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Editorial

Bridge for Direct Impedance Measurement

THERE are many bridges by means of which impedance can be measured, but most of them give the two components from which the impedance can be calculated. There are many cases in which it would be more convenient if, on balancing the bridge, one could read off directly the magnitude of the impedance at the frequency employed, and its phase angle. In the *L.M. Ericsson Review*, Nos. 7 to 9, 1930, Dr. Laurent showed how this applies to the measurement of telephone cable characteristics, and worked out the relevant formulae, using $|Z|$ and ϕ instead of the components R and jX. In our February number we published a paper by Mr. A. Serner in which he described what he called " a new bridge for the direct measurement of impedance," apparently not knowing that the Ericsson Company have manufactured and sold a large number of bridges of a very similar type. The Ericsson bridge was invented by Dr. Torbern Laurent in 1924 and includes some very ingenious devices which make the use of the bridge very simple and straightforward. Serner describes two forms of bridge. The first, shown in Fig. 1, is a variant of the high voltage bridge of Dawes and Hoover shown in Fig. 2 (see A.C. Bridge Methods by B. Hague, p. 333). This bridge was described in the journal of the American *I.E.E.* in 1926. The condenser C in Fig. 2 is replaced by the inductance L in Fig. 1, but this is an obvious variant and in no way alters the principle.

Serner's second bridge, which he calls a simplified form of the first, is shown in Fig. 3, whilst Laurent's bridge is shown in Fig. 4. The differences are that Serner uses (1) condensers instead of the resistances

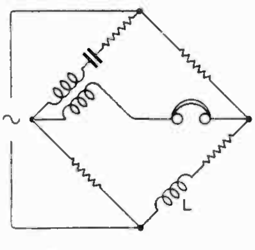

Fig. 1.—Serner.

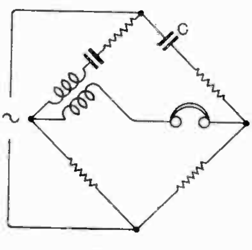

Fig. 2.—Dawes & Hoover.

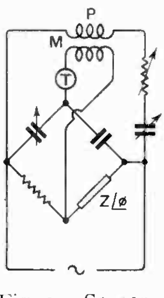

Fig. 3.—Serner.

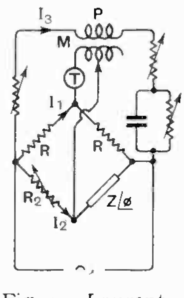

Fig. 4.—Laurent-Ericsson.

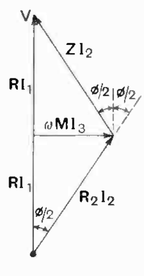

Fig. 5.

R, (2) a single valued mutual inductance, and (3) a slightly different arrangement for bringing the current in the P arm into phase. These are all relatively minor matters. Fig. 5, which is reproduced from Laurent's 1930 article should be compared with Fig. 2 in Serner's paper; it will be seen that they are identical. I_1, I_2 and I_3 are the currents through the R, R_2 and P arms in Fig. 4. By means of resistances and condensers the self-inductance of P is balanced out and the current I_3 brought into phase with the voltage across the bridge. The e.m.f. ωMI_3 induced in the telephone arm is therefore in quadrature with this voltage as shown in Fig. 5, and when a balance is obtained $|Z|$ must be equal to R_2 and $\phi = 2 \tan^{-1} \omega MI_3/RI_1$. By making the resistance of the P arm variable and by bringing out a large number of tappings from the secondary winding of the mutual inductance, the bridge can be made applicable to a large range of frequencies and can be calibrated so that when set for a given frequency, $\phi = 2 \tan^{-1} aM$ where a is a constant, and ϕ is therefore determined solely from the value of M which gives a balance. This simplification is obtained by making the impedance of the P arm proportional to the frequency at which the bridge is to be operated. The shunted condenser and resistance to the right of P balance out its self-inductance, whilst the variable resistance on the left of P makes up the total impedance to the necessary value corresponding to the frequency. This is done by setting the three upper knobs in Fig. 6 (a) (which correspond roughly to the three variable resistances shown in Fig. 4) to the desired frequency. Of the eight decade switches four vary R_2 and give the magnitude of the measured impedance, and four vary the mutual inductance and give tan $\phi/2$. The toroidal mutual inductance wound on a former of insulating material can be seen in Fig. 6 (b); the secondary can be reversed by means of one of the switches in the top right-hand corner of Fig. 6 (a). In the actual apparatus there are several refinements to which we have not referred.

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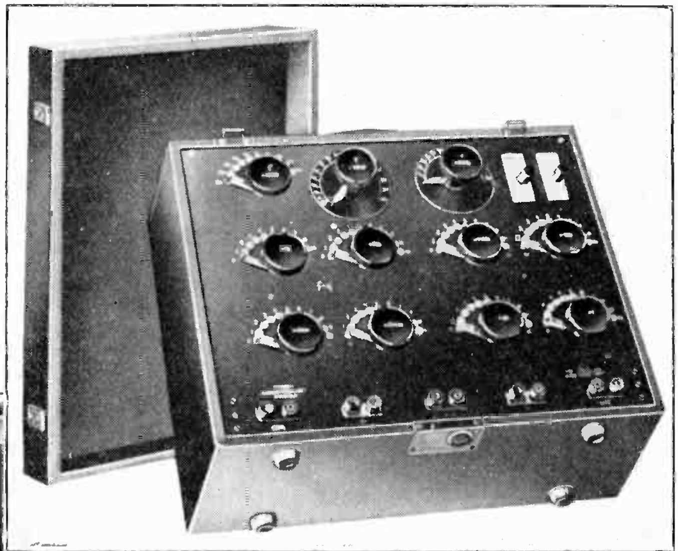

