{1}{C_1} - \frac{1}{C_2}\right)\right\}$	$1 >> 2\omega C(2R + R_x + r)$
IVa	$200\omega^2 L_x C \cdot \frac{R_0}{R_0 - R}$		
V	$-200\,\omega^2 L_1 C$	$50\,C\left(\frac{1}{C_1} + \frac{1}{C_2}\right)$	$1 >> \omega CR_x$
VI	$100\omega^2 C\left\{2L_1 + L_x \cdot \frac{2R_0 - 8R + r - R_1}{2(R_0 - R)}\right\}$	$50C\left\{3\left(\frac{1}{C_1} + \frac{1}{C_2}\right) + 2\left(\frac{1}{C_1} - \frac{1}{C_2}\right)\right\}$	$1 >> 2\omega^2 RCC_A$
VIa	$200\,\omega^2 C\left\{L_1 + L_x \cdot \frac{R_0 - 2R}{R_0 - R}\right\}$		$1 >> \omega C(R_x + r)$

For small values of $\omega^2 L_1 C$ and $\omega^2 L_x C$, the error produced in measuring the resistance is therefore 200 $\omega^2 C\left(L_1 + L_x \frac{R_0 - 2R}{R_0 - R}\right)$ per cent. For the inductance the error is the same as in case VI.

Summary of Results

Table I gives a summary of the results obtained in the foregoing when the values of $\omega^2 L_1 C$ and $\omega^2 L_x C$ are small. Where the error is different for the external meter condition this is indicated. Column 4 gives the assumptions made in order to obtain the results of columns 2 and 3. These assumptions are in addition to those which are common to all the cases, namely :—

TABLE II

Case	$2R_0$ Ohms	$2R$ Ohms	C_2 μμF.	C_1 μμF.	Measured Resistance	Measured Industance	Calculated Resistance		Calculated Inductance	$\frac{Rm}{R_{c1}}$	$\frac{Rm}{R_{c2}}$	$\frac{Lm}{Lc}$
					R_m Ohms	L_m μH.	Rc_1 Ohms	Rc_2 Ohms	L_c μH.			
I	6.84	2.17	375.2	299.6	4.67	16.95	4.60	4.775	17.45	1.013	0.979	0.9725
II	8.30	1.16	376.2	283.5	7.14	22.05	7.12	7.075	22.25	1.001	1.008	0.9925
III	8.30	2.29	472.5	353.5	6.01	17.95	6.12	6.10	18.15	0.9825	0.985	0.990
IV	7.58	1.66	469.0	353.5	5.92	17.70	5.97	5.96	17.56	0.9925	0.993	1.008
V	6.49	1.91	420.0	326.2	4.58	17.45	4.66	4.775	17.25	0.984	0.962	1.011
VI	9.70	2.33	427.0	309.4	7.37	22.55	7.18	7.175	22.20	1.025	1.026	1.016

(1) All the impedances to ground are equal and capacitive.

(2) The impedances to ground are large compared with the resistances of the meter and the unknown.

Experimental Check

The results obtained above for the first condition, i.e. when the indicating meter is placed in the testing circuit, were checked by setting up each of the arrangements tabulated in column 2 of Fig. 6 and measuring the resistance and inductance of a coil whose true values were known. The circuit values chosen were :—

Frequency = 1,000 kc/sec.
L_1 = 50 micro-henries
$r = R_1$ = 3 ohms
C = 50 μμF.
L_x = 15 micro-henries
R_x = 5.73 ohms.

In order to include the effect of the second order terms, the normal stray capacities to ground (of the order of 10 μμF.) were increased to 50 μμF. by the addition of external condensers.

The results obtained are shown tabulated in Table II, and it is seen that in no case does :—

(*a*) The resistance Rc_1, calculated from the formulae which include the second order terms, differ from the measured value by more than 2.5 per cent.

(*b*) The resistance Rc_2, calculated from the formulae tabulated in Table I, differ from the measured value by more than 4 per cent.

(*c*) The inductance Lc, calculated from the formulae of Table I, differ from the measured inductance by more than 3 per cent.

We can therefore conclude that, except for very special cases, the errors in substitution measurements arising from the presence of stray capacities to ground can be estimated with sufficient accuracy from the formulae of Table I.

Note.—In the above measurements, $2R_0$ was not kept at the same value in all cases because the resistance employed consisted of a 10 ohm eureka slide-wire graduated at one end in cms. and at the other end in mms. It was therefore necessary to make the value of $2R_0$ such that the value of $2R$ could be read off on the latter scale.

Conclusions

A.—From the formulae of Table I the following conclusions can be drawn with regard to the resistance measurement :—

(1) In all cases the error is directly proportional to the square of the frequency and to the value of the stray capacity to ground.

(2) When $L_x < L_1$, Case IV should give the smallest error provided that the resistance of the meter can be kept small. This restriction does not arise in Case IVa.

(3) In Cases I, II, V and VI the error is directly proportional to L_1, therefore the value of this inductance should be kept as small as possible when any of these arrangements are employed.

(4) In Case II the error is $200\ \omega^2 L_1 C$ per cent. when the initial value of the measuring resistance is set so that $2R = 0$ with the unknown in circuit. Since the error in Cases I and V is $- 200\ \omega^2 L_1 C$ per cent. the mean of the values obtained in Case I or V and Case II should approximate very closely to the true resistance. For example, the results of Table II show that, although the errors obtained in Cases I, V and II exceed 20 per cent., the mean of the readings in Cases I or V and Case II gives a value which is within 3 per cent. of the true resistance. It follows that, in any given measurement, the magnitude of the error to be expected can be estimated by noting the difference between the readings obtained for Case I (or *V*) and Case II.

B.—Cases I and V give the smallest error in the measurement of the inductance.

Correspondence

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

Johnson Noise

To the Editor, The Wireless Engineer

Sir,—The difficulty raised by Mr. Robin in connection with Johnson noise (*W.E.*, March 1936) may be resolved as follows.

The direct result of a collision between an electron and an atom is radiation of frequencies far outside the radio band—i.e. heat ; but the secondary result is a disturbance in the progress of the electron, and hence a minute change in the magnitude of current flowing. The noise observed in any actual circuit is the sum of the effects of innumerable electron collisions, occurring in random manner, which together produce variations in current flow much larger than could be caused by a single electron.

We have, then, a current whose plot against time is an irregular line made up of random fluctuations about a mean value ; and this we may investigate with an analysing instrument having a time-constant of say 1/100th second. In effect we shall be cutting up the line into successive lengths corresponding to 1/100th second, and analysing each in turn. But since the fluctuations are quite random, each such length will have a different Fourier analysis, and any given frequency will be strong in some but not in others ; hence the observed result that any particular frequency is to be found occurring fairly frequently but not continuously.

D. A. Bell.

Chelmsford.

Distribution of A.C. in Some Circuits

To the Editor, The Wireless Engineer

Sir,—In Professor Möller's book, *Die Elektronenröhren* (3rd ed., Brunswick, 1929) there is a paragraph entitled " Oberwellen " (Chap. III, pp. 123–125) in which the problem of the magnitude of the harmonics in a valve oscillator is examined. As that paragraph contains an incorrect statement I would be obliged if you would permit the necessary correction to be published.

In that paragraph the following example is considered : the oscillatory circuit, the decrement δ of which is given by $\frac{\delta}{\pi} = 0.04$, is connected in the anode circuit of the valve. The anode current is assumed to be of rectangular form (Barkhausen's approximation) and, therefore, contains only odd harmonics, the amplitudes of which are in ratio of $1 : \frac{1}{3} : \frac{1}{5} : \ldots : \frac{1}{2n+1} : \ldots$ The amplitude of the fundamental of the current in the oscillatory circuit I_L is to that of the anode current I_a as π to δ ; $I_L : I_a = \pi : \delta = 25$ for our example.

Further, it is continued as follows : " The higher harmonics distribute themselves between the branches of the circuit in the inverse proportion to the impedances. Thus $\frac{1}{10}$ of the current of the 3rd harmonic $\frac{1}{10} I_{a3}$ flows through the inductive branch, and $\frac{9}{10} I_{a3}$ flows through the capacitive one, and so on." This statement is incorrect. In fact, applying Kirchhoff's laws to the present case we obtain :

$$I_{Ln} = -\frac{1}{n^2 - 1} I_{an},\ I_{Cn} = \frac{n^2}{n^2 - 1} I_{an},$$

where I_{Ln}, I_{Cn}, I_{an} denote the vector amplitudes of the nth harmonic of the currents in the branches L, C and of the anode current, respectively. Thus in the example quoted above ($n = 3$) we have :

$$I_{L3} = -\frac{1}{8} I_{a3},\ I_{C3} = \frac{9}{8} I_{a3}.$$

The error, as we see, arises from the substitution for the complex impedances of their moduli (or, in other words, from neglecting the phase difference between the currents in the branches). Such a substitution would not lead to a mistake if it were used only to determine the ratio of the amplitudes of the currents in the branches.

Further, a table of relative values of the amplitudes of the current in the L branch and of the P.D. across the branches for several harmonics is given. Being calculated as in the above quotation these values are erroneous ; therefore, I add a table containing these values and the correct ones.

Order of Harmonic.	Amplitude of Current.		Amplitude of P.D.	
n	Incorr.	Corr.	Incorr.	Corr.
1	1		1	
3	$\frac{1}{750}$	$\frac{1}{600}$	$\frac{1}{250}$	$\frac{1}{200}$
5	$\frac{1}{3250}$	$\frac{1}{3000}$	$\frac{1}{650}$	$\frac{1}{600}$
7	$\frac{1}{8750}$	$\frac{1}{8400}$	$\frac{1}{1250}$	$\frac{1}{1200}$

On the whole, the matter is rather simple, and as Professor Möller is an acknowledged authority in theoretical problems the error was, no doubt, due to an oversight. Unfortunately, however, this error is found not only in the 3rd edition of the book, but also in the other two (1920 and 1922).

From the above formulae the following well-known feature results : the currents in the branches are opposite in phase, one of them being in phase with the main current and exceeding it in magnitude. As regards this feature, there is one similar case I should like to mention. This is a remarkable case which was pointed out for the first time by Lord Rayleigh in 1886.* It is as follows : the two branches in parallel are two coils coupled by mutual induction. Let L_1, L_2 and M denote respectively the self-inductances and the mutual inductance of the coils. It is assumed that there is no leakage, hence $M = \sqrt{L_1 L_2}$ and that M is positive in sign. Similarly to the above case, the resistances are taken as zero. Under these conditions we obtain :

$$I_1 = \frac{n_2}{n_2 - n_1} I,\ I_2 = \frac{n_1}{n_1 - n_2} I,$$

where I_1, I_2, I denote the vector amplitudes of the currents in the coils and in the main respectively, and n_1, n_2 denote the numbers of turns of the coils. It results that the currents in the branches are opposite in phase, one of them (in the coil with the smaller number of turns) being in phase with the main current and exceeding it in magnitude. Furthermore, it may happen that the main current is not only less than the greater of the two currents in the branches, but is also less (numerically) than either of them (this requires $2n_2 > n_1$, if $n_1 > n_2$). In an example given by Lord Rayleigh $n_1 : n_2 = 3 : 2$, then $I_1 : I_2 : I = 2 : 3 : I$. It should be remarked that the distribution of the currents in Lord Rayleigh's case seems to be somewhat peculiar even at present.

Moscow. E. LIVSHITZ.

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* *Phil. Mag.*, vol. 21, pp. 376–378, 1886 ; *Phil. Mag.*, vol. 22, p. 495, 1886 ; *Scient. Papers*, vol. II, pp. 432–483, 575–576 ; *Theory of Sound* (2nd ed.), vol. I, § 235 m.

Book Review

Thermionic Emission

By T. J. Jones, pp. 108 + viii. 17 Figs. Methuen & Co., Ltd., 36, Essex Street, London, W.C.2. Price, 3s.

This is one of a series of monographs on physical subjects being issued by the publishers. The author is the research physicist for Lissen, Ltd., and for Pye Radio, Ltd., and is, therefore, in close touch with the industry. The subject matter is divided into six chapters entitled respectively, introduction, theory of thermal emission, experimental technique and electron emission data for clean metals, atomic film emitters, oxide-coated emitters, and thermal emission of positive ions. There is a very extensive bibliography to which references are given throughout the text ; the book being necessarily very condensed, these references to original papers and more detailed articles are a valuable feature. Probably as the result of this condensation we find a statement on p. 10 which, if not wrong, is far from clear. "N is the number of particles incident per second on unit area of a solid surface immersed in the gas. But the number condensing on the surface will be $N(1 - r)$ where r is the reflection coefficient. Under equilibrium conditions the number leaving the surface per second must equal the number condensing in that time." That is to say, for every 100 striking the surface, 50 condense and 50 are reflected ; the surface gains 50 at the expense of the gas : in what sense can this be called equilibrium ? If the nature of the surface were such that as many left as arrived, *i.e.*, 100 per cent. reflection, there would be equilibrium. But perhaps we have misunderstood the author. With the exception of this small detail we have found the volume to be what the author claims for it in the preface, viz., a concise, complete, and up-to-date survey of the fundamental principles of thermionic emission. To anyone interested in the subject, even the bibliography alone would make the book valuable.—G. W. O. H.

The Measurement of Amplification and Phase Shift in Amplifiers*

By E. E. Wright, B.Sc., and G. E. G. Graham, B.Sc., A.R.C.S., D.I.C.

(Baird Television, Ltd.)

Summary.—A method of Measuring the Amplification and Phase Shift in Amplifiers of Current up to a Frequency of about Two Megacycles per Second is described.

Introduction

THE object that led to the development of the apparatus described below was the determination of the performance of television amplifiers, with reference to variations of amplification and phase shift with frequency up to a maximum frequency of about 2 Mc. per second. The method of measurement adopted is illustrated in Fig. 1.

An oscillator *O* feeds the amplifier *A* under test through an adjustable attenuator *At.* A voltmeter *V* is adapted to indicate the amplitude of the input to the attenuator, the output from the amplifier and the amplitude of the vector sum of these two signals.

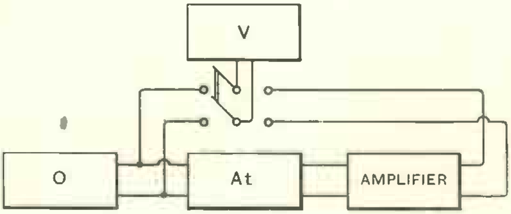

Fig. 1.

In practice, the loss in the attenuator is varied until the output from the amplifier is equal to the input to the attenuator. The amplification is then equal to the loss in the attenuator. At the same time the vectorial sum of the two signals is determined and the phase shift ϕ is given by

$$2 \cos \tfrac{1}{2} \phi = V_2/V_1,$$

where V_1 is the amplitude of the output signal of the amplifier or, what is the same thing, the input signal to the attenuator and V_2 is the amplitude of the vectorial sum of the signals.

Apparatus

1. *The Attenuator*

This consists of a series of six constant resistance attenuating networks producing 1, 2, 4, 8, 16 and 32 decibels loss, respectively, so that by means of switching arrangements any loss from 0 to 63 decibels may be obtained in steps of 1 decibel.

The circuit and values of the attenuator resistances are shown in Fig. 2. It will be seen that each subsidiary network is of the "inverted L" type, having a constant resistance of 100 ohms.

For high frequency measurements it is essential that the resistance of the attenuator be low, so as to reduce the importance of unavoidable stray capacities. On the other hand, a very low value of characteristic resistance involves very low parallel resistance arms which are difficult to make with accuracy and at extremely high frequencies the inherent self inductance of these low resistances may introduce considerable error. In the present case a compromise of 100 ohms was arrived at.

The resistance elements of the present attenuator are "Erie" $\frac{1}{4}$-watt type composition resistances. These may be obtained correct to a stated value to within 5 per cent. Three of each of the required resistances were ordered (the resistances cost only a few pence each), and it was found on careful measurement that the resistances supplied were, in fact, correct to within about 2 per cent. of the required value. The measured values were carefully studied and by choosing a characteristic resistance of 99 ohms it was possible to pick out resistances with self-consistent ratios so that the greatest error was about 0.1 per cent.

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* MS. accepted by the Editor, March, 1936.

The switches used were Bulgin toggle switches, which have low self capacity, and the whole was enclosed in an aluminium box.

2. *The Voltmeter*

This consists of a diode voltmeter fed by two high frequency pentodes having a common anode resistance but separate grid circuits, which may be connected to the input of the attenuator and the output of the amplifier respectively. The circuit used is shown in Fig. 3.

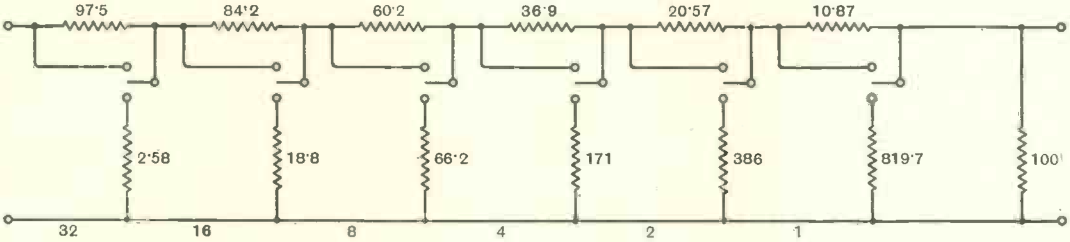

Fig. 2.

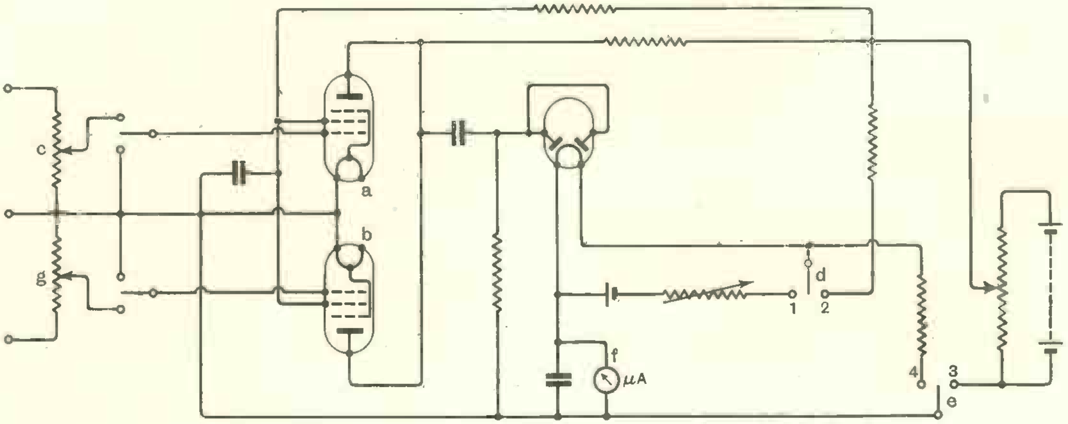

Fig. 3.

The valves *a* and *b* are preferably picked for equal mutual conductance and the effective gain of the circuit of the valve *a* is finally adjusted to equal that of the valve *b* by means of the potentiometer *c*.

It will be seen that the switching arrangements are such that when the grid of either of the valves is disconnected from its appropriate input circuit it is connected to earth. This prevents pick-up through the small capacity of the switch. Further, the voltmeter is self-checking with respect to L.T. and H.T. supply. Thus when the switch *d* is in position 2 while the switch *e* is in position 3 the meter *f* indicates the H.T. supply voltage ; on the other hand, when the switch *d* is in position 1 and the switch *e* in position 4 the meter *f* indicates the L.T. supply voltage. When the switches *d* and *e* are in positions 1 and 3, respectively, the meter indicates the anode current of the diode, but when they are in positions 2 and 4 the apparatus is completely switched off.

A further potentiometer *g* is used to equate accurately the signals for differences of fractions of a decibel, and may be calibrated in tenths of a decibel. With this circuit arrangement the grids of both valves are connected to their input circuit and the input to the diode corresponds to the vectorial sum of the two separate input signals. The meter is calibrated in decibels and since the phase shift depends upon the ratio of either of the applied voltages to the vectorially combined voltages, it follows that a given decibel increase indicated on the meter corresponds to a certain phase angle between the two signals. A graph showing the relationship between difference in phase angle and decibel gain of the combined signals over either of the input or output signals according to equation 1 is shown in Fig. 4.

Practice

The method of measurement has been adumbrated in the introduction. Flexible screened concentric cable is used for connecting the components of the apparatus. This cable has low self-capacity and the leads are made as short as possible so as not to impose extra load on the output stage of the amplifier at high frequencies.

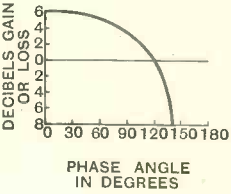

Fig. 4.

The apparatus is first checked for equal effective gain of both valves. The oscillator is connected to the valve *a* and the input of the attenuator as in Fig. 1, but the output from the attenuator is taken directly to the valve *b*, the loss in the attenuator being set to zero. The potentiometer *c* is then adjusted until the same reading is obtained for input and output voltages of the attenuator, the potentiometer *g* being in the "all-in" position. The apparatus is now ready for operation, and is joined to the amplifier as in Fig. 1.

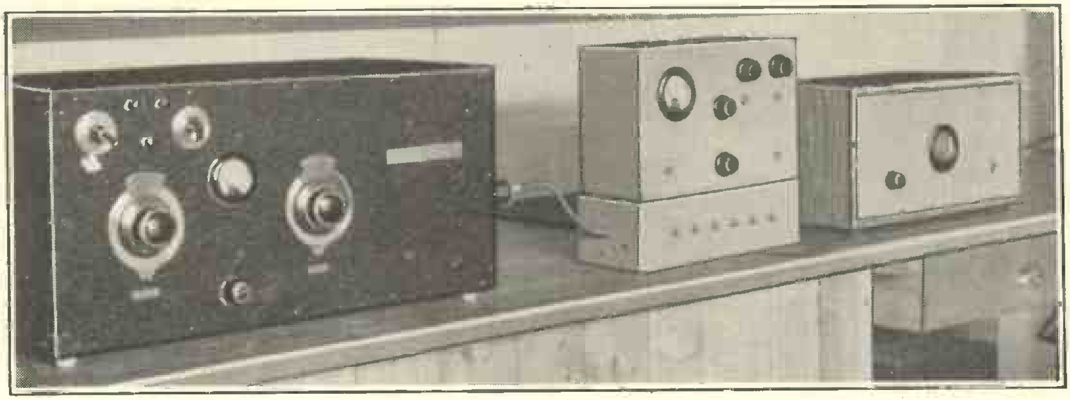

Fig. 5.

There are three main sources of error which may appear :—

1. Instability of the amplifier. This causes a deflection of the meter when the voltmeter is connected to the output of the amplifier, there being no applied input signal.

2. Residual mains hum in mains-driven amplifiers, and external interference, *e.g.*, wireless signals, causing a similar effect as in 1, above.

3. Limiting, or overloading of one or more valves in the amplifier. If this effect be present, it will be observed that if the loss in the attenuator is changed by 1 decibel, the reading of the meter will fail to change by an amount corresponding to 1 decibel.

The cure for sources of error 1 and 2 lies in more efficient screening, etc. A cure for 3 may be effected by measuring the amplifier characteristic in separate stages or groups of stages, provided that the overloading does not arise in the first stage.