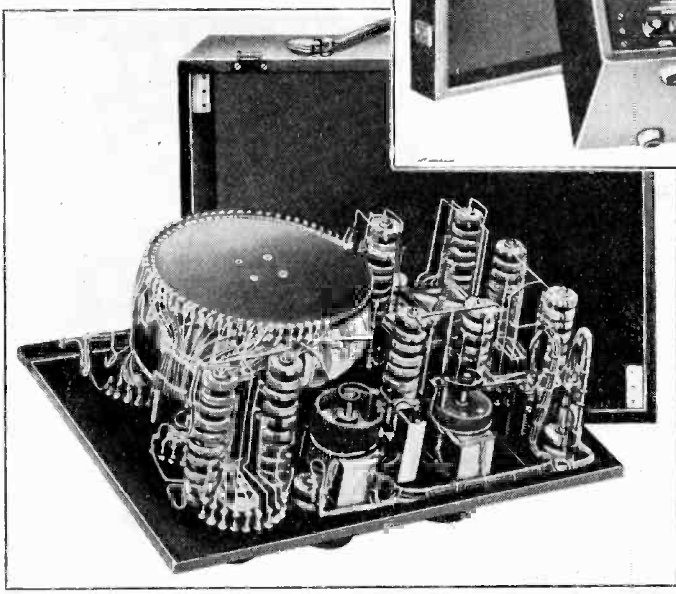

Fig. 6 (a).—*The Ericsson impedance measuring set.*

(*Left*) (b) *The set removed from its case.*

The Control of a Gas-Filled Valve Through a Phase-Shifting Input Valve*

A Versatile Mains-Operated Relay-Amplifier of This Kind

By L. B. Turner, M.A., M.I.E.E.

SUMMARY.—The instrument described, to which the preliminary theoretical examination is directed, is a combination of a high-vacuum triode as input valve serving as phase-shifter for controlling a gas-filled valve as output valve. By the motion of a switch it operates either as a "relay," in which condition an input signal of the order of 1/20th of a volt across ½ a megohm turns on and off a power which may be as large as some 30 watts; or as an "amplifier," in which condition this output power is smoothly controlled by an input signal reaching some ¼ of a volt. It is fed from the A.C. mains, and includes no battery.

The output current is always in the form of unidirectional pulses at the mains frequency. The instrument operates most favourably with input signals either of quasi D.C. (slow-change) type, or themselves derived from the mains; but there is also fitted a small rectifier enabling signals of acoustic or wireless frequencies to be effective. There is only one adjustment, a potential divider which determines the grid bias of the input valve. The instrument is therefore a self-contained relay or amplifier by means of which almost any kind of electrical signal of small strength may be made to control a power adequate for gross switching, heating or other operations which can be effected by unidirectional pulses of current. Provision is made for operation by photo-cell.

The known simple principles of control by phase shift are shown to be inadequate to explain the observed phenomena, which are studied with the aid of oscillograms.

Some additional equipment which has been embodied in the instrument for independent objects, and is referred to as "compensator," enables the output to be controlled by fluctuations of mains p.d. of a few parts in 10,000 when operating as a relay, or reaching a few parts in 1,000 when operating as an amplifier.

The performance of the constructed instrument is described with the aid of graphs showing the experimental observations. It is demonstrated that the instrument may be used to control, with relay-like or amplifier-like action, a bank of gas-filled valves of unlimited capacity.

1. Introduction

THERE is a vast field of electric signalling operations in which the high-vacuum valve is a willing and elegant agent; but it is sometimes pressed into rather reluctant service outside that field. One instance of this is its use as an intermediary between an electric signal of quasi D.C. character and an electro-mechanical switch or relay. For the small vacuous valve as an amplifier has a grid-anode transconductance of only a few milliamperes per volt, and it is not capable in itself of trigger action. The gas-filled valve—of which in this country the British Thomson-Houston Co.'s series of thyratrons are one example, and the General Electric Co.'s gas-filled relay type G.T.1 is another—is an obviously attractive substitute, especially when it is desired to obtain an output much larger than is sufficient to operate a delicate electro-mechanical relay. It provides a relatively very large current with an available power of many watts, and this power may be drawn directly from the A.C. mains; it will give the on-off trigger action of a relay without any mechanically moving contacts; and alternatively it will give continuous amplifier-like regulation of the controlled power. It is well known,†

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† For a recent account of gas-filled valves and their applications, see A. L. Whiteley, "Applications of the hot-cathode grid-controlled rectifier or thyratron," *Journal I.E.E.*, vol. 78 (1936), p. 516. General introductory descriptions of gas-filled valves and their modes of use are given by S. K. Lewer and C. R. Dunham, "Gas-filled relays," *G.E.C. Journal*, vol. III, Nos. 2 and 3 (1932); and by the B.T.H. Co., "Industrial applications of thyratrons," *The Engineer*, Aug. 1934.

however, that the best way of controlling a gas-filled valve* with A.C. anode feed is by adjustment of the phase of the grid excitation (of constant liberal amplitude). In mechanically controlled operations this is, of course, easily effected, as by turning the handle of a condenser or rheostat; but where the input signal is electrical some translator is necessary to enable a small change of electric p.d. to produce the change of phase. The requisite translator is almost inevitably a vacuous valve, to the grid of which the input signal is applied. The fundamental principles are very simple, but it has been found in practice that considerable complexities arise.

2. Basic Circuit Theory

The internal physics of the gas-filled triode leads to a performance which for our purposes may be approximately and briefly stated as follows.† (i) If e_a is the instantaneous anode potential, there is a critical instantaneous grid potential e_c which is equal to $(-e_a)$ divided by a positive constant m called the control factor. (ii) When e_a is negative no anode current flows. (iii) When e_a is positive, the anode conducts immediately the grid potential e_g is greater (algebraically) than e_c. (iv) Once established, current continues to flow until e_a ceases to be positive, whatever e_g may be. (v) The instantaneous value of anode current (if any) is e/R, where R is the external resistance of the anode circuit (here supposed to be devoid of inductance and capacitance), and e is the instantaneous e.m.f. of the source of supply in that circuit.

In the curves of Fig. 1, e_a is portrayed by a full line, e_c by a dot-dash line, and e_g by a dotted line. In accordance with convention, time advances from left to right and potential increases upwards. The phase angle of the grid potential is said to be θ when θ is the *lead* of the grid potential on the anode potential. For compactness e_a and e_c are drawn with the same amplitude, so that the ordinate scale of one is m-times that of the other.

* Especially the usual mercury-filled valve, on account of its intrinsic sensitivity to ambient temperature.

† More accurately, in place of e_a we should write (e_a less 15 or 20 volts), to allow for the ionisation p.d. in the valve. Similarly in Section 5, 15 or 20 volts should be subtracted from e.

Consider Fig. 1 (*a*), in which θ is 180 deg. There is no anode current at any instant.

Consider Fig. 1 (*b*), in which θ is rather more than 180 deg. Anode current flows during the shaded portion of the cycle; and

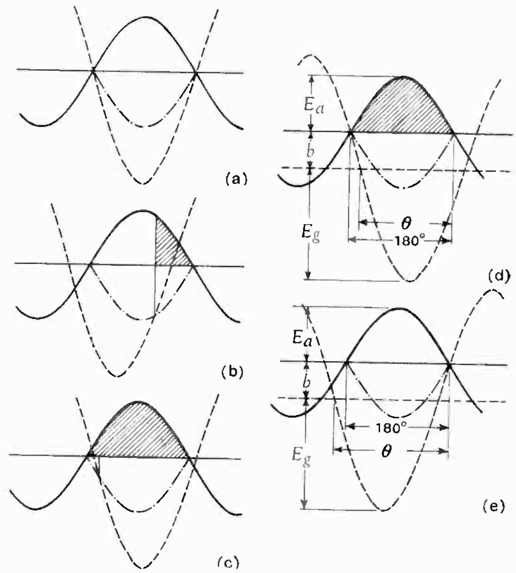


Fig. 1.

if θ is further increased towards 360 deg., the duration of flow will increase towards occupation of the full half-cycle. Thus phase change between 180 deg. and 360 deg. would give continuous control (amplifier-like action) between zero mean current and the full mean current $\frac{1}{\pi}\frac{|E|}{R}$.‡

Consider Fig. 1 (*c*), in which θ is slightly less than 180 deg. Ignition has occurred as e_a rose through zero. Thus as θ decreases through the critical value 180 deg., there is trigger (relay-like) action, the mean current changing suddenly from zero to the full value $\frac{1}{\pi}\frac{|E|}{R}$. As θ is further decreased towards 0 deg., the mean current remains unchanged at the full value.

These considerations are familiar to all who are acquainted with gas-filled valves (but may be a little perplexing to those who are not), and there is no difficulty in providing

‡ If the peak value E_g is about twice the peak value of e_c, the mean current has half full value at $\theta = 240$ deg.

phase-shifting devices suitable for manual operation.* In the descriptions of such devices it is customary to assume that grid current is made of no account by connecting the grid circuit to the grid via a large resistance (e.g. 10 kΩ to 1 MΩ). It should be noticed that according to this account of grid-phase control, whereas pure A.C. excitation is capable of giving satisfactory amplifier-like performance, it is not capable of giving the performance we are accustomed to expect from a relay. It is true that as the operative signal (i.e., a decrease of θ) causes θ to pass through a critical value (180 deg.), the mean current leaps discontinuously from zero to full value; but an applied signal of reverse sign (i.e., an increase of θ from 180 deg.) also produces a current, albeit a rise of continuous and not explosive character. In a relay we expect a reverse signal to have no effect on the output circuit, and there are many applications of relays in which this characteristic is essential.

To remedy this defect in the relay-like control it is necessary to add a negative D.C. bias to the A.C. excitation of the grid. Let this negative bias be $-b$. Conditions just after ignition are now shown by Fig. 1 (*d*). A reverse signal no longer has any effect until it is so large that the condition of Fig. 1 (*e*) is reached. A further increase in the strength of the reverse signal thereafter effects a gradual rise of mean current from zero. In Fig. 1 (*d*), $\theta = 180 \text{ deg.} - \sin^{-1}\frac{b}{|E_g|}$; and in Fig. 1 (*e*), $\theta = 180 \text{ deg.} + \sin^{-1}\frac{b}{|E_g|}$; so that the reverse signal must reach a strength sufficient to change the phase through $2\sin^{-1}\frac{b}{|E_g|}$ before causing any current to flow. For satisfactory relay performance $\frac{b}{|E_g|}$ should therefore, on this analysis, be so large that, with the particular phase-changing device employed, no reverse signal is competent to shift the phase as much as $2\sin^{-1}\frac{b}{|E_g|}$.

* There seems to be a mistake in this connection in the paper by Lewer and Dunham (*loc. cit.*, p. 229). Their Fig. 40*c* is said to be suitable for trigger action, but it is adapted for phase shift above and below 270 deg. and not about 180 deg.

We now consider how the phase angle θ is to be made dependent on an input signal in the form of an electric p.d.; that is, in effect, how the gas-filled valve is to be controlled, not by rotating the knob of a condenser or a resistor or a polyphase phase-swinging transformer, but by changing the potential of the grid of a vacuous valve.

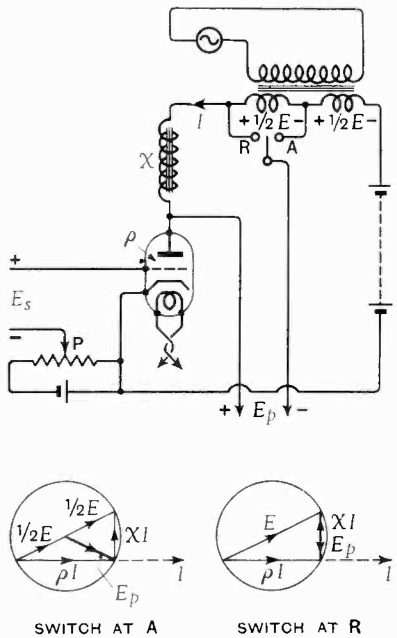


Fig. 2.