Finally, some means must be arranged for determining whether a phase shift has a leading or lagging angle. This may be done by setting up an auxiliary circuit of known phase characteristic following the output of the amplifier, and observing whether the phase shift is increased or decreased.

A photograph of the layout is shown in Fig. 5.

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

1695. THE RECEPTION OF 8 METRE WAVES FROM THE EIFFEL TOWER TELEVISION TRANSMITTER [Request for Reports].—(*L'Onde Élec.*, March, 1936, Vol. 15, No. 171, p. 141.)

1696. AUDIBILITY OF A LIMITING WAVE (10 M) AND SOLAR PHENOMENA.—K. Stoye. (*E.N.T.*, January, 1936, Vol. 13, No. 1, pp. 17–20.)

Fig. 1 shows the audibility of 10 m waves (*cf.* 1697, below); notable features are the absence of signals during the summer from 1928 to 1931 and in the spring of 1931. Reception and traffic possibilities were good in the summer from 1932 to 1934. A statement by Plendl (1932 Abstracts, p. 29) is modified as follows: "At sunspot maximum the paths of wireless waves are less curved and the skip distance increased; at sunspot minimum the curvature of the paths is greater and the skip distance less." Figs. 2–5 show the duration of audibility for each day of the months May–August, 1935; sectional audibility and pauses in reception were noted. The best traffic conditions occur round sunset. Fig. 6 shows days of terrestrial magnetic disturbance and good 10 m reception for 1935. The 27-day period observed in 1933/34 changed in 1935 to 28 and then 29 days. The 10 m reception data divide into two parts, of which one corresponds to magnetically quiet days and the other to no obvious magnetic sequence. Since good 10 m reception days occur regularly, they must correspond to definite regions of emission on the sun which have no obvious effect on terrestrial magnetism. The rôle of observational data on 10 m as a means of research on geo- and astrophysics is stressed.

1697. AUDIBILITY OF DISTRICTS [Short-Wave Signals received in Germany from the Different Districts in U.S.A.: Comparison with Terrestrial Magnetic Period].—K. Stoye. (*Hochf:tech. u. Elek:akus.*, January, 1936, Vol. 47, No. 1, pp. 21–22.)

A short résumé, expressed in diagram form (Figs. 2, 3), of the results of observations during March/April 1935 of the audibility in Germany of short-wave stations in the various districts in the U.S.A. A comparison is made with terrestrial magnetic disturbances; signals were particularly weak near the 14th and 15th days of the terrestrial magnetic period and also round the 5th day. "The so-called 'good short-wave days' are clearly seen on the left side of the table." Attention is called to various other points in the diagrams.

1698. AN ACTIVE GROUP OF SUNSPOTS AND UNUSUAL CONDITIONS IN THE IONOSPHERE.—H. W. Newton. (*Nature*, 29th Feb. 1936, Vol. 137, p. 363.)

Data of observations of a bright eruption visible in the hydrogen line are given; a short time later "there was a marked diminution of reflection from the ionosphere over a very wide area." Two days later a magnetic disturbance began which was "characterised by some rapid movements in the horizontal force trace." The phenomena seem to give a hint of a relationship "between bright solar eruptions and distinctive conditions in the ionosphere." *See* also 1699.

1699. AN ACTIVE GROUP OF SUNSPOTS [in Mid-February, 1936: Hydrogen Eruptions].—(*Nature*, 22nd Feb. 1936, Vol. 137, pp. 311–312: short note only).

1700. LONG-WAVE RADIO TRANSMISSION PHENOMENA ASSOCIATED WITH A CESSATION OF THE SUN'S RAYS [Houlton, Chatham (N.J.) and Cupar Observations on Rocky Point, Tuckerton, Nauen, Ongar: 18–68 kc/s: Eclipse Results: Conclusions].—A. Bailey and A. E. Harper. (*Bell S. Tech. Journ.*, January, 1936, Vol. 15, No. 1, pp. 1–19.)

Among the tentative conclusions reached are the following:—"The time interval between sunset at any point on the transmission path and the instant of minimum field has an annual and an apparently fortuitous daily variation. As a result of these variations the minimum does *not* occur [as was originally thought] when the sun is at a fixed angular altitude at any point on the path. The time interval between sunset at some fractional path point and the instant of minimum field, and likewise the angular altitude of the sun referred to the plane of the horizon at such a point, increases with both the path length and the wavelength, and is maximum during the winter months." Analysis of the data indicates that long waves over long paths are transmitted predominantly by sky waves. Empirical methods based on observations over a particular path may be used to forecast the approximate time of occurrence of field variations.

1701. EXPERIMENTS ON THE MEASUREMENT OF SPACE RADIATION FROM BROADCASTING EMITTER AERIALS.—Eppen and Scheibe. (*See* 1778.)

1702. ELECTROMAGNETIC WAVES FROM A POINT SOURCE [Theoretical Deviations from Inverse First-Power Law of Spherical Waves of Most General Type: Consequences].—W. T. Howell. (*Phil. Mag.*, February, 1936, Series 7, Vol. 21, Supp. No. 140, pp. 384–398.)

The most general solution of Maxwell's equations in spherical polar coordinates is given and the electric and magnetic force components derived from it. The transverse electrical forces decrease as the inverse first power of the distance and may be expected to "produce discernible effects at such distances from the source that the radial force has ceased to be important." The variation of intensity and amplitude with distance from the source, and the behaviour of the wave-fronts and phase-velocities, are investigated. The theoretical possibility of a centre of concentration, movable through a limited distance, is worked out. The outflow of energy and angular momentum are calculated.

1703. THE DIFFRACTIVE PROPAGATION OF RADIO WAVES [Extension of Eckersley's Formula: Application to Ultra-Short Waves].—B. Wwedensky. (*Tech. Phys. of USSR*, No. 6, Vol. 2, 1935, pp. 624–639: in English.)

Author's abstract:—Starting from the works of Watson and of Laporte, a formula for the diffraction field of a Hertzian dipole situated on the earth's surface is deduced. With this formula, which constitutes an extension of Eckersley's formula [Abstracts, 1933, p. 29: *see* also 1932, p. 514], the propagation of radio waves round the earth can be calculated without neglecting the earth's resistivity (but without taking into account the effect of the atmosphere). The condition that the curve should pass asymptotically into the Sommerfeld-van der Pol curve (flat earth) is fulfilled for the two cases computed ($\lambda = 1550$ m and $\lambda = 5$ m, sea water), whilst the Eckersley curve only satisfies this demand for $\lambda = 1550$ m. The calculations with the proposed formulae (eqns. 7.2 and 7.1) are somewhat more complex than those with Eckersley's formula, since in the former account is taken of the relation between the "amplitude" and the conductivity.

1704. FORMULAE RELATING TO THE PROPAGATION OF ELECTROMAGNETIC WAVES [Discrepancy between Eckersley's Formula and That deduced from the "Cymomotive Force" of a Vertical Semi-Dipole].—Sacco and Tiberio. (*Alta Frequenza*, February, 1936, Vol. 5, No. 2, pp. 117–119.) *See* 1354 of April.

1705. A RADIO METHOD FOR DETERMINING THE ABSOLUTE TEMPERATURE OF THE IONOSPHERE.—J. Fuchs. (*Meterolog. Zeitschr.*, No. 2, Vol. 53, 1936, pp. 41–44.)

Author's summary:—It is shown that the theory of the ionisation of the earth's atmosphere through the sun's ultra-violet radiation, and the theory of the propagation of radio waves, allow the already undertaken numerous observations of the frequencies and equivalent heights of the radio waves reflected from the ionosphere to be worked out to give the temperatures reigning at these heights. The calculated temperature values range, for the F region at the equator, from 400 to over 1000°. They show a clear dependence on the electron densities and thus support the hypothesis that the temperature of the earth's atmosphere at great heights is chiefly determined by the solar ultra-violet energy absorbed in the ionisation processes.

1706. THE UPPER ATMOSPHERE [Survey of Recent Advances in Knowledge of the Temperature of the Upper Air: Luxembourg Effect].—E. V. Appleton. (*Nature*, 29th Feb. 1936, Vol. 137, pp. 369–370.)

1707. THE PRESENCE OF RADIATION OF WAVELENGTHS BELOW 3 000 Å IN THE SPECTRUM OF THE NIGHT SKY AND THE PROBABLE EXISTENCE OF LUMINOUS LAYERS IN THE UPPER ATMOSPHERE.—J. Cabannes, J. Dufay and J. Gauzit. (*Comptes Rendus*, 24th Feb. 1936, Vol. 202, No. 8, pp. 612–614.)

It is found that the intensity of the lines 3 019 and 2 958 Å is such that they are probably emitted by the ozone layer. In combination with former results, the data suggest that there are two luminous layers in the upper atmosphere, the higher one ($>$ 100 km) directly excited by electronic impact and the lower one due to the destruction of ozone. The transitions necessary to produce the lines are considered.

1708. THE STRUCTURE OF THE ULTRA-VIOLET ABSORPTION SPECTRUM OF OZONE.—Jakowlewa and Kondratjew. (*Physik. Zeitschr. der Sowjetunion*, No. 1, Vol. 9, 1936, pp. 106–108: in English.)

1709. FRAUNHOFER'S SPECTRUM IN THE NEIGHBOURHOOD OF 96 000 Å [Absorption Spectrum of Solar Radiation: Lines of Strongest Rotation-Vibration Band of Ozone Molecule: Structure of Molecule].—A. Adel, V. M. Slipher and O. Fouts. (*Phys. Review*, 15th Feb. 1936, Series 2, Vol. 49, No. 4, pp. 288–290.)

1710. DIFFUSE LIGHT AND POLARISATION OF TURBID MEDIA [with Application to Absorption of Solar Radiation by the Atmosphere and Scattered Light from the Sky].—H. von dem Borne. (*Zeitschr. f. Physik*, No. 1/2, Vol. 99, 1936, pp. 73–102.)

1711. Applications of Wireless among High Mountains.—B. Decaux. (*See* 2019.)

1712. Experimental Contribution to the Problem of Underground Broadcast Reception at a Distance.—D. Doborzyński. (*Hochf:tech. u. Elek:akus.*, January, 1936, Vol. 47, No. 1, pp. 12–13.)

A short note on reception experiments in two large, damp caverns near Cracow at depths of 20–25 m below the surface. Very good reception of all European stations of high and medium power was obtained; there was little difference in signal strength below and above the surface, except in the case of the local station (17 km distant) which gave distinctly weaker signals in the caverns.

1713. The Propagation of Alternating Current in the Earth below an Infinitely Long, Vertical Conducting Loop, Open at One End, in the Air.—Buchholz. (*See* 1818.)

1714. Sinusoidal Travelling Waves [Theory of Transients for Distortionless Transmission Line: Solution permitting Simple Graphical Treatment: Oscillographic Confirmation].—Weber and Kulman. (*Elec. Engineering*, March, 1936, Vol. 55, No. 3, pp. 245–251.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

1715. Cathode-Ray Oscillographic Investigations on Atmospherics [between Feb. and Aug. 1934, using Horizontal Aerials: 1934 U.R.S.I. Paper "with Small Additions"].—H. Norinder. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 287–304.) For previous papers *see* 3331 of 1935 and 890 of March, and their back references. The paper ends with a definition and discussion of "lightning-flash type" atmospherics, and an illustration of the differing wave-forms of "clicks" and "grinders."

1716. The Nature of Atmospherics [H.F. Group drawing ahead of L.F. Pulse: Radio Research Board Results confirmed].—G.W.O.H.: Norinder & Nordell. (*Wireless Engineer*, March, 1936, Vol. 13, No. 150, p. 118.) Addition to the Editorial referred to in 890 of March.

1717. Earth-Potential Measurements made during the International Polar Year.—G. C. Southworth. (*Bell S. Tech. Journ.*, January, 1936, Vol. 15, No. 1, p. 175: summary only.) For an earlier paper *see* 1934 Abstracts, pp. 145–146.

1718. Standardisation of Impulse-Voltage Testing.—T. E. Allibone and F. R. Perry. (*Journ. I.E.E.*, March, 1936, Vol. 78, No. 471, pp. 257–284.)

1719. Recent Developments in Cosmic Rays [Comprehensive Survey].—A. H. Compton. (*Review Scient. Instr.*, February, 1936, Vol. 7, No. 2, pp. 71–81.)

PROPERTIES OF CIRCUITS

1720. On Filters terminating in Negative Resistances [Elimination of Transmission Losses].—S. P. Chakravarti. (*L'Onde Élec.*, March, 1936, Vol. 15, No. 171, pp. 150–166.)

In practice, band-pass filters produce an attenuation in the pass band owing to the resistance of the coils and the losses in the condensers. If, in addition, the filter is connected between two impedance differing from the characteristic impedance, another attenuation is added by reflection losses. The total attenuation may be serious when, for example in carrier-current working over cables, many filters in series are employed. "We have found that if a filter having a non-reactive characteristic impedance Z_0 in the pass band is terminated by a pure negative resistance $-Z_0$, a gain of voltage and power can be obtained in the pass band from the fact of reflection; there is no de-phasing of the output current with this termination $-Z_0$, any more than there is with a termination $+Z_0$. The present study shows how the voltage and energy gains resulting from these reflections can be measured, and gives the theory of the phenomenon." Figs. 7 A, B and C show three methods which were used to provide the negative resistances: they each employ a s.g. valve in series with a purely ohmic variable resistance.

1721. A Network Theorem ["Symbol Substitution Theorem" applying to Quantities specifying Over-all Action of Transducer with Load: condensing Entire General Transducer Theory: Unsuspected Close Relation between T and Pi Sections: etc.].—J. G. Brainerd. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 316–327.) There is one impedance which does not obey the theorem—the transfer impedance under load.

1722. The Design of 2-Pole Networks containing One Positive and One Negative Reactance.—L. C. Pocock. (*Elec. Communication*, January, 1936, Vol. 14, No. 3, pp. 201–208.)

1723. The Conversion of Power by Means of Triodes [Conversion of D.C. Current to R.F. and Other Alternating Current].—C. Matteini. (*Alta Frequenza*, February, 1936, Vol. 5, No. 2, pp. 58–103: to be continued.)

Author's summary:—The problem of the conversion of d.c. power into a.c. power by means of triodes is examined, with particular regard to communication engineering. After reviewing the most important work on this subject, a method is described, based on the classic study of Prince, for calculating the working conditions from the practical characteristics of the triode.

A simplified method is then developed, based on consideration of the Vallauri equation and on the use of a new triode coefficient $P_p/(S_0 V_a^2)$ (ratio of the anode dissipation to the product of the maximum mutual conductance and the square of the d.c. anode voltage—there is a misprint here in the author's summary), by which the working conditions and the conversion efficiency can be established. The different classes of amplifiers

(A, B and C) are examined separately. Numerical examples illustrating the method are worked out and verified experimentally.

1724. ON THE THEORY OF COUPLED VIBRATIONS OF TWO SELF-EXCITED GENERATORS.—A. Mayer. (*Tech. Phys. of USSR*, No. 5, Vol. 2, 1935, pp. 465–481 : in English.)

" So far as the author is aware, the case of two coupled self-excited generators has not yet been treated in the literature ; the reason seems to lie in the particular difficulties which the usual ' linear ' theory encounters in this case." In the present paper the case of a " strong " coupling is treated with premises which enable the problem to be reduced to the consideration of a system of two degrees of freedom closely approximating a linear conservative system ; to simplify the computation the characteristics of the valves are assumed to be cubic parabolas. The fundamental non-linear differential equations are treated as follows :—First the approximate equations are formed by van de Pol's " method of slow variation of coefficients " : these also are non-linear, though considerably simplified, and yield systems of two equations of the first order. These equations are then studied by Poincaré's method, and general formulae are deduced for amplitudes, stability of equilibrium states, harmonic and biharmonic motions (motions very nearly represented by a sum of two harmonic motions), etc. Finally, a detailed examination is made of two strongly coupled self-excited generators differing only in the capacities of the oscillating circuits : in particular, the " bifurcation points " (at which the qualitative picture of possible phenomena changes) and the " exchanges of stability " of possible stationary motions are examined.

1725. EXPLORATION OF THE PLANE OF VAN DER POL VARIABLES WITH THE AID OF THE CATHODE-RAY OSCILLOGRAPH.—Bendrikov and Gorélik. (*Tech. Phys. of USSR*, No. 6, Vol. 2, 1935, pp. 545–551 : in French.) Dealt with in the Russian version (486 of February).

1726. ON THE THEORY OF FRÜHAUF'S [Symmetrical Two-Triode] RELAXATION OSCILLATION CIRCUIT [as used for Time Bases].—L. Cholodenko. (*Tech. Phys. of USSR*, No. 6, Vol. 2, 1935, pp. 552–559 : in German.)

Frühauf's circuit has been analysed by Hollmann (1932 Abstracts, p. 45) but " although his theory correctly gives the main points of the processes involved it is not, mathematically, strictly satisfactory. It seems, therefore, of interest to examine this circuit with the help of the new, more rigorously accurate methods which have been successfully applied to other ' trip ' circuits [*e.g.* 928 of March]. From the standpoint of this new method, the necessity of taking into account the anode retroaction, in the analysis of the Frühauf circuit, is of interest. The method here used to calculate this retroaction can evidently be applied to other similar circuits." The theoretical results are confirmed by cathode-ray oscillographs.

1727. INFLUENCE OF THE " SMALL PARAMETERS " ON THE STATIONARY STATES OF A DYNAMIC SYSTEM [States which appear Stable when slightly " Idealised " by Neglect of Certain Terms in Equation may actually be Unstable : etc.].—S. Chaikin. (*Tech. Phys. of USSR*, No. 5, Vol. 2, 1925, 449–464 : in French.)

Even in systems here characterised as " grossiers," in which a small variation of the parameters does not involve any essential modification in the character of the movements, a " small " parameter whose introduction raises the order of a differential equation may modify qualitatively even a characteristic so apparently definite as the stability of the system. But the fact that the condition of equilibrium becomes unstable does not of itself influence the character of the movements studied. That character changes because the " small " parameter, besides rendering the state of equilibrium unstable, also makes it necessary to introduce new initial conditions, so that the fact that the system does not remain in the state of apparently stable equilibrium is due to two effects acting in concert—the loss of stability and the existence of small differences in the initial conditions. Thus we ought to regard the initial conditions for the complete equation and for the shortened equation as " neighbouring " but not identical, and it is these differences which enable the " small " parameters to exert an essential influence. The writer illustrates his argument with examples of an arc circuit (Fig. 2 : neglect of C or L if it is small in value) and a valve circuit (Fig. 8) : " the setting up of ' parasitic ' oscillations in certain systems, appearing and disappearing without apparent cause, is perhaps often due to variations undergone by ' small ' parameters [such as the inductance of a lead] in the regions of ' doubtful ' equilibrium such as we have just studied."

1728. ELECTRICAL CIRCUITS CONTAINING RECTIFIERS [treated by Heaviside Operational Calculus].—E. F. Ghiron and A. Pernier. (*Alta Frequenza*, February, 1936, Vol. 5, No. 2, pp. 104–116.)

1729. THE USE OF THE ELECTRONIC TUBE AS A DETECTOR BY MEANS OF THE CURVATURE OF THE GRID CHARACTERISTIC. WEAK AND STRONG SIGNALS.—D. Milossavliévitch. (*Comptes Rendus*, 2nd March, 1936, Vol. 202, No. 9, pp. 735–738.)

The work of a previous paper (1382 of April) is extended to include the grid/anode capacity. A differential equation for the grid voltage is obtained which may be solved analytically for weak signals and graphically for strong signals. Illustrative numerical data are given.

1730. GRID CURRENT AND THE RESULTING DAMPING.—Kautter. (*See* 1749.)

1731. A CONTRIBUTION TO THE PROBLEM OF SKIN EFFECT IN LAYERED CYLINDRICAL CONDUCTORS [Experimental Results by Thermal Method : Theory yielding Practical Formulae : Practical Conclusions].—H. W. Steinhausen. (*Telefunken-Zeit.*, March, 1936, Vol. 17, No. 72, pp. 45–57.)

" So far as the writer knows, there exist at present only two papers having for their object the development of practically applicable solutions [Ekelöf and Kruse & Zinke, 2224 of 1935 and back reference]. It seems desirable to test the results of these works experimentally." The investigation was over a frequency range of 0.6 to 10 Mc/s, and the method of measuring the real component of the h.f. resistance was to heat the conductor to a definite temperature first by d.c. and then by h.f. current: the ratio of a.c. to d.c. resistance is thus found directly from the value of the two currents.

The theory developed gives formulae yielding values most of which agree with the measurements within the limits of accuracy of the latter (about 3%). It involves a special definition of penetration depth as the distance in cm from the outer surface at which the current density and magnetic field-strength have decreased in the ratio $1/e$: penetration depth thus plays a similar rôle for damping in space to that played by the time constant T in the damping according to time. The investigation was extended to ferromagnetic materials. Among the practical conclusions are that the outer coating should not exceed the penetration depth in thickness, if it is to control the value of the resistance. Silver-plating a copper core brings no advantage, owing to the small difference in conductivities; similarly, a badly conducting outer layer need not be feared provided its thickness is small compared with the penetration depth; owing to the small penetration depth of ferromagnetic materials these materials show considerably higher h.f. resistance.

1732. CONTINUOUS REFLECTIONS IN UNBALANCED CABLES [Theory of].—W. I. Ilschenko. (*Arch. f. Elektrot.*, 28th Jan. 1936, Vol. 30, No. 1, pp. 36–45.)

The discussion is based on the equilibrium of electric and magnetic energies for any point on the cable. When the equilibrium is disturbed (*i.e.* the cable is unbalanced), additional waves are propagated in both directions. Reflection is thus not only a property of the points of connection between cables but also of the cable itself. Various special cases are considered.

1733. MAGNETIC FORCES IN A RECTANGULAR CIRCUIT [explicable by Ampère's Force Equation for Magnetic Force between Current Elements].—F. F. Cleveland. (*Phil. Mag.*, February, 1936, Series 7, Vol. 21, Supp. No. 140, pp. 416–425.)

TRANSMISSION

1734. THE PRODUCTION OF MAGNETRON OSCILLATIONS BY MEANS OF TRIODES.—M. Jahoda. (*Hochf:tech. u. Elek:akus.*, January, 1936, Vol. 47, No. 1, pp. 22–26.)

An experimental investigation is described of magnetron oscillations produced by a triode in which the potential of both anode and grid was positive. Here two types of characteristic must be considered (Figs. 1–3). These are the variation of grid and anode currents respectively with the magnetic field intensity, for constant grid and anode voltage. The critical anode and grid voltages are given by eqns. 3 and 4. Two types of oscillation are found in the triode (§ I); type I is identical with the "electronic" oscillations in the diode. Type II arises when the intensity of the magnetic field is such that some electron paths pass through the grid/anode space (eqn. 6); the wavelength decreases as the field intensity increases (Figs. 4, 5; eqn. 7) and also depends on the external circuit (§ II; Figs. 6, 7), though only within very small limits of variation of that circuit.

1735. OSCILLATIONS IN MAGNETRONS [Split-Anode Type: High-Frequency Impedance Measurements: Variation with Magnetic Field Intensity].—J. S. McPetrie. (*Nature*, 22nd Feb. 1936, Vol. 137, pp. 321–322.)

Results of experiments are given showing that "with variation in magnetic field there is change in the sign of reactance as the condition of oscillation is passed through. Below this condition, the capacity is negative, but changes to positive above. The resistance is negative, but at two regions of minimum negative resistance oscillation occurs."

1736. THEORY OF THE TRANSIT-TIME OSCILLATIONS OF THE MAGNETRON.—K. Fritz. (*Telefunken-Zeit.*, March, 1936, Vol. 17, No. 72, pp. 31–36.)

For a previous paper *see* 3379 of 1935. "The recently published representation of the electron paths in the magnetron [Müller, 2598 and 3378 of 1935] refers to some special cases which occur only occasionally in valves of usual form, as can readily be shown experimentally with the help of auxiliary electrodes in a magnetron. In the following paper a clear presentation is given of points of view which are important in connection with the setting up of oscillations. The important experimental facts can then be readily explained." Taking for the sake of simplicity two plane anodes forming a parallel-plate condenser (Fig. 38), the writer considers an electron entering at the left and drawn towards the right by a transverse field: in the absence of an alternating potential it will describe the "straight" cycloidal path shown in the bottom curve. The magnetic field is then adjusted so that a revolution-time is about equal to an oscillation period of an alternating field superposed on the steady condenser field. An electron whose y-component of velocity is opposed in phase to the alternating field will at every half revolution give up energy to the field: both its velocity and its radius of curvature will decrease, and a point will be reached where its residual energy is no longer enough for it to move against the field. It now is acted on only by the accelerating force of the alternating field: its y-velocity makes a phase jump and the electron takes back energy from the field, so that there is a periodic exchange of energy between electron and field (eqn. 3: middle curve of Fig. 38). There is a similar "beat effect" in the x-component. The time interval between the entrance of the electron into the field and the first minimum is shortest when there is exact phase opposition, and longest (infinitely long) when the phase between y-velocity and alternating field differs by ±90°, corresponding to a capacitive or inductive current component for the external circuit. The process resembles that of an electron, in atomic physics, rotating round an atomic nucleus; except that the magnetron electron does not jump from one radius to another and thus absorb or set free a quantum of energy.

The above representation, with its equations, is applied to explain various experimentally found phenomena in two-split and four-split magnetrons: for instance, the relation between optimum angle and emission current in first-order oscillations; the heating and secondary emission at the cathode by high-frequency effects, even when the filament is connected symmetrically with regard to the external circuit; etc. "The energy conversion in transit-time oscillations of the two-split and four-split magnetrons goes on in such a way that the electrons with predominating 'correct-phase' components give up their energy, after many revolutions, to the alternating field and thus lose their speed, while the 'wrong-phase' electrons increase their velocity and energy from the alternating field and thus change their paths until captured. A determining factor for damping reduction is the difference between energy taken up and given out: this may be negative, even when the electrons entering the alternating field . . . display no phase-arrangement."

1737. ON THE THEORY OF A SPLIT-ANODE MAGNETRON [particularly the Explanation of "Dynatron" Oscillations of Period much greater than Electron Transit Times: Electron Paths plotted by Graphico-Analytical Method].—G. Grünberg and W. Lukoschkov. (*Tech. Phys. of USSR*, No. 5, Vol. 2, 1935, pp. 482–492: in German.)

"These paths, and the analysis of the fields in the magnetron, show that for certain relations between the electric and magnetic fields the moving electrons pile themselves up in a definite zone, namely in the neighbourhood of the half-anode with the lower potential. The existence of such a zone explains in principle the shape of the static characteristic of a magnetron. An appendix describes briefly the mathematical foundations of the constructional method by which the paths were obtained." Eqn. 3 of this appendix shows that the field inside a magnetron can be represented as the superposition of two fields—the radial field of a cylindrical condenser with the potential difference $(V_1+V_2)/2$ between the inner and outer cylinders, and a field occurring between the two halves of the outer cylinder (in the absence of an inner cylinder) with a potential difference of $(V_1-V_2)/2$. In one zone these fields mutually strengthen each other, in the other they weaken each other, so that in one half of the cylinder the electric field is in general considerably weaker than in the other, explaining the completely different character of the motions in the two halves.

1738. THE PRODUCTION OF DECIMETRE WAVES [General Discussion of Known Methods: Principles of B-K, Magnetron, Dynatron Oscillators: Paraboloidal Reflectors].—E. C. Metschl. (*Naturwiss.*, 14th Feb. 1936, Vol. 24, No. 7, pp. 97–102.)

1739. THREE-INCH CUBE MICRO-WAVE TRANSMITTER, WITH TWO TEN-INCH RODS AS AERIAL, "SENDS VOICE FOUR MILES."—O. B. Hanson. (*Sci. News Letter*, 15th Feb. 1936, Vol. 29, p. 103.) Using an "acorn" valve and 0.2 watt.

1740. CRYSTAL CONTROL FOR DECIMETRE WAVES.—H. Straubel. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 627–629.)

In continuation of previous work (3383 of 1935), it is found that moderately thick tourmaline plates may be used for frequency control if they are excited in their second harmonic. The stabilisation of waves below 60 cm is described (emitter Fig. 2, receiver Fig. 3) with practical hints on construction. B-K oscillations could be stabilised to give a beat note only if they were worked from batteries alone; this may also be expected with magnetron oscillations.

1741. QUARTZ OSCILLATORS [Survey, with Bibliography, of the Search for Very Low Temperature Coefficients: New Telefunken Researches].—R. Bechmann. (*Telefunken-Zeit.*, March, 1936, Vol. 17, No. 72, pp. 36–45.) For previous papers *see* 1381 of 1935, and 1556 of April.

1742. SYNCHRONISED VALVE GENERATOR [Anode Voltages from Main Emitter and Auxiliary Control Emitter introduced into Different Diagonals of Bridge Circuit].—Central Radio Laboratory, Leningrad. (*Hochf:tech. u. Elek:akus.*, January, 1936, Vol. 47, No. 1, p. 29: German Pat. 618 863 of 30.10.1933.)

1743. DISCUSSION ON "PARASITES AND INSTABILITY IN RADIO TRANSMITTERS" [Standing Waves on Filament Bus-Bars and Grid Leads: etc.].—J. Greig: Fyler. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 328–329.) *See* 3850 of 1935. For Greig's paper referred to *see* 2616 of 1935.

1744. A NEW METHOD FOR HIGH EFFICIENCY MODULATION [by Coupling Variation].—S. I. Tetelbaum. (*Izvestia Elektroprom. Slab. Toka*, No. 1, 1936, pp. 1–9.)

The method proposed is based on the operation of the final power amplifier with a constant anode-swing/feed-voltage ratio, so that the efficiency of the power amplifier at any point of the modulation characteristic is the same as when operating under telegraphy conditions. It is shown that this can be obtained and the linearity of the modulation characteristic preserved if (a) the inductive coupling between the power amplifier and the aerial circuit varies as the first power of the modulating voltage, and (b) the anode current of the power amplifier varies as the second power of the modulating voltage. After a brief comparison of this method with other modulation systems the following practical suggestions are given for satisfying (a) and (b). On longer wavelengths (of the order of 1000 m) condition (a) can be obtained if the magnetic flux through the core of the coupling transformer is regulated by the audio-frequency currents (Fig. 4 & 5).

On shorter wavelengths (below 100 m) the result is more conveniently obtained by the use of a variable condenser in which one of the plates is vibrated by the audio-frequency currents (Figs. 6 & 7). Condition (b) would be fulfilled if the characteristic of one of the stages following the modulated amplifier, or of one of the stages of the audio-frequency channel, were made conformable to the square law. In conclusion it is pointed out that this paper is a preliminary communication only and that a great deal of further investigation of the method proposed is required. *Cf.* Michel, 1400 of April.

1745. Survey of the Various Systems of Modulation at Improved Efficiency, employed for Broadcasting Transmitters.—J. Loeb. (*L'Onde Élec.*, Feb. and March, 1936, Vol. 15, Nos. 170 and 171, pp. 81–101 and 142–149.) For a previous paper, covering much the same ground, *see* 1934 Abstracts, p. 319.

1746. Present Methods of Modulation in Broadcasting need Complete Re-Examination [Possibilities of Predistortion-Restoring and Compressor-Expander Systems added to Frequency Modulation: 100% Limit to Amplitude Modulation avoided by Exponential Modulation: etc.].—A. Hazeltine. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 140–143: in his Inaugural Address.) "If we had to do it over again, I feel certain that we would use frequency modulation universally for broadcasting. Does this not indicate that it must force its way in eventually?"

1747. Optimum Operating Conditions for Class B Radio-Frequency Amplifiers.—W. L. Everitt. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 305–315). For similar treatment of Class C amplifiers, by the writer's rapid method of computation, *see* 1934 Abstracts, pp. 205 and 613.

1748. A Generator producing Sinusoidal Oscillations of Constant Amplitude over a Very Wide Range of Frequency [0.03–30 000 c/s].—A. M. Monnier and J. Bazin. (*Comptes Rendus*, 9th March, 1936, Vol. 202, No. 10, pp. 828–830.)

The generator, which involves no inductances, is based on a resistance-capacity bridge (Fig. 1), with diagonal resistance R small compared with the resistances in the arms, and unequal time-constants in the two sides. The anode currents of two triodes circulate in opposite directions in the two halves of R and the grids are connected to the other diagonal points of the bridge. The oscillation equations of the circuit are given and it is shown that, with suitable choice of circuit elements, the circuit will generate pure sinusoidal oscillations of constant amplitude and frequency between 30 000 and 0.03 c/s.

RECEPTION

1749. Grid Current and the Resulting Damping [in Audion and Mixing Valves, etc.: Derivation of Simple Formulae and Curves: Calculation and Use of "Audion Factor": etc.].—W. Kautter. (*Telefunken-Zeit.*, March, 1936, Vol. 17, No. 72, pp. 23–31.)

The principal formulae obtained are those for the mean value of the d.c. grid current for a given imposed a.c. amplitude: for the damping of an oscillator (or mixing-valve) oscillation due to a given d.c. grid current: for the damping exerted on an incoming oscillation by the grid current produced by the oscillator reinforced by the signal: for the audion factor (number of times, in a leaky-grid detector, the r.f. voltage on the grid must exceed the required a.f. voltage, the former being $m\%$ modulated): and for the variation with amplitude (its most troublesome property) of the grid damping in leaky-grid rectification.

1750. Retroaction in Audio Amplifiers.—Marinesco. (*See* 1821.)

1751. Experimental Contribution to the Problem of Underground Broadcast Reception at a Distance.—Doborzyński. (*See* 1712.)

1752. Dual Listening [Simulation of Stereophonic Transmission and Reception obtained by Suitably Adjusted Simultaneous Headphones - and - Loudspeaker Reception].—(*World-Radio*, 6th March, 1936, Vol. 22, p. 13.) *See* also *ibid.*, 13th March, p. 11.

1753. On the Subject of High Fidelity ["Undistorted 3 Watts Output" impossible with Standard Output Valves: Perfect Reproduction of All Frequencies prohibitively Expensive: Need for concentrating on Elimination of Non-Linear Distortion].—M. Chauvierre. (*L'Onde Élec.*, January, 1936, Vol. 15, No. 169, pp. 59–61.)

1754. A New Superheterodyne Principle [Part of Received Wave (in practice, Part of 100 kc/s Output of Preliminary Frequency-Changing Stage) used to produce Heterodyning Oscillation].—G. W. O. H.: E. G. Beard. (*Wireless Engineer*, March, 1936, Vol. 13, No. 150, pp. 117–118.)

Editorial on an Australian paper. The set is completely dead in the absence of the signal. Crystal filtering of the heterodyning oscillations may be used. Increased accuracy in direction-finding and very good results, particularly in the reception of modulated signals below the noise level, are claimed.

1755. Editorial on Automatic Stabilisation [Superhet-Tracking] and Tuning Correction.—P. Besson. (*L'Onde Élec.*, February, 1936, Vol. 15, No. 170, pp. 77–80.)

1756. Variable Selectivity and the I.F. Amplifier. Part I.—The Design of Transformers for Variable Selectivity [and a New, Three-Coupled-Circuit, Device].—W. T. Cocking. (*Wireless Engineer*, March, 1936, Vol. 13, No. 150, pp. 119–130.)

The writer first investigates the three-tuned-circuit arrangement, with two circuits variably coupled and the third (of half the efficiency of the others) isolated, described on p. 602 of Wheeler and Johnson's paper (3006 of 1935). The results of this investigation lead him to develop a three-coupled-circuit system to give similar results with great advantages, including economy in valves.

1757. The Use of Resistance Tuning in a New System of Multiple Carrier-Current Telegraphy.—Watanabe. (*See* 2057.)

1758. HIGH-FREQUENCY IRON CORES FOR THE COILS OF BROADCAST RECEIVERS [Survey].—H. C. Riepka. (*E.T.Z.*, 27th Feb. 1936, Vol. 57, No. 9, pp. 218–222.) Including table of loss angles of various condensers and coils, and a mains-driven equipment for measuring the figure of merit of coils.

1759. SHORT-WAVE INTERFERENCE [Image-Signal Suppression].—(*Wireless World*, 6th March, 1936, Vol. 38, pp. 236–237.)

1760. NOISE INTERFERENCE IN RADIO RECEIVERS [Its Mechanism, and the Consequent Definite Limitations to the Nature of Noise-Suppressing Devices].—G. Builder and J. E. Benson. (*A.W.A. Tech. Review* [*see* 512 of February], January, 1936, Vol. 2, No. 1, pp. 23–32.)

1761. OPERATING NOISE-SILENCING UNITS: PRACTICAL HINTS.—G. Grammer: Lamb. (*QST*, March, 1936, Vol. 20, pp. 11–12 and 72, 74, 78.) On the device dealt with in 1407 of April.

1762. VARIATION FORMS OF RADIO INTERFERENCE FROM ELECTRICAL APPARATUS [with Oscillograms].—H. Norinder and R. Nordell. (*Teknisk Tidskrift*, 7th March, 1936, Vol. 66, No. 10, Supp. pp. 37–40: in Swedish.)

1763. FREQUENCY ANALYSIS IN THE INVESTIGATION OF RADIO INTERFERENCE.—E. T. Glas. (*Teknisk Tidskrift*, 7th March, 1936, Vol. 66, No. 10, Supp. pp. 41–46: in Swedish.)

1764. ON THE FOURTH NATIONAL CONGRESS OF DEFENCE AGAINST RADIOELECTRIC INTERFERENCE.—M. Adam. (*Rev. Gén. de l'Élec.*, 8th Feb. 1936, Vol. 39, No. 6, pp. 231–238.)

1765. THE REUNION OF EXPERTS OF THE SPECIAL INTERNATIONAL COMMITTEE ON RADIOPHONIC INTERFERENCE.—(*Rev. Gén. de l'Élec.*, 15th Feb. 1936, Vol. 39, No. 7, p. 271.) Summary only: some data are given.

1766. 132 KV LINE INSULATORS [Different Types tested under Various Weather Conditions: Prevalence of "Fog Surging"].—J. S. Forrest. (*Electrician*, 28th Feb. 1936, Vol. 116, pp. 287–288.) Summary of I.E.E. paper.

1767. A THREE-VALVE RECEIVER WITH A NEW TYPE OF CIRCUIT [Undistorted Reproduction free from Mains Hum, though with Cheaper Smoothing Arrangements, by feeding Output Valve direct from Double-Diode supplied with H.F. up to 200 Volts].—R. Oechslin. (*Radio, B., F. für Alle*, January, 1936, pp. 1–4.)

1768. DEVELOPING A MODERN QUALITY SUPERHETERODYNE *and* THE QA SUPER [for High Quality Reception].—W. T. Cocking. (*Wireless World*, 14th Feb. 1936, Vol. 38, pp. 150–154: 28th Feb. and 6th March, 1936, Vol. 38, pp. 204–207 and 230–235.)

1769. SMALL PORTABLE RECEIVERS WITH GOOD REPRODUCTION [made possible by "K" Series of Pinless 2-Volt Valves, etc.: Constructional Suggestions].—F. C. Saic. (*Funktech. Monatshefte*, February, 1936, No. 2, pp. 59–62.)

1770. TWO TWO-CIRCUIT THREE-VALVE RECEIVERS: PHILIPS-HAMBURG D43 GW AND SCHALECO-TRAUMLAND.—(*Funktech. Monatshefte*, February, 1936, No. 2, pp. 78–80.)

1771. "MASTERPIECE IV" OF THE SILVER SERIES.—P. Besson. (*L'Onde Élec.*, January, 1936, Vol. 15, No. 169, pp. 65–74.)

1772. FURTHER DEVELOPMENT OF THE THREE-VALVE "SINGLE-SPAN" SUPERHET FOR A.C. MAINS.—H. J. Wilhelmy. (*Funktech. Monatshefte*, February, 1936, No. 2, pp. 63–68.) Continued from 1430 of April.

1773. THE DUCRETET RECEIVER TYPE C.6.311 [Superhet. with Low-Loss Circuits, Fading Control and Variable Selectivity].—P. Besson. (*L'Onde Élec.*, March, 1936, Vol. 15, No. 171, pp. 187–200.)

1774. THREE TELEFUNKEN RECEIVERS [Short-Wave "Overseas," Car Receiver, and "Deutschland," D.C. Mains Model].—(*L'Onde Élec.*, February, 1936, Vol. 15, No. 170, pp. 133–140.)

AERIALS AND AERIAL SYSTEMS

1775. AN EXPERIMENTAL STUDY OF PARASITIC [*i.e.* Radiation-Excited] WIRE REFLECTORS ON 2.5 METRES [Vertical Aerial with Parallel Rod Reflectors, especially Parabolic Arrays: Dependence of Forward Radiation, Directivity, and Backward Radiation on Dimensions of System, not only on "Aperture:" Agreement with Foreign Results: etc.].—A. W. Nagy. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 233–254.)

1776. CONTRIBUTION TO THE CALCULATION OF [Parabolic] REFLECTORS FOR ELECTRIC WAVES.—R. Brendel. (*Hochf:tech. u. Elek: akus.*, January, 1936, Vol. 47, No. 1, pp. 14–21.)

A rough general formula is first given (§ II 2) for the amplification, which is found to be approximately equal to the square root of the total area of the reflector and the solid angle subtended by it at the focus, where the emitter is assumed to be. The reflector must therefore have as large a surface as possible. The more exact calculation treats the reflecting elements separately; § II 3 deals with the mutual coupling between them considered as elementary dipoles of length equal to half the wavelength used, and determines the effective current in the tuned grating as a function of the distance between the elements (Figs. 1, 2): *see* also Sammer, Abstracts, 1930, p. 278.

The direct radiation (§ II 4a), the reaction of the reflector on the emitter (§ II 4b), and the effect and necessary dimensions of a "skull-cap" round the emitter to prevent unreflected radiation escaping (§ II 4c), are discussed. In § II 5 the intensity distribution and phase relations are calculated for (1) a parabolic cylinder, (2) an all-round parabolic reflector; formulae for the amplification are found and compared (§ 6: Figs. 4–6) with measurements by Köhler (1932, p. 525). The agreement is best for large reflectors. The optimum height of the parabolic cylinder can also be estimated. The radiation characteristic is calculated in § II 7 and compared with Ollendorff's formulae and Köhler's experiments. Fig. 8 shows the horizontal characteristic of the cylindrical and Fig. 9 that of the all-round reflector. In § II 8 a general discussion is given, summarised by the curves in Fig. 10. The all-round parabolic reflector is found to be the best but can only be used for very short waves. The parabolic cylinder is easier to build and need not be very high. The tuned parabolic grating reflector is least to be recommended. *See* also Darbord, 1932, pp. 346 and 525.

1777. Investigations on the Vertical Diagram of High [Single-Mast Anti-Fading] Broadcasting Aerials.—W. Berndt and A. Gothe. (*Telefunken-Zeit.*, March, 1936, Vol. 17, No. 72, pp. 5–12.)

Authors' summary:—" It is shown by tests on models, and by calculations, that the practical vertical diagram of high broadcasting aerials, and consequently the fading reduction, depends on the standing and travelling waves in the aerial. The travelling wave's harmful influence on the diagram can, fundamentally, be kept small by feeding the aerial at the current antinode. If the aerial is fed at its base, the ratio radiation-resistance/characteristic-impedance must be as small as possible. With a single-mast aerial fed at the current antinode [as at Munich and Freiburg], the theoretically expected diagram cannot actually be obtained owing to the unavoidable radiation from the feeder. Single-wire aerials fed at the bottom give similar and better diagrams. Radiating iron-mast aerials have a diagram inferior to those of wire aerials; the worst is the 'fish-belly' mast [double pyramid, as at Budapest]. Even the latter, however, gives a reduction of field strength at the angle of 65° (so important for fading reduction) to about one-third of that given by a quarter-wave aerial": and it is pointed out that where fading reduction is less important than the increase in horizontal field (as is the case for common-wave transmitters) even the rather large residual radiation at the minimum, given by iron-mast aerials, is not a serious fault.

The model tests were made on a wavelength of about 3 m: the aerials were horizontal, each being provided with a duplicate, end to end, to act as a substitute for its image aerial. The double system was rotatable about a vertical axis, the two aerials being fed by a symmetrical vertical feeder screened to prevent radiation. Reception, at a distance of 70 m, was on a horizontal frame, backed by a wire grid to screen the receiver and the battery leads.

1778. Experiments on the Measurement of Space Radiation from Broadcasting Emitter Aerials.—F. Eppen and H. Scheibe. (*Hochf:tech. u. Elek:akus.*, January, 1936, Vol. 47, No. 1, pp. 8–12.)

In order to cut out the ground wave and measure the space radiation alone, a frame was used in a plane perpendicular to the line joining the emitter and receiver. It was found that in the day-time a good zero was obtained with a sensitive screened receiver even quite close to a powerful station. The night-time signal must be due either to rotation of the plane of polarisation of the space wave on reflection from the ionosphere or to the point of reflection not being vertically above the mid-point between emitter and receiver. The night-time signal was recorded. Space waves were found to begin two or three hours before sunset, particularly with long waves, and to appear first of all at a short distance (about 10 km) from the station; their fluctuations were most rapid near the emitter. Much slower intensity variations (of period 20 min. to 1 hr) were superposed on the rapid fading. The maximum field strength generally occurred four to five hours after sunset. The field strength at a distance of 1 km from the emitter is calculated from a formula involving the total distance to the ionosphere (height 100 km) and back in which no absorption and 100% reflection are assumed. Fig. 1 shows a typical record. A test was made to ensure that the maximum values found with the transverse frame really did correspond to the maximum values of the incident space waves (omitting considerations of multiple reflection). Simultaneous measurements were also made with the frame and a vertical aerial with semi-circular vertical polar diagram; the agreement was good.

The wavelengths investigated were 300–400 m and 1500–1600 m. In evaluating the results it was assumed that the plane of polarisation had been rotated through 90°. Figs. 2–5 show the vertical polar diagrams of various emitters, calculated for a distance of 1 km. Smaller values of the reflected field-strengths were found in the summer than in the winter. The assumption of 100% reflection from the ionosphere in the winter is justified by the fact that the measured values for the ground wave fit well into the polar diagrams deduced from space wave measurements.

1779. Some Equivalence Theorems of Electromagnetics and Their Application to Radiation Problems [particularly the Calculation of Power radiated from Open End of Coaxial Pair].—S. A. Schelkunoff. (*Bell S. Tech. Journ.*, January, 1936, Vol. 15, No. 1, pp. 92–112.)