If these fluctuations of potential are of a quasi D.C. character, it seems that, whatever circuit is adopted, its action must depend on change of anode resistance with change of grid potential; the valve must be worked in the curvilinear and not the rectilinear region of its characteristics. A circuit working in this way is shown in Fig. 2. Here the anode circuit contains an alternating e.m.f., so its resistance undergoes cyclic change; harmonics must be introduced into the anode current and exhibit themselves as a p.d. across X. But if we ignore these harmonics—and they could be rendered ineffective by some filter provision—we can make an approximate analysis by treating the anode resistance ρ as a constant—say, its actual time-mean value during a cycle—but a constant which can be raised and lowered by the potential divider P or by the appearance a D.C. signal E_s. Taking ρ as constant, and X a pure reactance, and letting E, E_p and I stand for the vector quantities, we get the two vector diagrams shown. The phase-controlled e.m.f. E_p is controlled by the value of ρ, and is available for application to the grid of a gas-filled valve whose anode excitation (we will assume) is in phase with E.

It is seen from the vector diagrams that, according to whether the switch is at R or at A, E_p is the vector $_rE_p$ or $_aE_p$ respectively, where

$$_rE_p = |E| \frac{X}{\sqrt{X^2+\rho^2}} \underline{\big| 180 \text{ deg.} + \tan^{-1}\frac{\rho}{X}},$$

$$_aE_p = \tfrac{1}{2}|E| \underline{\big| 180 \text{ deg.} + 2\tan^{-1}\frac{\rho}{X}}$$

The phase angles of both these vectors are most sensitive to fractional change of ρ when ρ is equal to X, when they are 225 deg. and 270 deg. respectively; and they are quite insensitive when ρ/X is zero or infinity. It is therefore desirable to work with values of ρ neither very much smaller nor very much greater than X. To permit this, a suitable non-variable phase-changing circuit can be interposed between E_p and the grid of the gas-filled valve. If the grid potential is retarded (say) 30 deg. behind E_p, as in Fig. 3 for example, we obtain a relay threshold (θ near 180 deg.) with $\rho = 0.58\,X$, and a mid-amplifier condition (say θ near 240 deg.) with $\rho = X$.* The single-pole two-way switch RA (Fig. 2) converts the circuit from relay working to amplifier working. Note that with ρ near $0.58\,X$, the magnitude of $_rE_p$ does not vary rapidly with ρ, and is about $0.86\,|E|$; and the magnitude of $_aE_p$ is constant and equal to $\frac{1}{2}|E|$. Control of the output current from the gas-filled valve would therefore depend upon θ substantially as described with reference to Fig. 1. With the switch at R the output current would change from zero to full on *decreasing* ρ through a critical value; and with the switch at A the current would grow with *increasing* ρ.

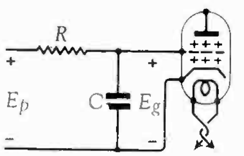


Fig. 3.

With the conditions assumed, however, these adjustments are not satisfactory: some negative bias must be added to the grid of the gas-filled valve to prevent a reverse signal from being effective. With the switch at R (Fig. 2) the greatest phase displacement which can be produced by a large reverse signal (in Fig. 2, E_s large and positive) must be less than that which corresponds with the change from $\rho = 0.58\,X$ to $\rho = 0$; i.e., less than a change of 30 deg. Ignition by a reverse signal, however strong, is thus prevented by a D.C. bias b such that

$$2\sin^{-1}\frac{b}{|E_g|} \not< 30 \text{ deg., i.e., } b \not< 0.26\,|E_g|.$$

3. Phase Control in the Actual Instrument

The circuit adopted, based on those in Figs. 2 and 3, is shown in Fig. 4. It will be seen that the output valve is the mercury-filled Osram G.T.1, and the input (phase shifting) valve the vacuous Osram M.H.4, with D.C. supplies derived from a Westinghouse metal rectifier. The G.T.1 valve has a control factor m of 25 or 30; its anode is excited with $|E| = 250\sqrt{2}$ volts, so that the critical grid potential e_c has a peak value

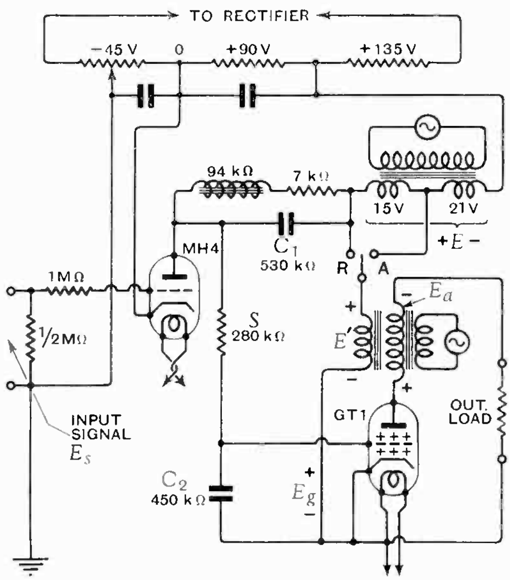


Fig. 4.—*Actual control circuit of RAC instrument.*

* The actual values are affected by any appreciable current taken by condenser C—which current is here neglected.

of 14 or 12 volts. The grid is excited from a source of 36 V (r.m.s.), supplemented by the e.m.f. E' (3.6 V) referred to below. The condenser C_1 (0.006 μF) was inserted with a view to reducing the harmonics due to mains impurity, which would otherwise appear reinforced across the inductor L (300 H). The reactance values marked are for 50 c/s.

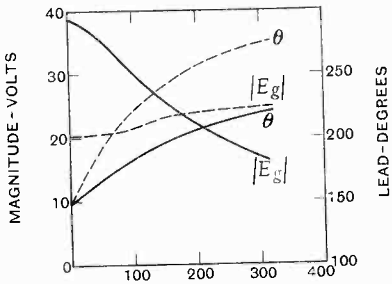


Fig. 5.—*Magnitude and phase of grid potential* $E_g\underline{|\theta}$ *Full lines = Relay connection, Dotted lines = Amplifier connection.*

On our assumption that the effect of the grid current taken by the G.T.1 valve may be neglected, it is calculated from the dimensions given in Fig. 4 that the potential of the grid is in the relay connection,

$$ {}_rE_g = F[E - E'(1 - j\,0.0081\rho)] $$

and in the amplifier connection,

$$ {}_aE_g = F[E - (E' + 15)\,(1 - j\,0.0081\rho)] $$

where the units are volts and kilohms, $j = \sqrt{-1}$, and

$$ F = \frac{-1}{(0.0051\rho + 1) - j(0.0059\rho - 0.62)}. $$

In the actual instrument the vectors E and E' are in phase and have magnitudes $36\sqrt{2}$ and $3.6\sqrt{2}$ volts respectively. Fig. 5 gives the magnitudes of ${}_rE_g$ and ${}_aE_g$, and their angles of lead with respect to E, as calculated from the above formulas. It shows that, according to the theory we have set out, and neglecting the minor effects of small added D.C. bias and the not quite constant magnitude of ${}_aE_g$, we should expect the relay to trip (θ near 180 deg.) as ρ is decreased through a critical value near 90 kΩ; and that amplifier current would increase with increasing ρ, passing through its mid value (θ near 240 deg.) somewhere near 145 kΩ.