For a semi-infinite coaxial pair, this power is given by egn. 37: $W = \pi^2/360 . (S/\lambda^2 \log b/a)^2 . V^2$ watts, where S is the area of the opening. The effect of radiation on the transmission line can be simulated by a resistance $R = 180/\pi^2 . (\lambda^2 \log b/a/S)^2$ ohms, shunted across the open end; the radiation resistance seen by a generator placed at a current antinode is $R_G = 20\pi^2 S^2/\lambda^4$ ohms.

1780. View Points on the Calculation of [Transmitting and Receiving] Aerials.—L. Nyström. (*Teknisk Tidskrift*, 7th March, 1936, Vol. 66, Supp. 46–47.)

1781. The Marconi "Phase Aerial" for Short-Wave Directive Transmission and Reception, as used for Rome/E. Africa Service.—(*Alta Frequenza*, February, 1936, Vol. 5, No. 2, pp. 142–143.)

1782. Dummy Aerials for Broadcast Frequencies [I.R.E. Standard Dummy: Necessity for "Picture Rail" Dummy in addition: Characteristics of Indoor Aerials: Difficulties regarding Short-Wave Dummy].—F. S. Maynard. (*A.W.A. Tech. Review* [*see* 512 of February], January, 1936, Vol. 2, No. 1, pp. 33–38.)

1783. VDE Draft Regulations on Aerials [including Earthing Switches, Crossing of Power Lines, etc.].—(*E.T.Z.*, 20th Feb. 1936, Vol. 57, No. 8, pp. 213–215.)

1784. On the Radiation emitted by a Multipole and Its Angular Momentum.—W. Heitler. (*Proc. Camb. Phil. Soc.*, January, 1936, Vol. 32, Part 1, pp. 112–126.)

VALVES AND THERMIONICS

1785. A New Type of Gas-Filled Amplifier Tube [Types up to 50 Watts Rating: Use as Ultra-High-Frequency Oscillator].—Le Van and Weeks. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 180–189.) The full paper, a summary of which was referred to in 3040 of 1935.

1786. Experimental Investigation of the Path Curves of the Electrons in the Split-Anode Magnetron [by Model with Rotatable Ray-Producing Cathode and Fluorescent Anodes].—M. Grechowa. (*Tech. Phys. of USSR*, No. 6, Vol. 2, 1935, pp. 560–566: in German.)

The model was first worked as a whole-anode magnetron by joining the two half-anodes: Fig. 2 shows the fluorescent spot displacement in degrees, on switching on the magnetic field, for three different anode voltages: the last points on each curve give the angles at which the spot disappears (between 85° and 90°). This agrees with Hull's conclusions on this type of magnetron. Treating the model then as a split-anode type, with different voltages on the two anodes, the shape of the field becomes much more complex: Fig. 3 shows the equipotential surfaces for $V_1/V_2=2$, obtained by the electrolytic trough method applied to a model. Path curves are drawn for three different magnetic fields, 0.95, 1.2 and 1.5 times the critical field value, and for different values of V_1/V_2. The characteristic curves $I_2=i\alpha_2=f(\Delta V)$, where i is the ray current and α_2 the angle limiting the zone in which the electrons coming from the cathode arrive at the half-anode A_2, are plotted in Fig. 8 for the three magnetic fields: the curves resemble the oscillograms of a real magnetron (Fig. 9: *see* also 1787) closely enough to indicate that the model results satisfactorily represent the actual electron movements in a real magnetron.

1787. Characteristic Curves of the Split-Anode Magnetron [Cathode-Ray Oscillograms taken with Special Circuit].—Bovsheverov. (*Tech. Phys. of USSR*, No. 6, Vol. 2, 1935, pp. 567–573: in German.)

"The most important material for the radio-technical theory of the magnetron generator are the characteristic curves. The usual 'point by point' method of plotting characteristics gives, mostly, curves mutilated by oscillations and does not ensure that all details of the curves are obtained. By the use of the circuit shown in Fig. 1 we have succeeded in eliminating the disturbing factors and in observing the true characteristics with all details of their form. This is attained chiefly by the transformer, which alternates the potential between the two anodes, so that during the short times in which the falling parts of the characteristic are traversed the magnetron cannot excite itself: moreover, the oscillatory circuit in which the magnetron can excite oscillations—the secondary winding of the transformer—is short-circuited by the comparatively low resistance R_1." The defects of the circuit, and the consequent departures of the results from the true characteristics, are discussed. Finally the conclusions which can be drawn from the experiments are set out. *See* also 1786.

1788. Theory of the Transit-Time Oscillations of the Magnetron.—Fritz. (*See* 1736.)

1789. Improvements to Magnetron Valves [Diminution of Losses and Increase of Power by Semi-Cylindrical Anodes eccentrically placed with regard to Cathode].—Telefunken. (French Pat. 791 001, pub. 2.12.1935: *Rev. Gén. de l'Élec.*, 29th Feb. 1936, Vol. 39, No. 9, p. 70 D.) So that the cathode/anode distance increases more and more as one follows the electron trajectory, thus decreasing the probability of an electron arriving at the higher-potential semi-anode.

1790. On the Theory of the Mode of Action of Thermionic Valves [Diodes with Plane and with Cylindrical Electrodes] under Rapidly Varying Anode Potentials. Part I.—G. Grünberg. (*Tech. Phys. of USSR*, No. 1, Vol. 3, 1936, pp. 65–80: in German.)

Benham (and later writers) calculated, under certain assumptions, the complex resistance of a plane-electrode diode as a function of the frequency of the applied voltage: although the case of a cylindrical-electrode diode is more difficult, his work included an approximate solution for this also, but only for small transit angles (1931 Abstracts, p. 212). The present writer, making the same simplifications as Benham in neglecting the initial electron velocity and assuming the velocity of light to be infinitely great, deals with both problems without any limiting assumption as to small amplitudes.

"The method employed allows all such cases to be dealt with in which at any point in the valve, at any moment, only electrons with one single definite velocity are present. The necessary and sufficient condition for this is that the total current through the valve shall not change its direction. By the fulfilment of this condition the equations of motion of the electrons can be fully integrated, for the plane-electrode case, provided only that the form of the total current flowing through the diode is assumed to be known [by "form" is meant the current value and all relative amplitudes and phases]. The general theory is illustrated by examples, at the end of the paper, of small varying amplitudes: here Benham's formulae are again arrived at. The cylindrical diode is then treated: the solution for small amplitudes is expressed by two auxiliary functions $W_1(Z)$ and $W_2(Z)$, which satisfy an ordinary linear differential equation of the second order, with numerical coefficients, which can be numerically integrated by the usual methods. Table II is calculated in this way, giving the values of $W_1(Z)$ and $W_2(Z)$ in the range $0 \leqslant Z \leqslant 7.5$. Outside this region certain asymptotic expressions for these functions can be used." The case of larger amplitudes will be dealt with in Part II, which will also give tables and curves for the calculation of the complex resistances of cylindrical valves as functions of the applied frequency and of the valve dimensions.

1791. THE LIMIT OF THE SENSITIVITY TO CHARGE IN THE VALVE ELECTROMETER. I [due to Shot Effect and Thermal Noise in First Valve: Dependence of Disturbances on Valve Properties and Working Conditions].—H. Alfvén. (*Zeitschr. f. Physik*, No. 1/2, Vol. 99, 1936, pp. 24–41.)

See also 1165 of March. The conditions in the first valve of the electrometer (Fig. 1) are investigated theoretically and experimentally. The chief disturbances in a valve with free grid are found to be the shot effect and thermal noise in the grid and anode circuits. These are analysed theoretically; the formulae obtained (eqns. 21 and 28) are tested experimentally. The sensitivity to charge is calculated and tested. The most important properties for the first valve to possess are (1) small grid current and good grid insulation, (2) steep characteristics and small static grid/earth and grid/anode capacities.

1792. THE USE OF THE ELECTRONIC TUBE AS A DETECTOR BY MEANS OF THE CURVATURE OF THE GRID CHARACTERISTIC. WEAK AND STRONG SIGNALS.—Milossavliévitch. (*See* 1729.)

1793. FLUCTUATION NOISE IN VACUUM TUBES WHICH ARE NOT TEMPERATURE-LIMITED [Thermal Agitation in Anode Stream Not Necessarily Involved: Shot Effect Interpretation is Adequate].—F. C. Williams. (*Journ. I.E.E.*, March, 1936, Vol. 78, No. 471, pp. 326–332.) Experimental investigation with very small anode currents, as in Pearson's work (1077 of 1935), but leading to different conclusions.

1794. POTENTIAL RELIEFS OF HIGH-VACUUM AND GAS-FILLED DETECTORS AND RECTIFIERS.—Gottmann. (*Funktech. Monatshefte*, February, 1936, No. 2, pp. 57–59.) Continued from 1458 of April.

1795. OPTIMUM OPERATING CONDITIONS FOR CLASS B RADIO-FREQUENCY AMPLIFIERS.—Everitt. (*See* 1747.)

1796. A METHOD OF DETERMINING THE OPERATING CHARACTERISTICS OF A POWER OSCILLATOR [Performance at 60 c/s agrees with Radio-Frequency Measurements: Wave Forms and Phase Angles of Anode and Grid Voltages: Contour Diagrams on Anode/Grid Voltage Plane].—E. L. Chaffee and C. N. Kimball. (*Journ. Franklin Inst.*, February, 1936, Vol. 221, No. 2, pp. 237–249.) For earlier work *see* 1934 Abstracts, p. 563.

1797. CALCULATION OF GRID DRIVING POWER FOR HIGH-POWER TUBES [New Formula agreeing well with Measurements on Water-Cooled Valves].—M. Shimbori. (*Nippon Elec. Comm. Eng.*, February, 1936, No. 2, p. 158: in English.)

1798. THE USE OF THE 6E5 [Electron-Ray] VALVE FOR CHECKING MODULATION.—C. C. Moore. (*QST*, March, 1936, Vol. 20, p. 33.) For transmitted or received signals.

1799. NEW RECEIVING TUBES [including the 6R7 Metal Duplex-Diode Triode].—(*QST*, March, 1936, Vol. 20, pp. 29 and 70, 72.)

1800. A NEW TUBE FOR USE IN SUPERHETERODYNE FREQUENCY-CONVERSION SYSTEMS [Type 6L7].—Nesslage, Herold and Harris. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 207–218.) *See* 3055 of 1935. For previous references to this valve *see* 1455 of April. The paper includes a discussion of "an unusual phenomenon found at very high frequencies"—the flow of electron current to a negative grid, due to a transit-time effect.

1801. PENTODES AS CLASS AB AMPLIFIERS [in Pentode, not Triode, Connection].—(*QST*, March, 1936, Vol. 20, pp. 29 and 52.)

1802. TUNGSRAM TRANSMITTING VALVE TYPE O-250/2000 [also for Output Valve in Large P.A. Equipment].—(*Wireless Engineer*, March, 1936, Vol. 13, No. 150, p. 134.)

1803. PROGRESS IN TRANSMITTING VALVES.—Gutton, Ponte & others. (*Rev. Gén. de l'Élec.*, 7th March, 1936, Vol. 39, No. 10, pp. 348–350.) Summary of a series in *Bull. de la S.F.R.*

1804. THE ELECTRON-EMISSION IMAGE OF THORIATED TUNGSTEN AND THORIATED MOLYBDENUM. PART I.—FUNDAMENTAL PHENOMENA IN THORIATED TUNGSTEN.—PART II.—INFLUENCE OF CARBURISING PROCESS ON THORIATED TUNGSTEN.—E. Brüche and H. Mahl. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 623–627: No. 3, Vol. 17, 1936, pp. 81–84.)

Single pictures and strips of film of thoriated tungsten, taken with the electron microscope, are given to illustrate the most important phases of electron emission. The various stages of heating, reduction, activation and deactivation are analysed; it is found that the thorium only appears at discrete points, preferably at the edges of grains (not uniformly round the grain, however). After deactivation and reduction the thorium appears at new points; it may wander over the surface. The tungsten structure is more clearly seen when the deactivation is in an advanced state than when the specific emission is highest. The work described in Part II allows a number of conclusions to be drawn as to the effect of the carburising process (which was accomplished by heating the thoriated tungsten in naphthaline vapour). For previous work *see* 1933 Abstracts, p. 111 (Brüche & Johannson—two).

1805. Electron-Optical Investigations on the Incandescent Emission from Nickel in Caesium Vapour.—D. Schenk. (*Zeitschr. f. Physik*, No. 11/12, Vol. 98, 1936, pp. 753–758.)

For previous work on similar subjects *see* 3462 of 1935 ; *also* Brüche & Johannson, 1933 Abstracts, p. 111. Electron-optical images of an incandescent nickel cathode in caesium vapour, taken with a magnetic lens at various temperatures, are here given (Figs. 3, 5). The crystalline structure of the nickel is shown even more clearly than with barium vapour. A maximum of the emission is reached at a temperature of about 700° K ; the separate crystals reach the maximum at slightly different temperatures, so that the relative brightness of two crystals may change sign near this temperature.

1806. The Disintegration of a Monatomic Layer of Thorium on a Tungsten Cathode in a Mercury Discharge.—Morgulis and Bernadiner. (*Tech. Phys. of USSR*, No. 4, Vol. 2, 1935, pp. 333–352 : in English.)

For a preliminary communication *see* 143 of 1935. A detailed account is given of tests with special tubes having an auxiliary filament of pure tungsten in addition to the anode and the thorium-covered tungsten filament. Experimental curves are given showing the relation between the critical energy of the ions (minimum energy required for disintegration of cathode) and factors such as cathode temperature, anode potential, and pressure of vapour. A theoretical interpretation of the results is included.

1807. The Changes in Work Function of Metals at the Melting Point [Theory of].—H. Kurzke. (*Zeitschr. f. Physik*, No. 11/12, Vol. 98, 1936, pp. 684–691.)

1808. The Contact Difference of Potential between Barium and Silver. The External Work Function of Silver [Measurements on Surfaces prepared by Thermal Vapourisation in a Gettered Vacuum].—P. A. Anderson. (*Phys. Review*, 15th Feb. 1936, Series 2, Vol. 49, No. 4, pp. 320–323.)

1809. Adsorption Isotherms. Critical Conditions [Theory of Adsorption Equilibrium States].—R. H. Fowler. (*Proc. Camb. Phil. Soc.*, January, 1936, Vol. 32, Part 1, pp. 144–151.)

1810. The Dissociation Equilibrium of Hydrogen and Its Adsorption on Tungsten [Theory of].—J. K. Roberts. (*Proc. Camb. Phil. Soc.*, January, 1936, Vol. 32, Part 1, pp. 152–157.)

DIRECTIONAL WIRELESS

1811. On the Utilisation of Power in Equi-Signal Radio Beacons [and Comparison of Powers with and without Open Aerials and with Visual and Aural Type Receivers].—N. A. Miasoedov. (*Izvestia Elektroprom. Slab. Toka*, No. 1, 1936, pp. 10–23.)

For previous work on this type of beacon *see* 1082 of 1935. Author's summary :—" The problem of methods of obtaining, from a radio beacon, the greatest range in an equi-signal zone at the given power of its oscillator and at a given angle value of its equi-signal zone, is considered. Conditions for optimum operation of a beacon having an open aerial are determined, and a comparison made between this type of beacon and that having no open aerial. It is proved that with a sufficient sensitivity of the indicator for visual reception, the beacon with an open aerial can procure a given range and accuracy with an oscillator power 14–20 times lower than the aural beacon having no open aerial."

1812. The Distinguishability of Tone Impulses intermeshed and extending Each Other [Tests on Comparative Merits of E–T, A–N and U–D Morse Combinations for Equi-Signal Beacons, etc.].—P. Kotowski. (*Telefunken-Zeit.*, March, 1936, Vol. 17, No. 72, pp. 57–61.) All signal combinations giving, on the centre line, a prolonged dash of constant pitch are about equally good, and are greatly superior to two-tone combinations and to combinations not merging into a long dash.

1813. Radiogoniometric Deviations on Board an Aeroplane [Generalisation of Mesny's Formula for Distorting Field for Ships and Hilltops : Application to Aeroplane Conditions (with More or Less Complex Closed Circuits instead of Conductive Masses) : Practical Conclusions].—E. Fromy. (*L'Onde Élec.*, Feb. and March, 1936, Vol. 15, Nos. 170 and 171, pp. 113–132 and 167–181 : to be continued.)

1814. Some Applications of Wireless to Aeronautics [the " ZZ " Landing Procedure : Equi-Signal Beam : Lorenz Ultra-Short-Wave Beacon].—Portier. (*L'Onde Élec.*, January, 1936, Vol. 15, No. 169, pp. 33–39.)

1815. Blind Flying : Demonstration of the Lorenz Guiding System now in operation at Heston Airport.—(*Electrician*, 28th Feb. 1936, Vol. 116, p. 291.) *Cf.* 178 of January.

1816. The Radio Direction Finder on Board Ship [including Estimates of Accuracy].—F. G. Loring. (*Elec. Communication*, January, 1936, Vol. 14, No. 3, pp. 209–212.)

1817. New Swedish Radio Beacon [for Turkish Government : Rotating Beam Type, with Lower-Note Signal at every Tenth Degree].—(*Scient. American*, March, 1936, Vol. 154, p. 148.)

1818. The [Theoretical] Propagation of Alternating Current in the Earth below an Infinitely Long, Vertical Conducting Loop, Open at One End, in the Air.—H. Buchholz. (*Arch. f. Elektrot.*, 28th Jan. 1936, Vol. 30, No. 1, pp. 1–33.)

This paper continues the solution of the problem of the spreading of alternating current between two electrodes fed by a rectangular conducting loop (Fig. 1 : for the first part of the solution *see* 581 of February). The current system here discussed is shown in Fig. 2b. The vector potentials which define the electromagnetic field are found theoretically and given in §2.4. The form of the induced current field, the voltage field, and the coefficients of induction are calculated and illustrated by curves, including in particular the voltage induced by the given loop in a second infinite loop crossing the first at an arbitrary angle. A mathematical appendix gives details of the calculation of various integrals.

1819. The Electromagnetic Leader Cable: Study of the Radiation and Application to Aeronautics. Part 1: Theoretical Study of the Magnetic Field. Part 2: Experimental Studies and Verifications.—E. Fromy. (*Rev. Gén. de l'Élec.*, 22nd and 29th Feb. 1935, Vol. 39, Nos. 8 and 9, pp. 275–282 and 313–327.) Using Bourgonnier's simplifying method of replacing the currents induced in the ground by a current in a single image cable (1473 of 1935). For practical details the reader is referred to a paper by Larivière in *L'Aéronautique*.

ACOUSTICS AND AUDIO-FREQUENCIES

1820. On the Resistance-Stabilised Feeding-Back Amplifier Systems having a Linear Frequency Characteristic Amplification.—Z. Kamayachi. (*Nippon Elec. Comm. Eng.*, February, 1936, No. 2, pp. 150–154: in English.)

See also 3494 of 1935. "There has been no amplifier whose amplification increases proportionately as the frequency . . . Recently, the resistance-stabilised feeding-back amplifiers have been exceedingly well developed by Professor Y. Watanabe and the author, and then the author found that it is suitable for the linear frequency characteristic amplifier. Although some other systems may be also considered, this system is more practically preferable compared with the others for the reason that it is simply constructed and almost perfectly stabilised. The present paper describes its general principles and then fully discusses its amplification characteristics with special reference to the linearity with respect to frequency. Moreover some of the experimental results are shown."

1821. Retroaction in Audio Amplifiers [to improve Efficiency and Frequency Distortion Characteristics: the Removal of Non-Linear Distortion].—M. Marinesco. (*Wireless Engineer*, March, 1936, Vol. 13, No. 150, pp. 131–134.)

Extension of the work dealt with in 3365 (*see* also 3829) of 1935. By combining both types of retroaction—non-linear for compensating for non-linear distortion and linear for compensating frequency distortion—"we can greatly improve the efficiency and fidelity of such [audio-] amplifiers. This was tried with success in a model exhibited at the 'Exhibition of Roumanian Industries' in Bucharest in September, 1934" [*see* also *Génie Civil*, 7th March, 1936, Vol. 108, p. 240, for demonstration to the Société des Radioélectriciens].

1822. Design of Audio-Frequency Amplifier Circuits using Transformers [with Secondary loaded with Resistance: Formulae and Curves connecting Generator and Load Resistances for Various "Resonance Gains": Resistance/Reactance at Resonance ("Q_0") as "Persistence Constant": etc.].—P. W. Klipsch. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 219–232.)

1823. Johnson Noise [Thermal Agitation Voltage examined with Harmonic Analyser: Series of "Kicks," about 5 per Second, at Each Frequency between 0 and 17 000 c/s: Explanation required].—H. R. Robin. (*Wireless Engineer*, March, 1936, Vol. 13, No. 150, p. 134.) *See* also April issue, p. 200.

1824. Investigations of the Audibility of Transient Phenomena in Electro-acoustic Transmission Systems.—W. Bürck, P. Kotowski and H. Lichte. (*E.N.T.*, January, 1936, Vol. 13, No. 1, pp. 1–12.)

See also 634 of February and 1063 of March. Experiments with resonant circuits are here described; the connection between attenuation and audible transient time-constant is investigated by comparison with tones of exponentially increasing amplitude. Fig. 1 shows the calculated amplitude spectrum of a tone switched in for different lengths of time. Fig. 2 gives the scheme of the apparatus used; it contains a push-pull amplifier whose grid bias can be connected either through a circuit of variable time-constant or directly. Sinusoidal tones can be switched either directly or *via* the transmission unit under investigation. For one resonant circuit, the time-constant (1) determined from the resonance curve, and (2) found experimentally by aural comparison with a circuit of adjustable time-constant, show good agreement. For two or more circuits, the results are shown in Figs. 4–8. Experiments with a continuous frequency band with resonance peaks and hollows and other transmission systems show that, "particularly with loudspeakers, audible distortions of transient phenomena occur, which are not due to phase distortions but chiefly to the frequency curve; other faults in the systems are however more important causes of unsatisfactory performance"; these are (1) subharmonic oscillations of loudspeaker membranes ("son rauque"), and (2) "klirr" factor of amplifiers. Fig. 18 gives the circuit scheme for objective investigation of distortions, with no aural comparison.

1825. The Audibility of Cracks and Notes of Short Duration [Linearity of Aural Reception].—W. Bürck, P. Kotowski and H. Lichte. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 516–519.)

Examples are given which show that the ear behaves as a linear receiver from which, with a frequency curve corresponding to the aural sensitivity and a time-constant corresponding to a lag of about 100 msec., the loudness of acoustic phenomena can be calculated. The results are found to include those of Steudel (1933 Abstracts, p. 510). *See* also 219 of January.

1826. Frequency Spectrum and Tone Recognition.—W. Bürck, P. Kotowski and H. Lichte. (*Ann. der Physik*, Series 5, No. 5, Vol. 25, 1936, pp. 433–449.)

For experimental work on this subject *see* 219 of January and 634 of February. Here an explanation of all the observed phenomena is found in an approximate picture of the ear as a linear system with one frequency decaying aperiodically. The energy distribution in the spectrum (§ 3), the total energy (§ 4) and the energies in various parts of a spectrum (§ 5) are calculated and the results applied to the experimental observations (reproduced in Fig. 1); Fig. 2 gives a comparison of observed and calculated curves for the duration of a tone necessary for its recognition, as a function of frequency. An experimental confirmation of the calculated energy distribution is described in § 7. A very short current pulse (circuit Fig. 3) was passed through a resonance system of adjustable decrement; the decrement was adjusted by various persons until the impulse gave the impression of a definite tone. It was found that on an average a tone was recognised when 70% of the total energy was contained in a frequency range of ±5% of its frequency.

1827. The Effect of Phase-Change on the Cochlea [Interruption of Tone heard: Agreement with Resonance Theory of Audition].—H. Hartridge. (*Proc. Phys. Soc.*, 1st Jan. 1936, Vol. 48, Part 1, No. 264, pp. 145–148: Discussion pp. 148–152.)

1828. Production and Diminution of Noise in the Change of Electrical Energy into Other Forms [Noise from Electrical Machines].—E. Lübcke. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 576–580.)

Examples are given of the production of electromagnetic and acoustic disturbances in the change of electrical into mechanical energy and *vice versa*, and the methods of treatment for the different machines. Fig. 1 shows the acoustic field of d.c. machines, Fig. 2 their noise spectra under various conditions. Figs. 3 and 4 show the spectra of the magnetic noise made by a d.c. machine and an a.c. motor respectively. Fig. 5 illustrates the noise produced by altering the frequency of a d.c. machine. Numerical data for various machines are given (§ 3) and an equation is found for the variation of intensity among the different noise components. Enclosed construction, including absorption plates, is recommended as a means of lessening the noise (§ 4).

1829. Progress in Noise and Vibration Technique [Survey based on Stuttgart Papers of 11th Deutscher Physiker- und Mathematikertag].—E. Meyer. (*Zeitschr. V.D.I.*, 1st Feb. 1936, Vol. 80, pp. 123–126.)

1830. The Production and Measurement of Slow Sinusoidal Variations of Air Pressure [with Application to Properties of the Ear].—G. von Békésy. (*Ann. der Physik*, Series 5, No. 5, Vol. 25, 1936, pp. 413–432.)

For the investigation of the properties of the ear at frequencies below 30 c/s it is important that no overtones should be present. Two methods of producing slow variations of air pressure, free from harmonics, are described. In the first (§ 2, Fig. 1) the variations are produced by an eccentrically driven pump; the harmonics are then eliminated by an acoustic filter consisting of drops of mercury in a narrow tube. This method is useful for large variations. In the second method (§ 3, Fig. 7), two h.f. currents are superposed in the hot filament of a thermophone. This gives strong variations of the air pressure at a frequency equal to the beat frequency of the currents. If the h.f. currents are free from overtones, the low acoustic frequencies will also be pure.

The measurement of the magnitude and phase of the eardrum impedance at low frequencies is carried out by a substitution method (§ 5, Fig. 10) or, more accurately, with an acoustic analogy of a Wheatstone bridge (§ 6, Figs. 11, 12), which also allows oscillograms of non-linear oscillations of the ear-drum to be made (Fig. 13). Its "klirr" factor is generally very small; non-linear distortions in the ear at normal pressures are not due to ear-drum oscillations.

1831. The AEG Magnetic Recorder and Reproducer [using 0.05 mm × 6.5 mm Coated Band moving 1 m/sec.].—(*Zeitschr. V.D.I.*, 29th Feb. 1936, Vol. 80, No. 9, pp. 267–268.)

1832. A Device for Mechanical Sound Recording and the Field for its Application.—A. F. Shurin. (*Izvestia Elektroprom. Slab. Toka*, No. 1, 1936, pp. 32–37.)

An apparatus has been developed in which use is made of old cinematographic films. The sound is electrically amplified and the sound track is cut on the film by means of a ruby or corundum stylus. The apparatus can be instantaneously converted into a sound reproducer.

1833. Flutter in Sound Records [Frequency Modulation by Speed Non-Uniformity during Recording or Reproducing].—Shea, MacNair and Subrizi. (*Bell S. Tech. Journ.*, January, 1936, Vol. 15, No. 1, p. 174: short summary only.)

1834. The Sound Film.—von Lölhöffel. (*Telefunken-Zeit.*, March, 1936, Vol. 17, No. 72, pp. 12–23.) Continued from 3928 of 1935. The present instalment deals chiefly with reproduction.

1835. Some Instruments used in the Recording of Sound on Film [Physical Society's Exhibition Discourse].—R. A. Bull. (*Journ. Scient. Instr.*, February, 1936, Vol. 13, No. 2, pp. 37–46.)

1836. The Production of 16 mm Sound Films [particularly by Reduction from 35 mm Size].—C. A. Mason and G. S. Lucas. (*BT-H Activities*, Nov./Dec. 1935, Vol. 11, No. 6, pp. 177–181.)

1837. Delay Apparatus using Magnetic Recording.—Nagai, Nishimura and Hashimoto. (*Nippon Elec. Comm. Eng.*, February, 1936, No. 2, pp. 143–149: in English.) The full paper, a summary of which was dealt with in 604 of February.

1838. A NEW APPARATUS FOR AMPLITUDE MONITORING IN BROADCASTING AND OTHER ELECTRO-ACOUSTIC INSTALLATIONS [Sound Film and Gramophone Recording].—W. Nestel and H. G. Thilo. (*E.T.Z.*, 20th Feb. 1936, Vol. 57, No. 8, pp. 197–199.)

With a logarithmic scale over 5 nepers (amplitude ratio 1:150): short impulses of 10 msec. indicated with less than a 0.1 neper error: zero-return time about 1.5 sec. The usual "impulse-meter" condenser, with its high-resistance leak, is used; but it is charged not through the comparatively high grid/cathode resistance of a triode but through a double diode. This has a much lower internal resistance, and also gives full-wave rectification (an important point, since in speech and music the positive and negative amplitudes are often different). In the laboratory model the logarithmic scale was obtained by the use of an exponential (variable-mu) valve, but in the practical model this plan is abandoned because the commercial variable-mu valve is turned out with too large tolerances, and a dry-plate rectifier is used instead, as a potential divider composed of a constant component and a component varying logarithmically with the amplitude. A m.c. pointer instrument with a specially light moving system and a specially strong magnetic field is embodied in the instrument, but this can be supplemented by a relay and alarm bell, a recording instrument, or by the special auxiliary shown in Fig. 6, in which a sharp light spot moves over a ground-glass scale.

1839. NOTES ON THE DESIGN OF ATTENUATING NETWORKS: Part II.—W. G. Baker. (*A.W.A. Tech. Review*, January, 1936, Vol. 2, No. 1, pp. 42–44.) For Part I *see* 608 of February.

1840. THE "FADER" [and Its Design Calculation: Data for an Attenuator with a Maximum of 75 db, in Equal 3 db Steps].—J. Paillet. (*L'Onde Élec.*, March, 1936, Vol. 15, No. 171, pp. 182–186.)

1841. THE CONTROL OF TRANSIENT PHENOMENA IN BROADCAST TRANSMISSIONS.—Divoire. (*See* 1899.)

1842. ACOUSTIC "SCENERY" IN RADIO DRAMA [Variable-Reverberation Studios, etc., in Broadcasting House, Berlin].—H. J. von Braunmühl. (*Wireless World*, 13th March, 1936, Vol. 38, pp. 256–257.)

1843. SOUND TRANSMISSION THROUGH SINGLE WALLS AND THE INFLUENCE OF THE MATERIAL [Not Weight only, but also Bending Stiffness and Impenetrability to Air: etc.].—E. Lübcke. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 17, 1936, pp. 54–57.)

1844. A NEW DIRECT-READING METER FOR MUSICAL FREQUENCIES [using Thyratron Impulses].—Hunt. (*L'Onde Élec.*, January, 1936, Vol. 15, No. 169, pp. 2–3 D.) *See* also 1566 of 1935.

1845. TENTATIVE STANDARDS FOR SOUND LEVEL METERS.—R. G. McCurdy. (*Elec. Engineering*, March, 1936, Vol. 55, No. 3, pp. 260–263.)

1846. THE ACOUSTICAL WORK OF THE NATIONAL PHYSICAL LABORATORY.—G. W. C. Kaye. (*Journ. Acous. Soc. Am.*, January, 1936, Vol. 7, No. 3, pp. 167–177.)

1847. THE CALIBRATION OF MICROPHONES.—American Standards Association. (*Elec. Engineering*, March, 1936, Vol. 55, No. 3, pp. 241–245.)

1848. SOME TECHNICAL DATA ON THE GAUTRAT (NEUMANN LICENCE) CONDENSER MICROPHONE.—(*L'Onde Élec.*, January, 1936, Vol. 15, No. 169, pp. 1–2 D.)

1849. SOUND DISTRIBUTION IN P.A. WORK [Considerations affecting Placing of Loudspeakers].—P. G. A. H. Voigt. (*Wireless World*, 20th March, 1936, Vol. 38, pp. 293–295.)

1850. THE IMPORTANCE OF MATCHING IN P.A. EQUIPMENT.—N. Partridge. (*Wireless World*, 20th March, 1936, Vol. 38, pp. 288–290.)

1851. WIRELESS WORLD P.A. AMPLIFIER: THE "PUSH-PULL QUALITY AMPLIFIER" MODIFIED FOR LARGE OUTPUT [12 Watts].—W. T. Cocking. (*Wireless World*, 20th March, 1936, Vol. 38, p. 283.) *See* 1934 Abstracts, p. 445, for the original 4-watt amplifier.

1852. TELEPHONE INSTRUMENTS WITH AMPLIFIERS [contained in Usual Case].—M. I. Vitenberg. (*Izvestia Elektroprom. Slab. Toka*, No. 1, 1936, pp. 27–31.)

1853. PROPAGATION AND RESONANCE OF LONGITUDINAL WAVES IN PRISMATIC RODS [Theory predicts, and Experiment confirms, Large Number of Frequencies, belonging to Different Series, in Range above One of Lateral Resonance Frequencies].—R. Ruedy. (*Canadian Journ. of Res.*, February, 1936, Vol. 14, No. 2, Sec. A, pp. 48–55.)

1854. ON TRANSVERSE VIBRATIONS OF LONG RODS [Theory and Experiments: Relation between Frequency, Size and Elastic Properties].—I. A. Balinkin. (*Phil. Mag.*, February, 1936, Series 7, Vol. 21, No. 139, pp. 283–290.)

1855. THE VACUUM TUBE OSCILLATOR FOR MEMBRANES AND PLATES [Chladni Figures up to around 50 kc/s].—R. S. Colwell. (*Journ. Acous. Soc. Am.*, January, 1936, Vol. 7, No. 3, pp. 228–230.) *Cf.* 224 of January and 785 of 1935.

1856. METHOD OF STRIKING PIANO KEY HAS NO EFFECT ON TONE.—Weyl. (*Sci. News Letter*, 8th Feb. 1936, Vol. 29, p. 86.) But *cf.* Ferrari, 1061 of March.

1857. THE CONDUCTIVITY OF AN ORIFICE IN THE END OF A PIPE [Measurements agree with Theoretical Formula].—A. E. Bate. (*Proc. Phys. Soc.*, 1st Jan. 1936, Vol. 48, Part 1, No. 264, pp. 100–101.)

1858. Standing Sound Waves in the Boehm Flute measured by the Hot-Wire Probe.—R. W. Young and D. H. Loughridge. (*Journ. Acous. Soc. Am.*, January, 1936, Vol. 7, No. 3, pp. 178–189.)

1859. Essential Properties of Musical Tones [Interdependence of Frequency, Amplitude, and Harmonic Spectrum].—O. Vierling. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 528–533.)

An investigation of the interdependence of frequency, amplitude and harmonic spectrum of musical instruments, and their variation with time. The variation of attenuation with amplitude is studied in § 1 ; the two decrease together in stringed instruments (Figs. 1–4). The number of overtones present increases with the amplitude (§ 2) in all instruments. An oscillograph taking 7 simultaneous records (Fig. 5, scheme Fig. 6) was used to obtain oscillograms of the tone as a whole and of various audio-frequency ranges filtered out from it ; Figs. 8–13 show examples of the oscillograms. These illustrate the beginning and ending of notes on various instruments, particularly the flute (Figs. 11, 12), which shows how a vibrating air column can easily change from one frequency to another.

1860. Determination of the Working Coefficients of a Spark, regarded as a Source of Sound.—W. G. Abesgaus. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 5, 1935, pp. 975–983.)

1861. On the Sound Field of a Rotating Propeller.—L. Gutin. (*Physik. Zeitschr. der Sowjetunion*, No. 1, Vol. 9, 1936, pp. 57–71 : in German.)

1862. On the Theory of the Horn Receiver [Treatment yielding Amplification Coefficients of Parabolic, Conical and Exponential Horns used as Sound Receivers : Their Variation with Frequency : Comparison with Experimental Data].—L. Gutin. (*Tech. Phys. of USSR*, No. 1, Vol. 3, 1936, pp. 81–98 : in French.) For corrections *see* errata slip at end.

1863. The Application of Radio Technique to the Acoustic Aircraft Altimeter [Dubois-Laboureur System].—van Steenbergen. (*Radio-Centrum*, 24th and 31st Jan. 1936, Vol. 2, pp. 45–46 and 62–63 : in Dutch.)

1864. The Reaction of a Surrounding Liquid on the Oscillations of a Quartz Plate [with Application to Production of Supersonic Waves].—Becker. (*See* 1892.)

PHOTOTELEGRAPHY AND TELEVISION

1865. The Reception of 8 Metre Waves from the Eiffel Tower Television Transmitter [Request for Reports].—(*L'Onde Élec.*, March, 1936, Vol. 15, No. 171, p. 141.)

1866. Some New Experiments with Electron-Ray Film Scanning for High Line and Framing Numbers.—M. von Ardenne. (*Funktech. Monatshefte*, February, 1936, No. 2, Supp. pp. 9–13.)

The writer considers that in spite of the great promise of the new methods of Zworykin and Farnsworth, his own original fluorescent-spot scanning method maintains its importance, at any rate when it is a question of films and not of open scenes. In early days the great difficulty lay in the lag of the fluorescent screen, which prevented the use of higher definition than that corresponding to a waveband of about 2×10^5 c/s. The discovery of the materials discussed in his paper (1947 of 1935) made it worth while to take up again the development of his method (*see* also Schnabel, 1503 of April) and the present paper describes the preliminary calculations of such a film scanner as regards the dimensions of the screen raster necessary to give the required resolution for the smallest practically dependable spot diameter (0.3 mm) : the intensity of the light ultimately reaching the photocell, and its degree of modulation for 100% modulation of the electron energy, for various typical screen materials : the optical properties of the lens concentrating the fluorescent light on to the film : and the background noise, chiefly due to the thermal agitation in the photocell coupling resistance : etc. The last part of the paper describes the experimental equipment developed by the writer (in conjunction with the Lorenz Company) for frequencies up to 2×10^6 c/s, and some results obtained with it. With a cell of sensitivity 10×10^{-6} A/lumen a photo-current of about 3×10^{-7} A was obtained at the clearest parts of the film : with the input resistances employed, this was sufficient to produce voltage drops large compared with the noise level of 4×10^{-4} v.

1867. Need for High Amplification, for Satisfactory Modulation of Transmitter by Cathode-Ray Image Dissection, supplied by the "Multipactor."—P. T. Farnsworth. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 149–150 : summary only.)

For the early electron-multiplier *see* 207 and 208 of 1935 : also 140 of January. "Another type, consisting of a cylindrical cathode and a grid-type anode capable of oscillation, was analysed and produced efficiencies of conversion from d.c. power to oscillatory current power close to 100%". *See* also *ibid.*, p. 154.

1868. The Comparative Performance of Gas-Focused and Electron-Lens-Focused Oscillographs at Very High Frequencies—Piggott. (*See* 1920.)

1869. Methods, Results and Prospects of the Electrostatic Recording Process (Electrography).—P. Selényi. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 607–614.)

See also 3983 of 1935. § 1. Deviated-ray method (including the various known types of cathode-ray recording). § 2. Free-air recording (in which the apparatus is not enclosed in glass) with a short beam of ions (Figs. 7, 8), which may be of constant intensity or controlled by a grid. § 3. Recording process. § 4. Developing process (in which the electric figure produced on the screen is rendered visible by dusting the screen with a fine electrified powder). § 5. Recording with an ionic beam with a slit-shaped cross-section (*i.e.* a short line, not a point) § 6. Energy considerations, recording velocity and inertia (numerical performance data). § 7. Applications: time-marking, picture telegraphy, duplicating apparatus, television; in the latter it is suggested that electrography may replace photography in the intermediate-film receiving apparatus. Experiments with Lenard rays mentioned in § 1 seem, however, to be of more practical promise in this connection.

1870. FLUORESCENT SCREENS FOR CATHODE-RAY TUBES FOR TELEVISION AND OTHER PURPOSES.—L. Levy and D. W. West. (*Electrician*, 6th March, 1936, Vol. 116, p. 317.) Summary of I.E.E. paper.

1871. THE TELEVISION RECEIVER OF THE C.H.F. MÜLLER COMPANY [and the Question of the Best Colour of Fluorescence for Rooms which are Not Darkened].—(*Funktech. Monatshefte*, February, 1936, No. 2, Supp. pp. 15–16.)

1872. THE CAUSES OF THE DIFFERENT SHARPNESS OF SIGHT OF THE HUMAN EYE FOR WHITE AND COLOURED LIGHT.—H. Schober and H. Jung. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 17, 1936, pp. 84–93.)

1873. THE GERMAN TELEVISION-TELEPHONE [180-Line Two-Way Coaxial-Cable Service Berlin/Leipzig].—(*World-Radio*, 6th March, 1936, Vol. 22, p. 9.) Note on the service inaugurated on 1st March.

1874. A METHOD FOR THE CALCULATION OF TOLERANCE FIGURES FOR LINEAR (FREQUENCY) DISTORTION IN TELEVISION.—N. D. Smirnov. (*Izvestia Elektroprom. Slab. Toka*, No. 1, 1936, pp. 23–26.)

While the frequency response of non-compensated television amplifiers usually falls off at the upper and lower frequencies, the compensation introduced to correct the phase shift, etc., may result in an undesired boost of these frequencies. In this paper reception is considered of a rectangle consisting of a number of black and white strips of various widths, and formulae are derived determining the maximum permissible deviation of the frequency characteristic from the zero level. The formulae are based on the minimum difference in brightness perceptible to the eye, and the cases of low and high frequencies are treated separately. It appears that the tolerance figures depend on the depth of modulation and on the properties of the modulator. As an illustration, typical figures are calculated for various types of modulator. For a similar treatment of phase distortion *see* 1080 of March.

1875. THE MEASUREMENT OF LUMINOUS EFFICIENCY FROM A MERCURY DISCHARGE AT HIGH PRESSURE.—Klarfeld and Plokhotsky. (*Tech. Phys. of USSR*, No. 4, Vol. 2, 1935, pp. 353–356: in English.) *See* 497 of 1935.

1876. THE ELECTRO-OPTICAL EFFECT IN ZINC BLENDE [Measurements of Electro- and Piezo-Optical Constants: Comparison of ZnS-Cell with Nitrobenzol Cell].—C. Schramm. (*Ann. der Physik*, Series 5, No. 4, Vol. 25, 1936, pp. 309–336.)

See also von Okolicsanyi, 1933 Abstracts, p. 630. The theory of the electro-optical effect is shortly reviewed (§ 2); the usual optical methods of measurement were used (§ 3). Artificial double refraction and inhomogeneity in the crystals were found to be due to the preparation of the crystal (polishing, etc.); they may be eliminated by warming the crystal (§ 4.1). The best conditions for this are described. Measurements of the electro-optical effect are tabulated (§ 4.2); X-ray photographs are reproduced (§ 4.4; Figs. 6–11) to illustrate various types of distortion. Measured values of the piezo-optical constants are given in § 6; it is found that the electrical field exerts a direct influence on the passage of light through the crystal. In § 7 a ZnS-cell is compared with a nitrobenzol cell; the former needs a voltage three times smaller than that required by the latter. Data of apertures and capacities are given.

1877. THE CONTACT DIFFERENCE OF POTENTIAL BETWEEN BARIUM AND SILVER. THE EXTERNAL WORK FUNCTION OF SILVER [Measurements on Surfaces prepared by Thermal Vapourisation in a Gettered Vacuum].—P. A. Anderson. (*Phys. Review*, 15th Feb. 1936, Series 2, Vol. 49, No. 4, pp. 320–323.)

1878. ON SECONDARY EMISSION FROM CAESIUM [and the "Photo-Dynatron Cell].—P. V. Shmakov. (*Journ. of Television Soc.*, December, 1935, Vol. 2, Part 3, pp. 68–74.)

An account of experiments with photocells consisting essentially of a vacuum tube having two caesium-coated cathodes K and K_1 and a common metal mesh anode A situated between them. The anode is E_b volts positive with respect to K, and E_2 volts positive with respect to K_1. When light acts on K, the electrons liberated are attracted to A, and passing through the meshes strike K_1, liberating secondary electrons. These, together with the reflected primary electrons, are attracted to A and constitute the secondary emission current. A number of curves are given showing the relation between this secondary current and E_b, E_2, the geometry of the cell, etc. and it is pointed out that this type of cell, called by the author the "photo-dynatron," presents certain advantages over the more usual type.

1879. A PHOTO-MAGNETRON AND ITS APPLICATION TO THE MEASUREMENT OF TWILIGHT ILLUMINATION.—A. Dauvillier. (*Comptes Rendus*, 2nd March, 1936, Vol. 202, No. 9, pp. 738–740.)

A magnetic modulation is impressed on a photoelectric cell by two Helmholtz coils wound round it and carrying an alternating current. This replaces the usual mechanical modulation. Certain necessary precautions are described. The arrangement of the electrodes differs from that of the ordinary magnetron. "The apparatus should be applicable . . . . to electrical picture transmission."

1880. EFFECT OF TEMPERATURE ON THE PHOTOELECTRIC EFFECT AT A METAL/CUPROUS-OXIDE CONTACT.—J. Roulleau. (*Comptes Rendus*, 2nd March, 1936, Vol. 202, No. 9, pp. 749–751.)

The writer has studied the variation with temperature of the connection between the contact resistance and the photo-potential (1528 of March). The characteristic curves are found to move, as the temperature rises, in the direction of increasing photo-potential; their gradient remains constant for a given value of contact resistance. Apparent anomalies observed by Lange (Abstracts, 1931, p. 104) and Schottky (1932, p. 232) are thus explicable.

1881. ON THE LAWS GOVERNING THE BEHAVIOUR OF "RESISTANCE" [Internal Photoeffect] PHOTOELECTRIC CELLS, AND SOME QUANTITIES DEFINING THEIR PROPERTIES.—O. P. Fuchs and H. Kottas. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 17, 1936, pp. 47–54.)

Authors' summary:—(1) The laws of Barnard and Fournier d'Albe were tested and it was found that the former must be regarded as only partly valid and the latter as quite invalid. (2) The current/voltage relation found for semi-conductors (4075 of 1935) was checked against a large number of very different cells and repeatedly confirmed, at the least within wide limits [$i = i_1 . V^a$. where i_1 and a are constants of the cell, i the cell current and V the voltage on the cell: physically, i_1 represents the ohmic resistance of the cell for unity voltage]. The consequent discrepancies between the working conditions and short-circuit measurements were obtained mathematically and graphically. (3) The electrical modulation values obtainable for given light-flux modulations are given. For the purpose of easy estimation of the properties of a cell, certain quantities are defined [*see* table on p. 52] (4) Finally, the effects of inertia phenomena on the modulation values actually obtainable are pointed out and some inertia oscillograms shown.