In the actual instrument ρ is roughly known* for each position of the knob which controls the grid bias of the input valve. It varies between 80 kΩ and 400 kΩ over the range of adjustment (about 2 V), the corresponding mean anode currents being 400 μA and 50 μA respectively. At the observed amplifier mid-current position ρ is about 140 kΩ†, and current increases with increasing ρ. In the amplifier behaviour, therefore, no marked discordance from the theory is apparent. But the relay phenomena are in striking contrast with the above theoretical predictions. (i) The change from zero to full current occurs with increasing ρ (*c.f.* decreasing); (ii) the threshold occurs where ρ appears to be about 270 kΩ (*c.f.* 90 kΩ); and (iii) a small current is usually to be observed before the threshold, growing smoothly up to the point where a large discontinuous jump occurs. Effort was made to force a relay threshold at a low decreasing value of ρ, by applying external positive bias to the input grid, and short-circuiting the 1 MΩ grid resistor normally inserted (see Fig. 10); but the expected threshold was never attained.

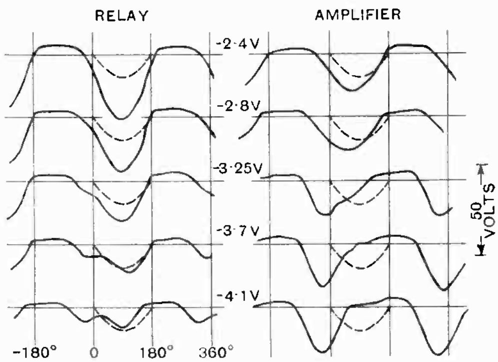


Fig. 6.—*Potential of grid of gas-filled valve (anode disconnected) at marked values of grid bias of input valve.*

The divergence of the observed phenomena from those predicted in Sections 2 and 3 might, it was recognised, find explanation in the neglected effects of the current taken by

* Measured as a small added constant e.m.f. (4.5 V) in the anode circuit, divided by the change of mean anode current thereby produced, while the alternating e.m.f. E (Fig. 4) was present.

† The closeness of this agreement with 145 kΩ is certainly fortuitous.

the grid of the gas-filled valve, and in the inconstancy of the anode resistance ρ of the input valve. An oscillographic examination was therefore undertaken. Fig. 6 is a series of oscillograms carefully traced from the cathode-ray tube, showing the actual cycle of potential of the grid of the gas-filled valve at various settings of the grid bias of the phase-shifting valve. In these tests, in order to prevent ignition the anode was disconnected; but to exhibit in the figure the conditions governing ignition when the anode circuit is completed, the phase of the anode supply p.d. is shown (anode positive from 0 to 180 deg.), and the curve of critical grid potential is drawn (dotted) correct to scale for anode potential 250 V (r.m.s.) with a control factor midway between the rated limits 25 and 30. These oscillograms proclaim that the actual grid potential has nothing like the constantly sinoidal form assumed in Section 3. First, the potential has a large negative mean value. A small part of this is due to the D.C. drop across the 7 kΩ of resistance in the inductor (Fig. 4), but clearly it is mainly due to the collapse of the grid resistance (in comparison with 250 kΩ) when the potential becomes a few volts positive. This is the thermionic effect familiar in vacuous valves; for the oscillograms show that the grid potential never rises enough to ionise the gas. Second, there is a marked distortion of the negative parts of the curves, especially in the relay connection, growing in severity with the successive increases in negative grid bias of the input valve.

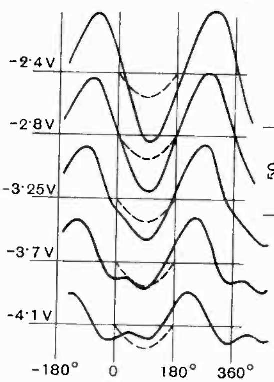


Fig. 6a.—*Grid potential in relay connection with cathode cold.*

It was not apparent from these oscillograms how the responsibility for this distortion is divided between grid current and inconstancy of ρ during the cycle. Another set of oscillograms was therefore taken, in the relay connection, with the cathode of the gas-filled valve left unheated. These are reproduced in Fig. 6a, and should be compared with those on the left of Fig. 6. Fig. 6a shows that if the influence of grid current were absent, a normal relay thres-

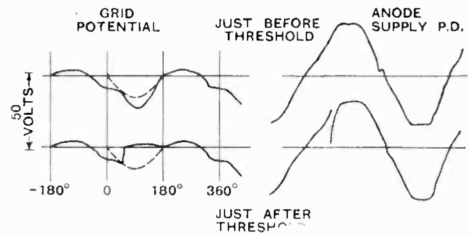


Fig. 7.—*Relay action. Load = resistance* 1000Ω *Grid bias of input valve about* -3.5 *V.*

hold (i.e., in accord with the treatment in Sections 2 and 3) would be encountered in passing from -3.25 V to -2.4 V. Indeed, by a happy chance, the curves at -2.8 V exhibit almost exactly the critical situation of Fig. 1 (*a*).