1882. THE ALL-UNION CONFERENCE ON SOLID RECTIFIERS AND PHOTOCELLS [including the Successful Use of Selenium Photocells for Sound Films: E.M.Fs up to 0.1 Volt by X-Ray Excitation of Selenium: etc.].—(*Tech. Phys. of USSR*, No. 5, Vol. 2, 1935, pp. 502–504: in English.)

1883. ON THE INFLUENCE OF THE BASE MATERIAL ON THE PHOTOELECTRIC EMISSION OF A METAL AT THE CONTACT WITH A DIELECTRIC.—G. Liandrat: Groschew. (*Rev. Gén. de l'Élec.*, 29th Feb. 1936, Vol. 39, No. 9, p. 328.) Summary and criticism of Groschew's paper (3579 of 1935).

1884. THE CONNECTION BETWEEN ILLUMINATION AND CURRENT INTENSITY IN BARRIER-LAYER PHOTOCELLS.—E. Elvegård. (*Physik. Zeitschr.*, 15th Feb. 1936, Vol. 37, No. 4, pp. 129–133.)

Measurements of the illumination and resulting photo-current intensities with various barrier-layer cells and external resistances are shown in Fig. 2. The results lead to an equation (eqn. 3, alternative form eqn. 4) between these quantities which enables illumination intensities to be measured exactly. Tests of the equation are described; the work of other writers is discussed (von Auwers & Kerschbaum, Abstracts, 1931, p. 103: Goldmann & Lukasiewitsch, 1933, pp. 220–221: *also* Goldmann, p. 221) and compared with the present results.

1885. ON THE EFFECT OF PLASTIC DEFORMATION ON THE INTERNAL PHOTOEFFECT IN SILVER CHLORIDE SINGLE CRYSTALS.—E. A. Kirilow and A. M. Polonsky. (*Physik. Zeitschr. der Sowjetunion*, No. 1, Vol. 9, 1936, pp. 100–101: in German.)

1886. ON THE EFFECT OF ADDITIONAL LIGHT ON THE CRYSTAL PHOTOEFFECT IN CUPROUS OXIDE [New Phenomenon].—N. O. Barbaumov and R. G. Jensch. (*Physik. Zeitschr. der Sowjetunion*, No. 1, Vol. 9, 1936, pp. 94–96: in German.)

Photoeffect produced by simultaneous action of different wavelengths is sometimes much greater than sum of individual photoeffects; as found for other types of photoeffect, *e.g.* Lapique (Abstracts, 1933, p. 454) and Marx (1930, p. 460).

1887. A SUGGESTION FOR THE PHOTOMETRY OF LIGHT SOURCES OF DIFFERENT COLOURS [Transformation of Frequencies to the Same Colour].—M. Pirani and R. Rompe. (*Naturwiss.*, 28th Feb. 1936, Vol. 24, No. 9, p. 142.)

The suggestion is to transform the frequency of the light sources so that the colours to be compared are the same. Phosphorescent materials or fluorescent liquids might be used, or the "frequency transformer" of Holst and his colleagues (1934 Abstracts, p. 331). The method becomes particularly simple when the concentration of a fluorescent liquid is so great that the whole of the spectral region in question is absorbed in a very short distance. The intensity of the fluorescence is then directly proportional to the number of incident quanta. Examples of measurements are given and sources of error discussed.

MEASUREMENTS AND STANDARDS

1888. A WAVEMETER FOR DECIMETRE WAVES.—L. Rohde. (*E.N.T.*, January, 1936, Vol. 13, No. 1, pp. 13–16.)

A simple absorption wavemeter for wavelengths of 30 to 500 cm is shown in Fig. 1, with circuit in Fig. 2. Several coils are required to cover the whole range; dimensions and numerical data are given in Table 1. An expression is found for the attenuation in terms of the various circuit elements and the frequency. The resonance point may be found by measuring the voltages in the circuit by means of a compensated diode. For this a special, very small valve has been designed (Fig. 4: *see* 1931 Abstracts, p. 616). Fig. 3a shows the circuit for use with a galvanometer and voltages above 0.1 v. Fig. 3b gives the circuit for use when greater sensitivity (down to 0.005 v) is needed or a milliammeter is to be employed. Fig. 4 shows an apparatus for 30–200 cm in which the inductance can be changed by winding or unwinding a copper band; the capacity of the condenser is varied in the usual way. For a larger range the condenser may be kept constant and the inductance varied by moving along a spiral (circuit Fig. 5, apparatus Fig. 6). New ranges are obtained by adding condensers. The wavemeter may be calibrated by a Lecher system or an interference method. A special coupling is required when the frequency of a weak oscillator is to be measured.

1889. A Null Method of Frequency Measurement [100–10 000 c/s].—K. Karandeev. (*Tech. Phys. of USSR*, No. 1, Vol. 3, 1936, pp. 51–64.) German version of the Russian paper dealt with in 1568 of 1935.

1890. Wedge-Shaped Piezoelectric Resonators [Note on the Series of Discrete Natural Vibrations of Every Finite Bounded Continuum, including Broadcasting Studios].—K. W. Wagner. (*Hochf:tech. u. Elek:akus.*, January, 1936, Vol. 47, No. 1, p. 28.) *See* 680 of February.

1891. Quartz Oscillators [Survey].—Bechmann. (*See* 1741.)

1892. The Reaction of a Surrounding Liquid on the Oscillations of a Quartz Plate [with Application to Production of Supersonic Waves: only One Resonance in Quartz Plate: Anharmonic Oscillation].—H. E. R. Becker. (*Ann. der Physik*, Series 5, No. 4, Vol. 25, 1936, pp. 359–372.)

Experiments are described in which a quartz plate immersed in a liquid was excited to high-frequency transverse oscillations. The resonance curves obtained (Fig. 5) show that the resonance frequency is relatively higher than that of the natural oscillation in air; the curves are also slightly asymmetrical. The movement of the quartz may therefore be regarded as an anharmonic oscillation. This is investigated theoretically and confirmed by further experiments in various liquids with progressive and stationary waves; an interferometer for the latter is described.

1893. Latest Results with Quartz Clocks.—Pavel and Uhink: Scheibe. (*E.T.Z.*, 19th March, 1936, Vol. 57, No. 12, p. 342: summaries only.)

1894. Propagation and Resonance of Longitudinal Waves in Prismatic Rods, *and* On Transverse Vibrations of Long Rods.—Ruedy: Balinkin. (*See* 1853 and 1854.)

1895. Improvements in the Photoelectromagnetic Drive of Precision Clocks [3-Photocell Arrangement with Driving Coil on Either Side of Pendulum].—O. Schmücking. (*E.T.Z.*, 6th Feb. 1936, Vol. 57, No. 6, pp. 155–156: summary only.)

1896. Remark on the Subject of Empirical Formulae for the Calculation of the Inductance of Air-Cored Cylindrical Coils.—J. Hak. (*Rev. Gén. de l'Élec.*, 7th March, 1936, Vol. 39, No. 10, pp. 346–348.)

Several empirical formulae and their curves of error are discussed: Fig. 2 shows that for a (aerial-length/mean-diameter) > 7.9 the exact formula due to Emde, but limited to two terms, is preferable to the empirical formulae. Two simple methods are given for the approximate calculation of the inductance of practical coils in which the thickness of the winding is not negligible.

1897. A Method for Determining the Residual Inductance and Resistance of a Variable Air Condenser at Radio Frequencies [responsible for Variation in Effective Capacitance and Power Factor with Frequency: Substitution Method and Typical Results].—R. F. Field and D. B. Sinclair. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 255–273.) The error in effective capacitance caused by inductance may reach 10% at 6 Mc/s for a setting of 1 100 $\mu\mu$F; the metallic losses may exceed the dielectric losses even at 1 Mc/s, making the assumption of constant input conductance seriously in error.

1898. Voltage Measurements at Very High Frequencies—II [Experimental Investigation of Peak Voltmeter with Special Diode].—E. C. S. Megaw. (*Wireless Engineer*, March, 1936, Vol. 13, No. 150, pp. 135–146).

For Part I (theoretical) *see* 1546 of April. Investigation of inertia error shows that accurate measurements can be made down to about 100 v at 100 Mc/s; using an empirical correction curve, approximate measurements can be made to about 10 v at 1000 Mc/s, but at this frequency the difficulties due to connecting-lead impedance are serious.

1899. The [Measurement and] Control of Transient Phenomena in Broadcast Transmissions [Quick-Acting Galvanometers *versus* Peak Voltmeters: a New Apparatus combining Advantages of Both].—E. Divoire. (*L'Onde Élec.*, January, 1936, Vol. 15, No. 169, pp. 40–58.)

The new peak voltmeter has a sufficiently short integrating time and a smaller zero-return time than the usual peak meter, and gives a correct representation of transient phenomena. A Muirhead recording oscillograph, with the inertia of its moving parts reduced, is used in conjunction with a special circuit in which the grid of the amplifier valve polarises in the positive sense during discharge; this considerably speeds up the latter process and improves the discharge curve (Fig. 7). In this way, according to the resistance used, an integrating time of 1 msec. and a pointer-return time of 1 second, or an integrating time of 10 msec. and a return time of 0.5 second, can be obtained. Tests to ascertain how short an integrating time was actually required led to the conclusion that in practice this time may well exceed 1 msec., so that the return can be made quick and the records can give a good representation of contrast. Thus in Fig. 9 the 1st adjustment, with 10 msec. integrating time, does not miss the peak measured by adjustment 3 (below 1 msec.) and yet records the troughs as effectively as the mean-impulse modulometer in the top curve. Some results obtained with the apparatus are discussed, together with their practical application to broadcast control.

1900. The Modulated Oscillator [a Necessity for Servicing Test Equipment : Comparison of Performances of Various Types : Attenuator Systems : etc.].—L. G. Dobbie. (*A.W.A. Tech. Review* [*see* 512 of February], January, 1936, Vol. 2, No. 1, pp. 39–41.)

1901. A [Triode-Circuit] Comparator for the Testing of Current Transformers [by the Differential Method].—F. Neri. (*L'Elettrotec.*, 10th Jan. 1936, Vol. 23, No. 1, pp. 2–6.)

1902. A Method of Determining the Operating Characteristics of a Power Oscillator [by 60 c/s Measurements].—Chaffee and Kimball. (*See* 1796.)

1903. Demodulation of Radio Broadcast Signals for Use as Sources of Electric Currents of High and Constant Frequency [for Precision Measurements of Dielectric Constants, etc.].—L. G. Hector and H. L. Schultz. (*Review Scient. Instr.*, March, 1936, Vol. 7, No. 3, pp. 139–143.)

1904. Dielectric Constants of Electrolytic Solutions [Variation with Concentration and Frequency : Comparison with Debye-Falkenhagen Theory].—G. Fischer and W. D. Schaffeld. (*Ann. der Physik*, Series 5, No. 5, Vol. 25, 1936, pp. 450–466.) For previous work *see* Orthmann, 1932 Abstracts, p. 112.

1905. Some Achievements in Modern Measuring Technique [including Dielectric, Magnetic, and Time and Frequency Measurement].—G. Keinath. (*E.T.Z.*, 23rd Jan. 1936, Vol. 57, No. 4, pp. 81–94.)

1906. The High- and Low-Frequency Conductivity of Electrolytic Solutions in Glycerine and Mixtures of Glycerine and Water.—J. Hiegemann. (*Ann. der Physik*, Series 5, No. 4, Vol. 25, 1936, pp. 337–358.)

1907. Electrometers [Survey : Pendulum, String, Quadrant, Duant, Capillary and Recording Types].—A. Palm. (*E.T.Z.*, 6th Feb. 1936, Vol. 57, No. 6, p. 156 : summary only.)

1908. The Limit of the Sensitivity to Charge in the Valve Electrometer. I.—Alfvén. (*See* 1791.)

1909. Portable Pointer Galvanometer and Multi-Range Millivoltmeter [with Double-Strung Strip Suspension—No Pivots or Control Springs].—Tinsley. (*Journ. Scient. Instr.*, March, 1936, Vol. 13, No. 3, pp. 100–101.)

1910. Magnetic Contamination of Galvanometer Coils [causing Zero Shift].—A. Christy. (*Review Scient. Instr.*, February, 1936, Vol. 7, No. 2, pp. 93–96.)

1911. Modern Tendencies in Zero Indicators.—A. Lucchini. (*L'Elettrotec.*, 10th Jan. 1936, Vol. 23, No. 1, pp. 6–10.)

1912. Electrical Units : Intended Substitution of the Practical Absolute System for the Existing International System.—(*Wireless Engineer*, February, 1936, Vol. 13, No. 149, p. 86.)

1913. The M.K.S. System of Units, *and* The M.K.S. System of Electrical Units.—A. E. Kennelly : R. Glazebrook. (*Journ. I.E.E.*, February, 1936, Vol. 78, No. 470, pp. 235–244 : 245–247.)

SUBSIDIARY APPARATUS AND MATERIALS

1914. The Momentarily Acting Cathode-Ray Oscillograph [and Its Advantages : Transportable Type with Sensitivity 10–15 V/mm, 100 km/s Recording Speed : Two-Ray Type (Single Ray split by Anode Screen) giving Good Simultaneous Contact Records at 1 Mc/s : etc.].—Stekolnikov and Slaschev. (*Tech. Phys. of USSR*, No. 6, Vol. 2, 1935, pp. 507–521 : in German.) Part of this work, in Russian, was dealt with in 708 of February.

1915. A High-Vacuum Cathode-Ray Oscillograph [for Extremely Wide Range of Frequencies : with High-Vacuum (Balanced) Time Base up to 300 kc/s or for Single Stroke : Phase-Reversing Valve : Safety Device : etc.].—Puckle. (*Journ. Scient. Instr.*, March, 1936, Vol. 13, No. 3, pp. 78–82.) Capable of showing individual cycles up to about 5 Mc/s.

1916. Thyratron Selector for Double-Trace Cathode-Ray Oscillograph [Thyratron/Neon-Diode Combination giving Square Wave alternately biasing, to Cut-Off, the Control Grids of Two Type 57 Pentodes, each Suppressor-Modulated by One Curve].—Hughes. (*Review Scient. Instr.*, February, 1936, Vol. 7, No. 2, pp. 89–92). The type 57 valve is "characterised by an extremely sharp cut-off." The circuit is stable and also has a voltage-gain of about 30 db between 60 and 11 000 c/s.

1917. Cathode-Ray Oscillograph with Transient and Two-Element Devices [using Ordinary Tube : Simultaneous Observation of Two Wave Forms up to 1 Mc/s].—Kurokawa and Tanaka. (*Nippon Elec. Comm. Eng.*, February, 1936, No. 2, pp. 132–143 : in English.)

1918. A High-Speed Simultaneous Recording System for Two Cathode-Ray Oscillographs [Bromide Paper Speeds up to 30 ft/s, giving Satisfactory Images with Voltages not exceeding 800 Volts].—Hall-Pike. (*Journ. Scient. Instr.*, March, 1936, Vol. 13, No. 3, pp. 92–95.)

1919. An Improved Cathode-Ray Relay Tube with Positive Auxiliary Electrode in front of Relaying Anode to prevent Disturbing Action of Latter on Ray.—Philips Company. (French Pat. 790 054, pub. 12.11.35 : *Rev. Gén. de l'Élec.*, 29th Feb. 1936, Vol. 39, No. 9, p. 70 D.)

1920. THE COMPARATIVE PERFORMANCE OF GAS-FOCUSED AND ELECTRON-LENS-FOCUSED OSCILLOGRAPHS AT VERY HIGH FREQUENCIES.—Piggott. (*Electrician*, 6th March, 1936, Vol. 116, pp. 316–317.) Summary of I.E.E. paper. *See* also 1921.

1921. THE UTILISATION OF THE HOLLMANN PHASE EFFECT, IN CATHODE-RAY OSCILLOGRAPHY AT VERY HIGH FREQUENCIES, TO PROVIDE TIME-BASE.—Piggott. (*See* 1920.)

1922. FLUORESCENT SCREENS FOR CATHODE-RAY TUBES FOR TELEVISION AND OTHER PURPOSES.—L. Levy and D. W. West. (*Electrician*, 6th March, 1936, Vol. 116, p. 317.) Summary of I.E.E. paper.

1923. THEORIES OF PHOSPHORESCENCE [A Few Facts and Complementary Remarks].—Curie. (*Comptes Rendus*, 2nd March, 1936, Vol. 202, No. 9, pp. 751–753.) *See* also 3209 of 1935.

1924. REMARKS ON THE FLUORESCENCE OF SODIUM SALICYLATE.—G. Déjardin and L. Herman. (*Comptes Rendus*, 24th Feb. 1936, Vol. 202, No. 8, pp. 651–654.)

1925. CONTRIBUTION TO THE STUDY OF THE FLUORESCENCE OF SOLUTIONS [and the Perrin "Fluorescing Power" and the Factors influencing It].—J. Bouchard. (*Rev. Gén. de l'Élec.*, 18th Jan. 1936, Vol. 39, No. 3, p. 102: summary of Paris Thesis.)

1926. THE FOCUSING OF CATHODE RAYS IN AN IONIC X-RAY TUBE [including a Device allowing Coaxial Focusing Cylinder to be Adjusted].—Danilow. (*Tech. Phys. of USSR*, No. 5, Vol. 2, 1935, pp. 444–448: in English.)

1927. RESEARCH APPLICATIONS OF COLLOIDAL GRAPHITE.—Porter. (*Review Scient. Instr.*, February, 1936, Vol. 7, No. 2, pp. 101–106.)

1928. SPECTRAL EMISSION, RESISTIVITY AND THERMAL EXPANSION OF TUNGSTEN-MOLYBDENUM ALLOYS.—Bossart. (*Physics*, February, 1936, Vol. 7, No. 2, pp. 50–54.)

1929. A SIMPLE STRAIN-ANALYSER FOR GLASS SEALS.—Hull and Burger. (*Review Scient. Instr.*, February, 1936, Vol. 7, No. 2, pp. 98–100.)

1930. A NEW TRIGGER CIRCUIT FOR CLOSING A SWITCH [at Predetermined Point on the Waveform of an A.C. Source: for Study of Transients].—Ruiz. (*Elec. Engineering*, December, 1935, Vol. 54, No. 12, pp. 1405–1407.) The switch or relay is controlled by a gas-filled triode, the firing of which is obtained by the distorted wave of a multivibrator. The phase relation between the multivibrator output and the a.c. voltage wave can be varied as desired.

1931. LENGTHENING THE LIFE OF HOT-CATHODE MERCURY-VAPOUR RECTIFIER TUBES [Metal Screen: Proper Adjustment of Phase between Heating and Anode Currents: Average Life will be Doubled].—Toki and Kano. (*Nippon Elec. Comm. Eng.*, February, 1936, No. 2, pp. 166–167: in English.)

1932. THE ANODE SUPPLY IN LARGE BROADCASTING STATIONS [Comparison of Methods: Progress in Filamentless Mercury-Vapour Rectifier Equipment].—de Martini. (*Rev. Gén. de l'Élec.*, 7th March, 1936, Vol. 39, No. 10, p. 79 D: summary only.)

1933. THE GENERATION AND USE OF HIGH TENSION DIRECT CURRENT [50–20, 50–250, and over 250 kv: Survey].—Grünewald. (*Zeitschr. V.D.I.*, 16th Nov. 1935, Vol. 79, No. 46, pp. 1375–1385.)

1934. AUTOMATIC CONTROL FOR MERCURY-ARC RECTIFIERS [Review of Present Day Practice].—Bany and Reagan. (*Elec. Engineering*, January, 1936, Vol. 55, No. 1, pp. 100–109.)

1935. THE ALL-UNION CONFERENCE ON SOLID RECTIFIERS AND PHOTOCELLS.—(*Tech. Phys. of USSR*, No. 5, Vol. 2, 1935, pp. 502–504: in English.)

1936. SELENIUM DRY-PLATE RECTIFIERS.—Körber. (*Zeitschr. V.D.I.*, 23rd Nov. 1935, Vol. 79, No. 47, pp. 1415–1417.)

1937. RESIDUAL INDUCTANCE AND RESISTANCE OF A VARIABLE CONDENSER: THEIR MEASUREMENT, AND THEIR EFFECT ON THE VARIATION OF EFFECTIVE CAPACITANCE WITH FREQUENCY.—Field and Sinclair. (*See* 1897.)

1938. DRY ELECTROLYTIC CONDENSERS FOR WORKING VOLTAGES OF 12, 250 and 400 VOLTS.—G. S. Venda, S. S. Gutin and L. N. Sakheim. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 5, 1935, pp. 1255–1259.)

A report on the dry electrolytic condensers developed at the Electro-Physical Institute of Leningrad. The construction of the condensers is as follows. A thin oxidised aluminium sheet (the anode) is placed between two layers of insulating paper impregnated with the working electrolyte, and covered with another aluminium sheet (the cathode). The whole assembly is rolled into a cylindrical shape and put into an aluminium or cardboard container. Particulars of the working electrolytes are given and the forming of the anodes described. The electrical properties of the condensers are shown in a number of tables and curves and a formula is derived showing that the angle of loss (tan δ) of this type of condenser is equal to the ratio of the resistance of the insulating layer to the capacitative reactance of the oxide layer. It is stated in conclusion that the condensers described are comparable to those of the best foreign manufacture.

1939. HIGH-FREQUENCY CABLES [New Low-Loss Dielectric Material " Styroflex "].—W. Kieser. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 629–634 : Discussion pp. 634–635.)

A short discussion of how the two types of high-frequency cable, the concentric and the screened symmetrical, behave towards external disturbances as regards attenuation and sensitivity, with particular emphasis on the importance of the insulation. §2. *Concentric cables.* (a) The known theory is shortly given and discussed ; the fundamental part played by the dielectric loss angle δ is emphasised. Fig. 1 shows how the external diameter of the cable increases with tan δ for given attenuation ; Fig. 2 gives the connection between attenuation and external diameter, for given loss angle. (b) Known forms of cable with various types of dielectric are mentioned. (c) A new type of insulating material is described which has the advantage of being pliable and having very small dielectric losses. This is known as " Styroflex " (*see* also 238 of January) ; every type of cable construction hitherto carried out with paper can be made with Styroflex on the same machines. It is non-hygroscopic, so that no special drying processes are necessary. The construction of a concentric cable with this material is described (Figs. 3–5) ; Fig. 6 shows how its attenuation varies with frequency. (d) The cable is almost completely insensitive to external high-frequency disturbances but not to low frequencies up to 20 kc/s, owing to the assymmetrical construction. For these, screened symmetrical cables are advised. §3. *Symmetrical cables.* (a) Theory and properties. (b) Cables with Styroflex are described (Fig. 7) ; they are useful for low-frequency transmission.

1940. NEW INSULATING MATERIALS FOR CONDENSERS [Improved Kerafar T, Kerafar U, Diacond].—(*E.T.Z.*, 27th Feb. 1936, Vol. 57, No. 9, p. 257.)

1941. NOTES ON FUSED JOINTS BETWEEN CERAMIC INSULATING MATERIALS AND METALS BY INTERPOSITION OF GLASS, AND ON LEADS FUSED INTO QUARTZ GLASS BULBS.—(*E.T.Z.*, 27th Feb. 1936, Vol. 57, No. 9, p. 257.)

1942. INSULATING MATERIALS : ACTIVITY IN MANY DIRECTIONS [in 1935].—Dunton. (*Electrician*, 31st Jan. 1936, Vol. 116, pp. 135–136.)

1943. THE MACHINING OF INSULATING MATERIALS.—Krüger. (*E.T.Z.*, 30th Jan. 1936, Vol. 57, No. 5, p. 126 : summary only.)

1944. THE ELECTRICAL PROPERTIES OF PARAFFINED PAPER CONDENSERS [Hygroscopic and Electrical Characteristics of Paper : Temperature Ratio, Loss Angle, etc., of Russian Condensers tested from – 100° to + 50°C].—E. M. Jakimetz. (*Izvestia Elektroprom. Slab. Toka*, No. 1, 1936, pp. 37–46.)

1945. PAPER CONDENSERS WITH HIGH SPECIFIC CAPACITY [Degree of Pressing of Sections is Chief Factor affecting Breakdown Voltage : Best Results are with Tightly Wound (Not Pressed) Sections : Reduced Size and Weight].—N. Bogoroditsky. (*Izvestia Elektroprom. Slab. Toka*, No. 1, 1936, pp. 47–54.)

1946. NOTE ON THE DIELECTRIC LOSSES IN PAPER [and the Rôles of Residual Moisture, Residual Salts, and the Structure of the Cellulose].—S. Sukhovolskaya. (*Tech. Phys. of USSR*, No. 1, Vol. 2, 1935, pp. 24–26 : in English.)

The first 2 factors are found to influence the losses mainly at low frequencies, while at high frequencies these losses depend chiefly on the nature of the cellulose. An explanation is suggested.

1947. RESIDUAL MOISTURE IN CELLULOSE DIELECTRICS [Mechanism by which Moisture is taken up or eliminated by or from Cable Paper : Electrical Behaviour of Adsorbed Ion Systems].—Greenfield. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, p. 195 : abstract only.)

1948. RESEARCHES ON PAPER FOR CONDENSERS [and the Important Rôle played by the Nature of the Paper.]—Nauk. (*Zeitschr. V.D.I.*, 25th Jan. 1936, Vol. 80, p. 98 : summary only.) *See* also 1277 of March : for other work *see* 2444 and 2795 of 1935.

1949. " IMPREGNATED PAPER INSULATION : THE INHERENT ELECTRICAL PROPERTIES."—Whitehead. (At Patent Office Library, London : Catalogue No. 75 761.)

1950. EFFECTS OF TEMPERATURE, AIR AND MOISTURE ON THE BREAKDOWN VOLTAGES OF IMPREGNATED PAPER.—Shimizu. (*Journ. I.E.E. Japan*, January, 1935, Vol. 55 [No. 1], No. 558, pp. 7–16 : English summary p. 4.)

1951. ESTERIFIED FIBROUS INSULATING MATERIALS. PART III [Great Improvement in Cotopa : Fireproofing : Insuwools and Insusilks : etc.].—New. (*Elec. Communication*, January, 1936, Vol. 14, No. 3, pp. 213–231.) For previous parts *see* 2805 of 1935.

1952. DUPRENE [Synthetic Rubber-Like Material resisting Ozone, Oil and Heat].—Hayden. (*Electrician*, 6th March, 1936, Vol. 116, p. 330 : summary only.)

1953. DIELECTRIC LOSSES IN GLASSES.—Bogoroditzki and Malishev. (*Tech. Phys. of USSR*, No. 4, Vol. 2, 1935, pp. 324–332 : in English.) *See* 769 of February.

1954. THE ELECTRICAL CONDUCTIVITY OF GLASS. PART III. CURRENT-VOLTAGE RELATIONSHIPS WITH HIGHLY RESISTANT LAYERS.—Kiehl. (*Physics*, January, 1936, Vol. 7, No. 1, pp. 20–25.)

1955. CONFERENCE ON DIELETRICS LOSSES IN GLASS.—(*Tech. Phys. of USSR*, No. 2/3, Vol. 2, 1935, pp. 252–254 : in English.)

1956. HIGH-FREQUENCY CONDUCTANCE OF PYREX GLASS IN THE PRESENCE OF VAPOURS [Experimental Curves at Various Temperatures : Rapid Increase in Conductance above Certain Degree of Saturation of Alcohol Vapour].—Roberds. (*Physics*, July, 1935, Vol. 6, No. 7, pp. 227–233.)

1957. The Electrical Breakdown of Inhomogeneous Dielectrics [Two Effects of Inclusions, causing Decreased Strength, separated Experimentally—Decreased Effective Thickness and Distortion of Uniform Field].—Gutin and Sackheim. (*Tech. Phys. of USSR*, No. 5, Vol. 2, 1935, pp. 493–501 : in German.) Thus quartz inclusions in resin, being a purely mechanical inhomogeneity which neither distorts the field nor decreases the effective thickness, have no bad effect on the dielectric strength.

1958. The Application of Debye's Theory of Polar Molecules to Solid Dielectrics [Fatty Acids : Theory Applicable if Substance has Property Analogous to Viscosity of Liquids].—O'Kane. (*Phil. Mag.*, February, 1936, Series 7, Vol. 21, Supp. No. 140, pp. 369–383.)

1959. Breakdown of Compressed Nitrogen in a Non-Uniform Field. II [Pressures up to 40 kg/cm^2].—Goldman and Wul. (*Tech. Phys. of USSR*, No. 1, Vol. 3, 1936, pp. 16–27 : in English.) For I *see* 2815 of 1935.

1960. "Dielektrische Polarisation" [Book Review].—Fuchs and Wolf. (*Hochf:tech. u. Elek:akus.*, April, 1935, Vol. 45, No. 4, p. 144.)

1961. The Electrical Breakdown in Insulating Liquids [Survey].—Koppelmann. (*Zeitschr. f. tech. Phys.*, No. 5, Vol. 16, 1935, pp. 125–141.)

1962. Molecular Theory of the Dielectric Constant of Non-Polar Liquids.—Yvon. (*Comptes Rendus*, 6th Jan. 1936, Vol. 202, No. 1, pp. 35–37.)

1963. Comparison of the Heating of Bare and Insulated Cylindrical Conductors [Greater, under Certain Conditions, in the Bare Conductor].—Brügger. (*Bull. Assoc. suisse des Élec.*, No. 15, Vol. 26, 1935, pp. 412–417 : in German.)

1964. A Contribution to the Skin Effect in Layered Cylindrical Conductors.—Werner. (At Patent Office Library, London : Catalogue No. 75 081 : Berlin Thesis, 1935 : in German.)

1965. A Contribution to the Problem of Skin Effect in Layered Conductors.—Steinhausen. (*See* 1731.)

1966. Beryllium-Copper Alloys. — Benford. (*Gen. Elec. Review*, June, 1935, Vol. 38, No. 6, pp. 297–299.)

1967. Electrical-Resistance Alloys of Copper, Manganese, and Aluminium [with Extremely Low Temperature-Coefficients].—Thomas. (*Journ. of Res. of Nat. Bur. of Stds.*, February, 1936, Vol. 16, No. 2, pp. 149–159.)

1968. Fluctuations of Potential at the Ends of a Metallic Conductor of Small Volume traversed by a Current [additional to Thermal Agitation Effect and similar to Shot Effect in Valves].—Bernamont. (*Comptes Rendus*, 2nd Dec. 1935, Vol. 201, No. 23, pp. 1106–1108 : *Rev. Gén. de l'Élec.*, 7th March, 1936, Vol. 39, No. 10, pp. 339–346.) For previous work *see* 1934 Abstracts, p. 503. *Cf.* also 4074 of 1935 ("rustle" voltage in carbon films).

1969. Methods for Joining Very Fine Wires.—Pearson. (*Review Scient. Instr.*, February, 1936, Vol. 7, No. 2, p. 108.)

1970. Eddy Currents in Composite Laminations [Inhomogeneity of Core found responsible for Large Discrepancies between Theoretical and Observed Frequency Dependence of Inductance and Resistance of Iron-Cored Coils—especially with Some Chromium Permalloy Cores : Etching-Off of Low-Permeability Skin removes Discrepancies : Extension of Theory].—Peterson and Wrathall. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 275–286.)

1971. High-Frequency Iron Cores for the Coils of Broadcast Receivers [Survey].—Riepka. (*See* 1758.)

1972. The "Sirufer Clock," a New Auxiliary for the Calculation of Iron-Cored Coils.—Schadow. (*Funktech. Monatshefte*, February, 1936, No. 2, pp. 69–72.)

1973. Separation of Magnetic Viscosity and Eddy-Current Lag.—Mitkevitch. (*Sci. Abstracts*, Sec. A, 25th Jan. 1936, Vol. 39, No. 457, p. 74.)

1974. Magnetic Properties of Colloidal Powders of Metallic Elements [Critical Survey].—Rao. (*Current Science*, Bangalore, February, 1936, Vol. 4, No. 8, pp. 572–576.)

1975. The Action of Alternating and Moving Magnetic Fields upon Particles of Magnetic Substances.—Hatfield. (*Physics*, February, 1936, Vol. 7, No. 2, p. 55.) *See* also 589 and 3233 of 1935.

1976. New Alloys with High Coercive Force [Survey of Past Work : New Results with Iron-Palladium, Iron-Platinum and Cobalt-Platinum Alloys].—Jellinghaus. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 17, 1936, pp. 33–36.) The last-named alloy gave a coercive force of 4 000 oersteds with a remanence of 3 900 gauss.

1977. Permanent Magnets and Their Calculation [with Particular Reference to the Large Magnet at the Curie Laboratory].—Surugue. (*Rev. Gén. de l'Élec.*, 1st Feb. 1936, Vol. 39, No. 5, pp. 171–178.)

1978. The Shape of Core for Laboratory Electromagnets [Curved Pole better than Cone].—Dwight and Abt. (*Review Scient. Instr.*, March, 1936, Vol. 7, No. 3, pp. 144–146.)

1979. Investigation of Magnetic Forces inside a Magnet, by the Use of Cosmic Rays.—Swann and Danforth. (*Science*, 6th Dec. 1935, Vol. 82, Supp. p. 12.)

1980. Alloys of Iron and Their Electrical Applications.—Colonna. (*Bull. Soc. franc. des Élec.*, June, 1935, Vol. 5, No. 54, pp. 593–604.)

1981. A Simple Method for the Determination of Magnetisation-Coercive Force.—Davis and Hartenheim. (*Review Scient. Instr.*, March, 1936, Vol. 7, No. 3, pp. 147–149.)

1982. Combinations of Circular Currents for producing Uniform Magnetic Fields.—McKeehan. (*Review Scient. Instr.*, March, 1936, Vol. 7, No. 3, pp. 150–153.)

1983. The Mathematical Expression of the Hysteresis Curve [Functional Relation expressing Hysteresis Cycle deduced by Operators and Fourier Series].—Neufeld. (*Comptes Rendus*, 13th Jan. 1936, Vol. 202, No. 2, pp. 125–126.)

1984. Analysis of the Dynamical Curves of Magnetic Permeability and of the Losses in Iron.—W. Arkadiew. (*Comptes Rendus*, 6th Jan. 1936, Vol. 202, No. 1, pp. 39–41.)

A short summary of the results of an analysis of Wilson's experimental curves (*Proc. Inst. Rad. Eng.*, Vol. 9, 1921, p. 56) by the writer's method (1933 Abstracts, p. 578). Numerical formulae are given for the "conservative" and "absorptive" permeability as functions of frequency. For the writer's early paper on the theory of magnetic permeability *see* 1932 Abstracts, p. 177.

1985. The Connection of Spontaneous and True Magnetisation with [Spectral] Emissive Power [of Nickel: Emissive Power and Electrical Resistance show Same Relation to Energy of Spontaneous Magnetisation: Emissive Power decreased by True Magnetisation: etc.]—Gerlach. (*Ann. der Physik*, Series 5, No. 3, Vol. 25, 1936, pp. 209–212.)

1986. [Spectral] Emissive Power of Nickel [Measurements: Decrease in Neighbourhood of Curie Point due to True Magnetisation].—Löwe. (*Ann. der Physik*, Series 5, No. 3, Vol. 25, 1936, pp. 213–222.)

1987. Ferromagnetic Increase of Resistance of Copper-Nickel Alloys [as Function of Concentration: Measurements]. — Svensson. (*Ann. der Physik*, Series 5, No. 3, Vol. 25, 1936, pp. 263–271.)

1988. The Effect of Tension on Magnetisation [of Nickel] above the Curie Point [True Magnetisation independent of Tension: Ferromagnetic Magnetisation depends on Tension].—Scharff. (*Ann. der Physik*, Series 5, No. 3, Vol. 25, 1936, pp. 223–232.)

1989. The Present Status of Ferromagnetic Theory.—Bozorth. (*Bell S. Tech. Journ.*, January, 1936, Vol. 15, No. 1, pp. 63–91.) *See* 755 of February: a few revisions and additions have been made.

1990. Variable-Potential Constant-Current Transformation [by Use of Transformer with Specially Shaped 3-Winding Core].—Somiya and Takahashi. (*Journ. I.E.E Japan*, May, 1935, Vol. 55 [No. 5], No. 562, p. 395: English summary p. 54.)

1991. A Transformer System with Logarithmic Response for Continuous Current [using Triode with Anode Current an Exponential Function of Grid Voltage].—Lambrey. (*Comptes Rendus*, 25th Nov. 1935, Vol. 201, No. 22, pp. 1023–1025.)

1992. Calculating the Torques of Electro-Magnetic Relays.—Shorigin. (*Elektritchestvo*, No. 6, 1935, pp. 21–29: in Russian.)

1993. Improved Sensitive Relays [Method of increasing Contact Pressure].—de Roumefort. (French Pat. 789 502, pub. 30.10.35: *Rev. Gén. de l'Élec.*, 29th Feb. 1936, Vol. 39, No. 9, p. 69 D.)

1994. Sliding Contacts—Electrical Characteristics.—Baker. (*Elec. Engineering*, January, 1936, Vol. 55, No. 1, pp. 94–100.)

1995. Rhodium Plating [and Its Possibilities for Improved Silver Contacts for Receiver Switches].—(*Funktech. Monatshefte*, February, 1936, No. 2, p. 68.)

1996. Electro-Magnetic Control of High Rotational Speeds [around 1000 r.p.s.].—Davis. (*Review Scient. Instr.*, February, 1936, Vol. 7, No. 2, pp. 96–98.)

1997. Relays with Mechanical Resonance [Pendulum, Balance Wheel, and Other Types] and Distant Control without Pilot Wire.—Lavet. (*Bull. Soc. franç. des Élec.*, January, 1936, Series 5, Vol. 6, No. 61, pp. 81–104.)

1998. An Electric Driving and Timing Apparatus for Microcinematography [giving Independent Adjustment of Exposure and Interval Times].—Goetz and Romer. (*Review Scient. Instr.*, January, 1936, Vol. 7, No. 1, pp. 6–11.)

1999. Two New Types of Mercury Safety Switches for Water-Cooled Apparatus.—Mönch. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 17, 1936, p. 61.)

2000. A New Rapid Compensation [Ink] Recorder for D.C. Measurements [of Small Currents and Voltages].—Geyger. (*Arch. f. Elektrot.*, 20th Dec. 1935, Vol. 29, No. 12, pp. 850–855.) *See* also 2001.

2001. A New Electric Automatic Compensating [Ink-Recording] Amplifier [for Very Small Currents and Voltages].—Geyger. (*Arch. f. Elektrot.*, 28th Jan. 1936, Vol. 30, No. 1, pp. 33–36.)

The search coil already described by the writer (*see* 2000) is here controlled by a moving-coil zero instrument without mechanical force; the search coil influences a comparison current from a valve amplifier and this flows through a moving-coil ink recorder. Circuit diagrams are given and described.

2002. A Heated Stylus for Use with Waxed Recording Paper [Friction largely Eliminated].—Haynes. (*Review Scient. Instr.*, February, 1936, Vol. 7, No. 2, p. 108.)

2003. The Production of High Velocity Particles in a Cyclotron by the Use of Multiphase Oscillators [Acceleration of Ions $2n$ Times per Revolution: Corresponding Reduction of Space Charge].—Moon and Harkins. (*Phys. Review*, 1st Feb. 1936, Series 2, Vol. 49, No. 3, p. 273: *Nature*, 22nd Feb. 1936, Vol. 137, pp. 316–317.)

2004. The Magnetic Resonance Accelerator [or "Cyclotron," for Production of High-Speed Ions up to 2 MV].—Livingston. (*Review Scient. Instr.*, January, 1936, Vol. 7, No. 1, pp. 55–68.)

2005. A Generator producing Sinusoidal Oscillations of Constant Amplitude over a Very Wide Range of Frequency [0.03–30 000 c/s].—Monnier and Bazin. (*See* 1748.)

2006. The Electrometer Triode Valve as a High Resistance and as an Earthing Key [Two Coupled Electrometer Triode Valves applied to Automatic Ionisation Spectrometer].—Wooster and Martin. (*Nature*, 7th March, 1936, Vol. 137, p. 406.)

2007. System of Two or More Coils of Variable Mutual Coupling [Flat Coil movable obliquely within Cylindrical Coil].—Rosenberger: G. Seibt A.G. (*Hochf:tech. u. Elek:akus.*, January, 1936, Vol. 47, No. 1, p. 29: German Patent 618 332 of 6. 4. 1934.)

2008. The Coordirectograph—a Mechanical Device for Rapid Quantitative Comparison of Curves dissimilar in Ordinate and/or Abscissal Values.—Green and Maurer. (*Review Scient. Instr.*, January, 1936, Vol. 7, No. 1, pp. 37–40.)

2009. New Planimeters and Integrators.—Ott. (*Génie Civil*, 7th March, 1936, Vol. 108, pp. 229–232.)

STATIONS, DESIGN AND OPERATION

2010. Some Engineering and Economic Aspects of Radio Broadcast Coverage [200–2 000 kc/s: Enormous Variation in Coverage with Frequency and Terrain: Costs per Sq. Mile: Economic Balance between Transmitter and Aerial Costs: Conclusions as to Allocation of Wavelengths: etc.].—Gillett and Eager. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 190–206.)

2011. Service Areas of Broadcasting Stations. Part I.—Standards of Service: Part II.—Daylight Coverage [Survey of Available Information and Selection of Simple Rules for Estimation of Service given by a Station].—A. L. Green. (*A.W.A. Tech. Review* [*see* 512 of February], January, 1936, Vol. 2, No. 1, pp. 3–22.)

2012. The Present Status of Broadcasting Installations in Japan.—Yonezawa. (*Nippon Elec. Comm. Eng.*, February, 1936, No. 2, pp. 91–107: in English.)

2013. A New Apparatus for Amplitude Monitoring in Broadcasting, etc.—Nestel and Thilo. (*See* 1838.)

2014. Discussion on "The Hawaiian Radiotelephone System" [on Ultra-Short Waves].—Harrington and Hansell. (*Elec. Engineering*, March, 1936, Vol. 55, No. 3, p. 290.) *See* 4095 of 1935.

2015. Micro-Ray Communication [particularly the Lympne/St. Ingelvert Link: Improved Receiver using Intermediate R.F. of 100 kc/s].—McPherson and Ullrich. (*Engineering*, 28th Feb. 1936, Vol. 141, pp. 241–242.) Summary of I.E.E. paper.

2016. Note on Ultra-Short-Wave Services in 1935 [including Barcelona/Soller (Majorca) 120-Mile Link].—(*Elec. Communication*, January, 1936, Vol. 14, No. 3, pp. 181–182.) Using 5 m vertically polarised and 4.5 m horizontally polarised waves respectively: carrier output about 10 watts, with AT-cut crystal control: unattended operation.

2017. Harbour Craft Radiotelephone System of the Atlantic Communications Corporation [Ultra-Short-Wave Tug-Boat System in Philadelphia Harbour Area: Receivers with "Codan" Device].—Woodworth. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 153–154: summary only.) For the "codan" device *see* also 91 of January.

2018. Ultra-Short-Wave Communication for Long Goods Trains.—Shepard and Evans. (*E.T.Z.*, 20th Feb. 1936, Vol. 57, No. 8, p. 205: summary only.) *See* also 1620 of April.

2019. Applications of Wireless among High Mountains [Broadcasts of Ascents: Communication with Alpine Shelters: Experiments on Mont Blanc Massif: etc.].—Decaux. (*L'Onde Élec.*, January, 1936, Vol. 15, No. 169, pp. 7–32.)

2020. Recollections of the Activities of the Telefunken High-Power Nauen Station in the World War.—Neumann. (*Telefunken-Zeit.*, March, 1936, Vol. 17, No. 72, pp. 61–66.)

GENERAL PHYSICAL ARTICLES

2021. On the Linearisation of the Energy Density of the Electromagnetic Field.—Born. (*Proc. Camb. Phil. Soc.*, January, 1936, Vol. 32, Part 1, pp. 102–107.)

2022. The New Action Function and the Unitary Field Theory.—Infeld. (*Proc. Camb. Phil. Soc.*, January, 1936, Vol. 32, Part 1, pp. 127–137.)

2023. Remark on the Theory of the Electromagnetic Field [Movement of Electromagnetic Deformation according to Laws of Analytical Mechanics: Model of Photon: Semi-Photons].—von Wisniewski. (*Zeitschr. f. Physik*, No. 11/12, Vol. 98, 1936, pp. 746–752.)

2024. The Definition of the Electromagnetic Field by Potentials and the Magnetic Moment of the Electron [which is implicitly contained in the Maxwell-Lorentz Equations].—Proca. (*Comptes Rendus*, 24th Feb. 1936, Vol. 202, No. 8, pp. 641–643.)

2025. [Theoretical] Interpretation of the Maxwellian Field in terms of Photons.—Benedictus. (*Comptes Rendus*, 17th Feb. 1936, Vol. 202, No. 7, pp. 560–562.)

2026. On a Probability Interpretation of the Electromagnetic Field [and the Dirac Theory Equivalent of Poynting's Theorem].—Prunier. (*Rev. Gén. de l'Élec.*, 29th Feb. 1936, Vol. 39, No. 9, pp. 311–313.)

2027. On the Theory of Dispersion [for Absorption in Hot Gases: Influence of Magnetic Properties on Refractive Index].—Herzfeld and Goeppert-Mayer. (*Phys. Review*, 15th Feb. 1936, Series 2, Vol. 49, No. 4, pp. 332–339.)

2028. On the Mutual Energy in Systems of Vibrating Particles, and a Suggestion regarding Electrostatic Energy [and Its Interpretation in Terms of Interaction of Vibrating Particles].—Jones. (*Phil. Mag.*, February, 1936, Series 7, Vol. 21, Supp. No. 140, pp. 337–355.)

MISCELLANEOUS

2029. The Ster and Stei Functions [Integrals of Differential Equations connected with Hankel Functions: Definitions: Recurrence, Integral, Asymptotic Formulae: Polar Forms, etc.].—McLachlan and Meyers. (*Phil. Mag.*, February, 1936, Series 7, Vol. 21, Supp. No. 140, pp. 425–436.)

2030. Integrals involving Bessel and Struve Functions.—McLachlan and Meyers. (*Phil. Mag.*, February, 1936, Series 7, Vol. 21, Supp. No. 140, pp. 437–448.)