We should expect from the oscillograms in Fig. 6 that, in the relay connection, at -2.4 V there would be no current, at -2.8 V and -3.25 V there would be a tiny mean current, and between -3.25 V and -3.7 V the mean current would jump suddenly to a large value not far short of what we have referred to as full value. These predictions from Fig. 6 are amply confirmed by the oscillograms in Fig. 7, and by the behaviour of the actual instrument. In both curves of Fig. 7 the incidence of anode current is evident on the curves of potential. The grid curve (left) is profoundly altered, owing to the cloud of positive ions which suddenly envelops the grid. The right curves show the p.d. of the 250 V secondary winding of the transformer supplying the anode circuit. Since the primary of this transformer is connected to the mains, in ordinary circuits there would appear across the secondary a p.d. of sine shape (or as near thereto as is the shape of the mains p.d.). But when the load on the transformer is a resistance in series with a gas-filled valve, on ignition at a moment of large anode potential the rate of rise of anode current is enormous. The kink in the upper right curve of Fig. 7, and the apparent gap in the lower curve, exhibit the leakage-reactance drop of the transformer when this change occurs. The gap, of course, is in reality closed by a nearly vertical line traversed by the oscillograph spot with a speed so great as to be invisible on the screen.

A small current setting in before the main relay threshold is reached has been observed throughout the empirical development of the instrument. In the early stages efforts were made to avoid it. This was found possible, but only with some sacrifice in other directions, for example, in shape of the amplifier response curve. Fig. 8 is an oscillogram of

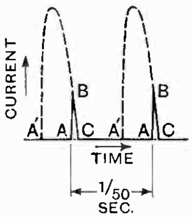


Fig. 8.—*Output current of RAC as relay. ABC when signal just below threshold: A′BC when signal just above threshold. Load = resistance.*

the output current in a resistance load. The chief practical significance of the small pre-threshold current is that when the instrument stands, perhaps month in month out, ready to relay a signal which seldom comes, the gas is ionised 50 times a second without cessation. It was feared that this might reduce the life of the valve; but Mr. Whiteley states* that the number of ignitions does not affect the life. In any case, the anode potential and current in these pre-ignitions is small; and the author is informed that a life of thousands of hours may be expected.

Turning now to the amplifier mode of operation, this is shown by the oscillograms on the right of Fig. 6 and in Fig. 9. These make the action quite plain, and are consistent with the observed behaviour of the instrument. There is nothing critical in the amplifier régime, and there is no experimental difficulty in obtaining satisfactory performance. Distortion of the grid potential curve is of relatively small significance, affecting only the shape of the response curve. By empirical adjustments of the phasing network, especially of E', S and C_2 (Fig. 4), the shape can be modified a good deal. In the present instrument the values finally adopted are the result of effort to obtain as rectilinear a relation as possible between input signal and output mean current without detriment to good performance as relay. The results reached will be seen in subsequent figures. Higher amplifier sensitivity could have been provided if rectilinearity of response, and provision for relay working in the same instrument, had been sacrificed.

* *Loc. cit.* p. 229 (p. 537 Discussion at Manchester).

4. Details of the Instrument

In Fig. 10 the complete circuit diagram, and dimensions of all component parts, are given; and in Fig. 11 a photograph showing the external disposition. Fig. 10 will be intelligible as regards R (relay) and A (amplifier) from the foregoing discussion with reference to Fig. 4. As regards C ("compensator"), this is not at all involved with R and A, and was included only for convenience in a contemplated particular application of R and A. The C component parts are enclosed in a dotted line in Fig. 10, and are marked C_1, C_2, C_3 in Fig. 11. The C function of the triple instrument RAC is briefly referred to in Section 6.

It will be seen from these figures that the whole apparatus is mounted on an aluminium panel, and is fed from a single connection to the A.C. mains (200 V, 50 c/s) through a switch *a* (Fig. 11). On the top of the panel are the output terminals *b*, which allow the output circuit to be connected direct or through a carbon lamp *d*. There is a panel

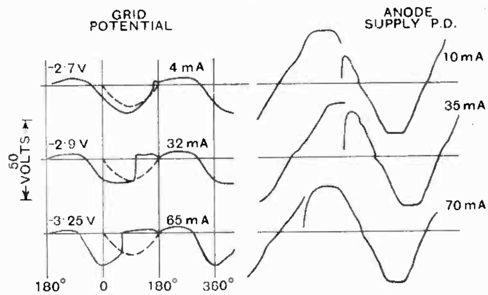


Fig. 9.—*Amplifier action. Load = resistance 1000Ω. Marked values of mean output current and grid bias of input valve.*

terminal *e* to be connected to earth, and three input terminals *f*, one of which is used for input signals of D.C. nature, one for signals themselves derived from the mains, and one for acoustic and higher frequencies. *g* is the switch for changing from relay to amplifier working. The only adjustment is by the knob *h*; this is scaled in tenths of a volt of negative grid bias of the input valve, and serves for relay and amplifier working. *i* is an ammeter showing the mean value of the output current, provided with a shorting switch *j*. *k* is a thermal-delay switch to protect the gas-filled valve while its cathode is warming up; and *l* is a fuse bulb to save this valve in the event of a misconnection. *m* is a group of seven terminals, shown as small black discs in Fig. 10, available for supplies to external apparatus (if any), such as a photo-cell or an amplifier valve.