2031. "Probability and Random Errors" [Book Review].—Bond. (*Current Science*, Bangalore, February, 1936, Vol. 4, No. 8, p. 603.)

2032. Some Equivalence Theorems of Electromagnetics and Their Application to Radiation Problems.—Schelkunoff. (*See* 1779.)

2033. Introduction to the Applications of the Heaviside Symbolic Calculus to the Problems of Electrotechnics: Errata.—Blondel. (*Rev. Gén. de l'Élec.*, 22nd Feb. 1936, Vol. 39, No. 8, p. 284: 21st March, p. 414.) *See* 1632 of April.

2034. Operational Solution of Electric Circuits [with Initial Conditions either Rest or Dynamic, instead of Rest only as usual].—Brunetti. (*Elec. Engineering*, February, 1936, Vol. 55, No. 2, pp. 158–164.)

2035. The Definition of Physical Quantities by Equations, Units, Nomenclature, Dimensions, Equations between Magnitudes, etc.—Fischer. (*Physik. Zeitschr.*, 15th Feb. 1936, Vol. 37, No. 4, pp. 120–129.)

2036. Preferred Numbers [for Standardisation Purposes: ASA Recommendations: Application to Radio Design].—Van Dyck. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 159–179.)

2037. Developments in the Electrical Industry during 1935.—Liston. (*Gen. Elec. Review*, January, 1936, Vol. 39, No. 1, pp. 7–71.) For Radio and electron tubes *see* particularly pp. 34–39.

2038. Progress of Science: Outstanding Achievements in 1935.—(*Sci. News Letter*, 21st Dec. 1935, Vol. 28, pp. 388–391 and 394–398.)

In Radio the following are mentioned: "temperatures of 1700°F. at a height of 150 miles," Appleton (3304 of 1935 and 1 of January): "another radio reflecting layer . . . at an altitude of 35 miles, called the D layer," Mitra and Syam (2539 of 1935): separation of positive and negative ions by high velocity air currents in thunderstorms, Gunn (2576 of 1935): X-rays from the sun, Müller (940 and 1316 of 1935): electronic tides due to moon, Stetson (1737 and 3312 of 1935): "base of stratosphere varies from 4.7 miles to 7.5 miles above the earth within a day," Massachusetts Institute: and some cosmic-ray results.

2039. Progress in Engineering Knowledge during 1935.—Alger. (*Gen. Elec. Review*, December, 1935, Vol. 38, No. 12, pp. 546–557.)

2040. The Activities of the Physikalisch-Technische Reichsanstalt in 1934.—Erk. (*Zeitschr. V.D.I.*, 14th Dec. 1935, Vol. 79, No. 50, pp. 1497–1499.)

2041. I.R.E. Convention Report [particularly Standardisation and Frequency Modulation].—(*Rad. Engineering*, December, 1935, Vol. 15, No. 12, pp. 4–6.)

2042. I.R.E. Fall Meeting [Notes of Various Papers].—(*Electronics*, December, 1935, Vol. 8, pp. 11–14.)

2043. The Twelfth Great German Radio Exhibition [General Notes: National Transmitter: New Valves: Broadcast Receivers: Power Amplifiers and Loudspeakers: Television].—Fuchs. (*Hochf:tech. u. Elek: akus.*, January, 1936, Vol. 47, No. 1, pp. 1–8.)

2044. Some Reflections on the Radio Exhibitions: *also* The 12th Paris Radio Exhibition: The Lyons Radio Exhibition: *and* The Radio Exhibitions Abroad [London and Berlin].—(*L'Onde Élec.*, November, 1935, Vol. 14, No. 167, pp. 695–739.)

2045. 26th Annual Exhibition of the Physical Society.—(*Wireless World*, 17th Jan. 1936, Vol. 38, pp. 58–59: *Electrician*, 10th and 17th Jan. 1936, Vol. 116, pp. 33–38 and 63–66.)

2046. The Physical Society's Exhibition: Notes on Exhibits of Radio Interest.—(*Wireless Engineer*, February, 1936, Vol. 13, No. 149, pp. 81–86.) *See* also *Journ. Scient. Instr.*, February, 1936, pp. 37–71.

2047. The Physical Society's Exhibition [including Multi-Element C-R Oscillograph, Receiver for Ignition Interference Investigations, etc.].—(*Engineer*, 10th Jan. 1936, Vol. 161, pp. 41–44: to be continued.)

2048. Report of Conference on Applied Physics.—(*Review Scient. Instr.*, March, 1936, Vol. 7, No. 3, pp. 113–123.)

2049. Radio Engineering in Books and Journals of the Year 1934.—Patermann. (*Telefunken-Zeit.*, March, 1936, Vol. 17, No. 72, pp. 66–71.)

2050. "Verdeutschung technischer Fremdwörter," 3rd Impression [Review of Official Pamphlet on Germanisation of Foreign Technical Words].—(*E.T.Z.*, 6th Feb. 1936, Vol. 57, No. 6, p. 168.)

2051. "Hilfsbuch für Rundfunk- und Verstärkertechnik" [Book Review].—Bergtold. (*E.T.Z.*, 5th Dec. 1935, Vol. 56, No. 49, p. 1348.) Formulae, tables, etc.

2052. "Radio Data Charts" [Book Review].—Beatty. (*P.O. Elec. Eng. Journ.*, January, 1936, Vol. 28, Part 4, p. 323.)

2053. "Hutchinson's Technical and Scientific Encyclopedia" [Book Review].—Hutchinson. (*P.O. Elec. Eng. Journ.*, January, 1936, Vol. 28, Part 4, p. 332.)

2054. A Biblio-Film Service [of the U.S. Department of Agriculture: Cheap Reproduction of Scientific Papers].—Mundkur. (*Current Science*, Bangalore, January, 1936, Vol. 4, No. 7, pp. 490–491.)

2055. Instructions for the Preparation of Articles for Technical Journals.—Lombardi. (*Alta Frequenza*, December, 1935, Vol. 4, No. 6, pp. 733–750.)

2056. "Making a Living in Radio," [Book Review].—Bouck. (*Electronics*, January, 1936, Vol. 9, p. 33.)

2057. A New Multiple Telegraphy System [10-Channel Carrier System using Resistance Tuning in place of Reactance Tuning].—Watanabe. (*Nippon Elec. Comm. Eng.*, February, 1936, No. 2, pp. 121–131: in English.)

2058. Application of Vacuum Tubes to Automatic Train Control [and Amplifiers for 100 c/s Wave modulated at $1\frac{1}{3}$, 2 and 3 c/s: "Q" Values around 5, partly due to Copper-Oxide Rectifier].—Allison and Crooks. (*Proc. Inst. Rad. Eng.*, February, 1936, Vol. 24, No. 2, pp. 154–155: summary only.)

2059. Measurement of Rapid Variations in Length [Ultra-Micrometer avoiding Previous Difficulties in Transmitting 0.001 mm Variations to the Condenser without Frequency or Amplitude Distortion].—Löffler. (*E.T.Z.*, 19th March, 1936, Vol. 57, No. 12, p. 336.) For use in railway bridge investigations, etc.

2060. The Selenium Rectifier Photocell: Manufacture, Properties, and Use in Photometry, *and* The Selenium-Iron Photo-Rectifier Cell: Its Characteristics and Response to Intermittent Illumination.—Preston: MacG. Morris and Billington. (*Electrician*, 13th March, 1936, Vol. 116, p. 345.) Summaries of I.E.E. papers.

2061. A Photoelectric Photometer [Simple, Accurate and Rugged].—Howlett. (*Canadian Journ. of Res.*, February, 1936, Vol. 14, No. 2, Sec. A, pp. 38–42.)

2062. A Suggestion for the Photometry of Light Sources of Different Colours [Transformation of Frequencies to the Same Colour].—Pirani and Rompe. (*See* 1887.)

2063. Zero-Potential Circuit for Blocking-Layer Photocells [for Reduction of Factors causing Lack of Linearity and Variation with Temperature].—Wood: Campbell and Freeth. (*Review Scient. Instr.*, March, 1936, Vol. 7, No. 3, p. 157.)

2064. Circuit employing Thyratron Tube, for Integrating Variable Photoelectric Current.—Powell and Clarke. (*Journ. Opt. Soc. Am.*, March, 1936, Vol. 26, No. 3, p. 113.) For daylight measurements at surface of ocean.

2065. A Photomagnetron and Its Application to the Measurement of Twilight Illumination.—Dauvillier. (*See* 1879.)

2066. New Cinematograph Arrangement for Registering Very Rapid Phenomena [Translation Velocities up to 200 m/sec: Rotor without Axis driven by Compressed Air].—Bull and Girard. (*Comptes Rendus*, 17th Feb. 1936, Vol. 202, No. 7, pp. 554–555.)

2067. Marconi-Therapy [with Short and Ultra-Short Waves].—Mancini. (*La Ricerca Scient.*, 15/31 Jan. 1936, Series 2, 7th Year, Vol. 1, No. 1/2, pp. 70–71: summary only.)

2068. A Recording Electrocardiograph.—Portier. (*L'Onde Élec.*, February, 1936, Vol. 15, No. 170, pp. 102–112.)

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. A selection of abstracts from patents issued in the U.S.A. is also included, and these bear a seven-figure serial number.

AERIALS AND AERIAL SYSTEMS

438 506.—Terminal arrangement for the concentric transmission line of a short-wave aerial (dipole) designed to attenuate interfering currents flowing along the outside sheath of the line.

W. S. Percival and E. L. C. White. Application dates 15th February and 27th July, 1934.

440 361.—Aerial and mast installation suitable for use in directional systems both for transmission and reception.

Marconi's W.T. Co. and S. B. Smith. Application date 27th June, 1934.

TRANSMISSION CIRCUITS AND APPARATUS

438 018.—Modulating system in which the signal voltage is applied from a single valve in push-pull across the two anodes of a magnetron.

Telefunken Co. Convention date (Germany) 21st August, 1934.

2 004 101.—A variable impedance in the grid or plate circuit of a back-coupled valve is used to produce an audible " squegging " note for modulating purposes. Or it may be used for quenching in a super-regenerative circuit.

R. Cole.

2 004 171.—Valve oscillator in which variations in the load do not affect the frequency generated.

H. Muth and W. Runge (assignors to Telefunken Co.).

RECEPTION CIRCUITS AND APPARATUS

437 306.—Homodyne receiver with variometer tuning.

Marconi's W.T. Co. and G. M. Wright. Application date 28th April, 1934.

438 177.—Telegraph receiver designed to separate signals transmitted on the same wavelength but having different tone-frequencies.

C. Lorenz Akt. Convention date (Germany) 2nd *February,* 1934.

438 565.—Method of automatic volume control based on the use of a control element consisting of silicon-carbide crystals (THYRITE) the resistance of which varies instantaneously with change of current.

Standard Telephones (assignors of D. H. Ring). Convention date (U.S.A.) 26th May, 1934.

439 103.—Super-regenerative circuit in which one branch of the anode circuit of a pentode valve is back-coupled to the grid at the signal frequency whilst a second branch is tuned to the quenching frequency and back-coupled to a second grid.

D. W. Pugh and Baird Television. Application date 31st August, 1934.

439 528.—Wireless set which can be switched-over from double side-band to single side-band reception, particularly for short-wave working.

Marconi's W.T. Co. (communicated by Radio Corporation of America). Application date 10th October, 1934.

439 755.—Ultra-short-wave amplifier in which the anode forms the outer wall of the valve and both the grid and anode are continued as telescopic extensions external to the valve.

J. Greig. Application date 24th August, 1934.

439 977.—Phase-shifting networks for compensating or preventing distortion in the wave-form of transmitted signals.

A. T. Starr and Baird Television. Application date 19th June, 1934.

440 494.—Automatic volume control arranged to discriminate between interference or " noise " and the signal to which the circuits are tuned.

Murphy Radio and L. A. Moxon. Application date 2nd July, 1934.

2 001 695.—Superhet receiver in which the local oscillator is arranged to develop higher voltages as it is tuned down the frequency scale in order to offset attenuation in the lower carrier frequencies.

P. O. Farnham (assignor to Radio Corporation of America).

2 014 509.—Receiver in which the volume is automatically controlled by the degree of modulation, as distinct from the amplitude, of the received signal.

H. O. Roosenstein and W. Runge (assignors to Telefunken Co.).

2 004 128.—Anti-fading system of diversity reception, with automatic volume control for the overall strength and individual control for each aerial input.

H. O. Peterson (assignor to Radio Corporation of America).

VALVES AND THERMIONICS

438 117.—Cathode-ray tube in which the electrodes are fitted with glass rods fused to parallel holding-rods which are sealed into the pinch.

E. Hudec. Convention date (Germany) 8th April, 1933.

439 636.—Cathode ray tube with deflecting electrodes arranged to influence the stream in the region between the cathode and anode.

A. C. Cossor (assignees of M. von Ardenne). Convention date (Germany) 12th June, 1933.

440 087.—Electrode system for focussing the electron beam in a cathode ray tube.

Fernseh Akt. Convention date (Germany) 24th May, 1934.

2 000 362.—Valve frequency-multiplier having an input impedance which varies with the applied voltage, and an output circuit which is tuned to the desired harmonic.

F. E. Terman.

2 002 238.—Thermionic oscillator having a negative resistance characteristic developed by the mutual repulsion of the electrons in the discharge stream.

E. H. Yonkers.

DIRECTIONAL WIRELESS

438 809.—Feeding an "array" of directional aerials so as to balance-out mutual reaction and the effect of changes in aerial impedance.

Marconi's W.T. Co. (communicated by R. M. Wilmotte). Application date 25th May, 1934.

438 852.—Wireless direction-finder in which the position of a beacon station is indicated directly by two o more Neon-lamp pointers.

A. Bertrand and M. Parisier. Application date 25th April, 1935.

438 900.—Directive aerial of the Adcock type in which provision is made for more completely eliminating the effect of horizontally polarised waves.

R. H. Barfield and L. H. Bainbridge-Bell. Application date 26th May, 1934.

439 608.—Apertured reflector for ultra-short wave directional signalling.

Telefunken Co. Convention date (Germany) 21st March, 1934.

ACOUSTICS AND AUDIO FREQUENCY CIRCUITS AND APPARATUS

439 307.—Parallel push-pull low-frequency amplifier in which the grids of the in-phase valves are connected through condensers of the order 0.01 mfd.

Standard Radio Relay Services and P. Adorjan. Application date 10th July, 1934.

440 038.—Loudspeaker magnet of the high coercivity type, made of an alloy of nickel, aluminium, and iron.

J. Lucas, Ltd., and E. A. Watson. Application date 19th June, 1934.

440 330.—Piezo-electric crystal unit suitable for loudspeakers and gramophone pick-ups.

Sonotone Corp. Convention date (U.S.A.) 24th May, 1933.

2 004 253.—Correcting the falling frequency-characteristic of a selenium cell by the use of shaping circuits in the subsequent amplifier stages of a light recording system.

H. G. Tasker (assignor to United Research Corporation).

TELEVISION AND PHOTOTELEGRAPHY

438 533.—Scanning arrangement for televising a scene containing "insets," for example, the picture of a person showing that persons changing thoughts.

J. C. Wilson and Baird Television. Application date 18th June, 1934.

439 146.—Television system in which the synchronising signals are produced by a triggered gas-discharge tube at the transmitting end.

Cie "Compteurs." Convention date (France) 17th March, 1934.

439 771.—Television system in which alternate images are presented a number of times so as to reduce "flicker."

J. L. Baird and Baird Television. Application date 25th September, 1934.

440 390.—Method of modulating the electron beam in a cathode-ray tube without altering the size of the spot of light projected on to the screen.

Marconi's W.T. Co. (assignees of R. T. Orth). Convention date (U.S.A.) 30th May, 1933.

440 577.—Optical system with condenser lenses for use in scanning a kinema film for television.

J. L. Baird and Baird Television. Application date 5th September, 1934.

2 004 790.—Cathode ray tube circuit with regenerative back-coupling for strengthening the light-intensity of the fluorescent screen.

F. W. Hehlgans (assignor to General Electric Co., U.S.A.).

2 017 092.—Helical scanning drum used with short line source of light to produce a television image which can be seen directly by several observers simultaneously.

F. Gray (assignor to Bell Telephone Labs.).

2 017 659.—Optical system for superposing images from different light sources so as to produce natural-colour effects in television.

H. E. Ives (assignor to Bell Telephone Labs.).

SUBSIDIARY APPARATUS AND MATERIALS

438 803.—Magnetic cores for high-frequency chokes, etc., consisting of a powdered alloy of iron and nickel mixed with colloidal clay and sodium silicate.

Standard Telephones (assignees of W. C. Ellis). Convention date (U.S.A.) 24th May, 1933.

439 178.—Telegraphone recorder for producing echo and reverberation effects, particularly in broadcasting.

Marconi's W.T. Co. and N. M. Rust. Application date 28th May, 1934.

439 579.—Preparing the photographic films used in "intermediate" systems of television so as to have a low value of "gamma" or average density.

A. G. D. West and Baird Television. Application date 10th July, 1934.

439 905.—Tuning scale formed with a series of inclined transparent points and a luminous cursor to indicate the name of the station being received.

G. B. Kemp. Application date 19th September, 1934.

441 259.—Tuning scale provided with means for illuminating a spot which indicates the station that is being received.

F. Hubner. Application date 30th July, 1935.

2 021 722.—Balancing the capacitive reactance of a piezo-electric crystal when used as a frequency-stabiliser.

H. E. Goldstine and J. W. Conklin (assignors to Radio Corporation of America).

MISCELLANEOUS

2 021 557.—System for transmitting power as directed beams of radio energy.

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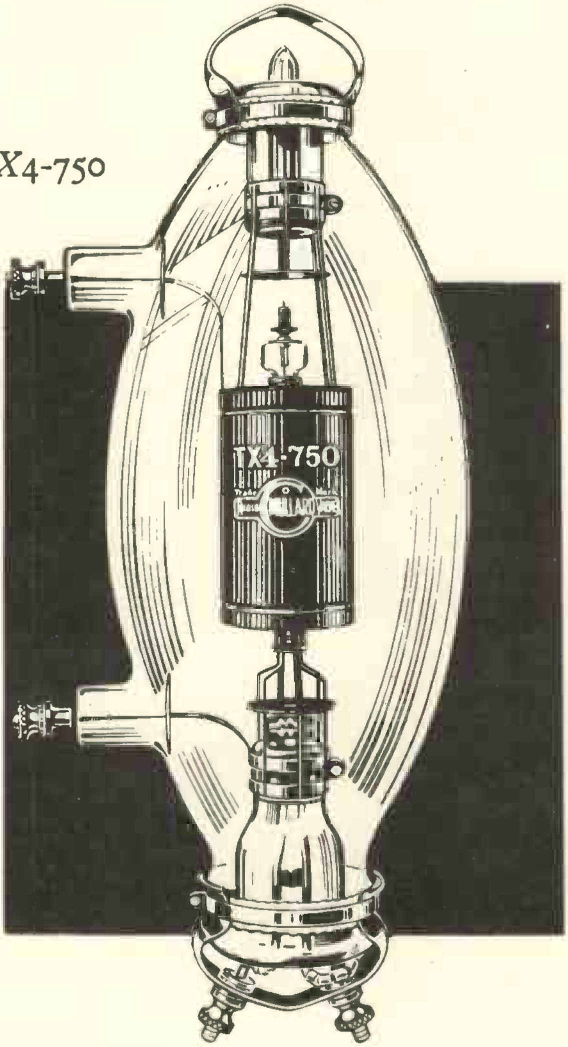

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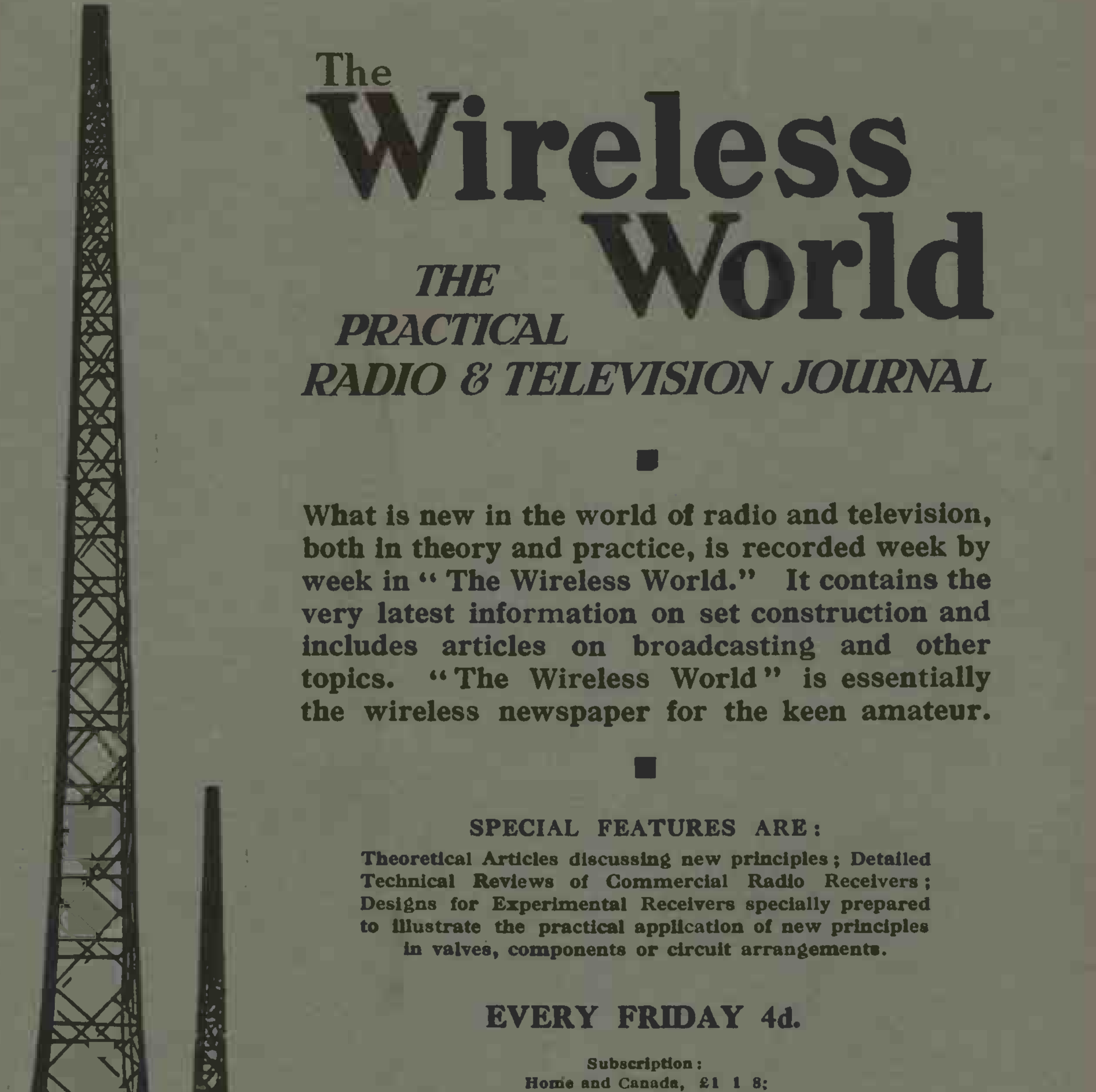

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