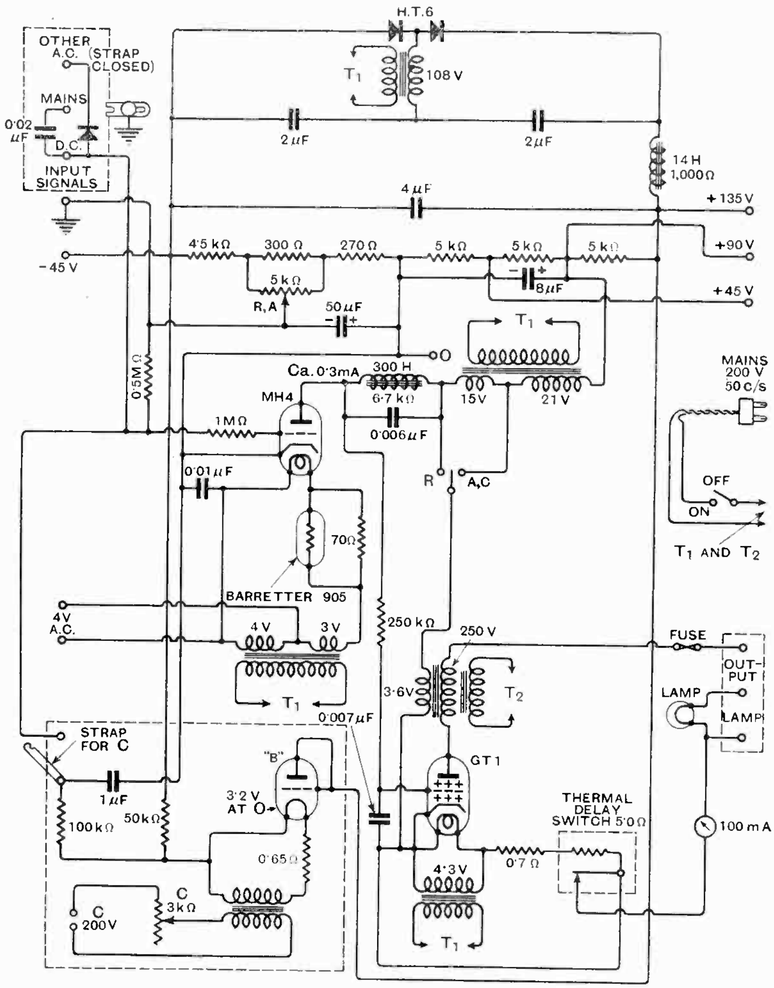


Fig. 10.—*Complete circuit diagram of RAC instrument.*

An important consideration in the design of any such instrument is that it must not be seriously affected by fluctuations of mains voltage. It was considered specially desirable in this instrument to keep the relay threshold as fixed as could be contrived. Now a rise of (say) 5 per cent. in mains voltage produces an equal fractional rise in the D.C. supplies to the anode and grid of the input valve, and in the A.C. anode and grid excitations of the output valve, and in the heaters of both valves. Each of these changes produces its effect on the relay threshold; but fortunately these are not all of the same sign, and it is theoretically possible over a limited range of mains fluctuation, by a partial reduction of one or more component effects, to reduce the overall effect to zero. The table gives an idea of the relations between certain component effects of a 10 per cent. rise of mains voltage, expressed as change of grid bias of the input valve at threshold.

Various schemes were investigated. In one a neon stabiliser held constant the D.C. anode supply, and a suitable portion of the D.C. grid supply, to the input valve. This was capable of complete over-all correction for slow mains changes (which are most to be feared because they reach large values at

Portion of instrument subjected to mains change.	Effect on threshold.
Anode supply to output valve, only	+0.14 V
Heater of input valve, only . .	−0.08 V
All except heater of input valve . .	+0.05 V

times); but, by its interference with the inherent fairly complete cancellation of the grid and anode effects on the input valve, it seriously increased the disturbance from a sudden change in the mains during the succeeding minute or so while the heater settles down to its new temperature.* The expedient finally adopted, shown in Fig. 10, was to use a "barretter" (Philips' "regulator lamp 905"), arranged to suppress about two-thirds of the change of p.d. on the heater of the input valve. This can be made to compensate slow changes almost perfectly over a wide range of mains fluctuation; and since the heater effect alone considerably exceeds the net result of all the other effects, the momentary change of threshold caused by sudden mains fluctuation is small also. Approximate compensation for both slow and sudden mains fluctuations is facilitated by the thermal lag of the barretter, which offsets the thermal lag of the valve heater.† Fig. 12 shows the observed resultant effect for slow changes.‡ The compensation, adjusted for

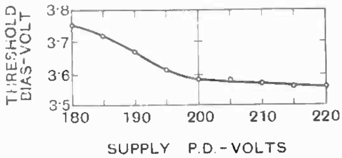


Fig. 12.—*Mains fluctuation and relay threshold.*

relay threshold, cannot be complete over the range of amplifier action. Fig. 13 shows, however, that between 200 V and 220 V the response is very little affected by mains fluctuation.

A relay of any sort in which, as in this, the threshold is smoothly adjustable can be operated with a sensitivity which is limited only (i) by the wandering of the threshold, and (ii) by various forms of retroaction from the output on the input system. Retroaction of a sort which makes the output signal tend to sustain itself causes "backlash," that is an off-threshold distinct from the on-threshold; and retroaction of the opposite sort produces "dither," that is a region of anomalous vacillation or even of quite regular oscillation. In an all-electric relay such as this, where an input power of (say) 2×10^{-8} of a watt (one-tenth of a volt across half a megohm) may control an output power one thousand million times greater, the minimisation of these evils calls for a good deal of thought and experiment. In the present instrument it is backlash, which may amount to as much as 0.05 V, which chiefly limits the sensitivity. It

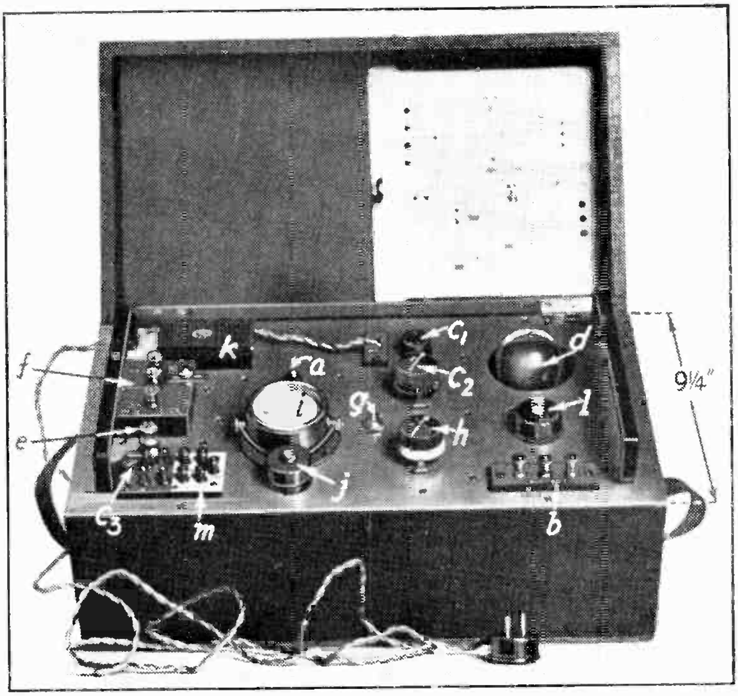


Fig. 11.—*The instrument RAC.*

* This was one reason for abandoning the neon stabiliser. Another was that the striking p.d. of the stabiliser, which began with the rated value of 125 V, after some use (and without, it is believed, any misuse) fell to 104 V.

† Concomitant with this property of a barretter is its sensitivity to ambient temperature, which is sometimes regrettable.

‡ For a nominal p.d. of 200 V the adjustment is not quite at its best, the heater fluctuation having been slightly over-compensated.

is with the object of reducing backlash and/or dither that the auxiliary e.m.f. E' (Fig. 4) is introduced. It was found that the adverse effects of the violent upheaval accompanying ignition of the gas-filled valve could be much reduced by the injection of this e.m.f., taken from the transformer which feeds the anode of that valve.

Experiment seemed to show that the resistor (250 kΩ) in series with the grid of the gas-filled valve must be large, and that the inductor (100 H) in the anode circuit of the input valve should preferably have an air-gap in the core.

Finally, with a mercury-filled valve the question of ambient temperature has to be considered. It is quite feasible to compensate for changes of ambient temperature,

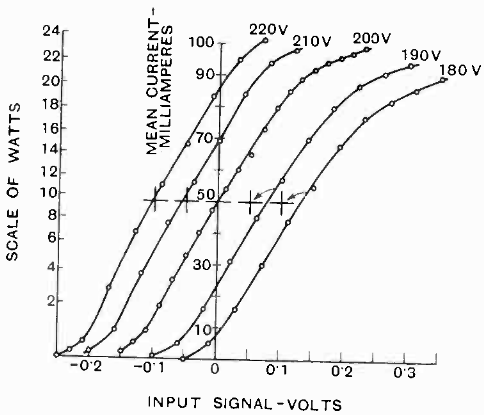


Fig. 13.—*RAC as amplifier for D.C. signals. Load = resistance 570Ω. Abscissa scale numbered for 200 V curve. Others displaced 0.05 V successively.*

for example, by introducing an appropriate amount of nickel as the resistance material between 0 and + 135 V in the chain of resistors (Fig. 10) connected across the 4 μF rectifier smoothing condenser. Moreover, if this nickel is wound on a paper or copper former slipped closely over the conical end of the gas-filled bulb (which is the cooler end and so determines the mercury pressure), the effect of a rise of temperature of the valve due to a long-continued signal will also be compensated.* In the present instrument, however, when it has not been freshly switched on, the temperature effect is not large enough to justify the complication. Fig. 14 shows a series of observations taken over a period when the ambient temperature slowly rose and fell through a wide range.

The temperature effect can be sensibly abolished, even directly after switching on, by the substitution of an argon-filled for a mercury-filled valve; and it has been

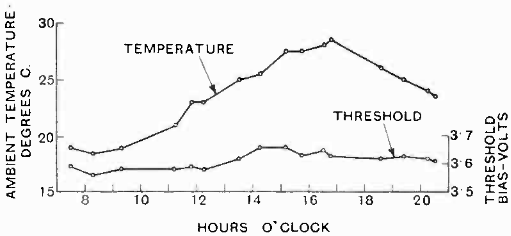


Fig. 14.—*Ambient temperature and relay threshold.*

ascertained that the substitution of an argon (or another mercury) valve does not upset the behaviour of the instrument. But the mercury valve has proved so satisfactory that it has been retained on account of its longer life and freedom from gradual clean-up of gas.

5. Operation by A.C. Signals

The instrument was originally intended for input signals of D.C. nature, and it has so far been discussed in that relation. During the course of the work, however, it was found that as good performance was obtainable with A.C. signals of mains frequency. It is easy to see how this occurs. The input valve and its inductor form an excellent amplifier for a frequency such as 50 c/s; the valve has an amplification factor of 40, and the inductor has reactance about equal to the anode resistance. A signal of 50 c/s impressed on the grid therefore reappears across the inductor much magnified and displaced in phase by some 45 deg., the phase being controlled by the grid bias just as the fixed e.m.f. injected in the anode circuit is controlled. It is found that, whether as relay or amplifier, good response is got from input signals derived from the mains without phase change; but some improvement in relay operation is got by advancing the phase 20 deg. or so. In the amplifier régime, signals which are syn-phased or which have this same advance give sensibly equal per-

* This device was found effective in another connection.

formance. The input terminal labelled "mains" (Fig. 10) is provided for use when syn-phase mains-derived signals are to actuate the instrument. Fig. 15 shows the observed performance with such signals.

The instrument having proved already so adaptable to a variety of uses, it was tempting to make the trifling addition to render it usable with input signals of any frequency. A tiny copper-oxide rectifier, consisting of one pair of elements extracted from a Westinghouse "Westector WX6" is located, with the 0.02 μF condenser, below *f* in Fig. 11, and is seen at the top left in Fig. 10. The appropriate input terminal being used, and the "mains" terminal being connected to panel by the strap, input signals of any frequency are rectified and applied to the grid. Fig. 16 gives the performance as amplifier over a range of frequencies extending from 50 c/s to 10^6 c/s. In this series the mains frequency was included for theoretical interest. In practice it is a unique privileged frequency, giving much better performance when applied to the special terminal provided

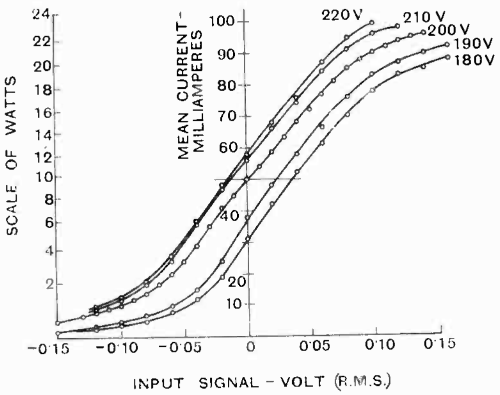


Fig. 15.—*RAC as amplifier for mains-frequency signal. Load = resistance 570Ω.*

for it. For the 50 c/s signals it was necessary to connect an external condenser of 0.25 μF across the 0.02 μF; and for the 0.1 kc/s signals a 2 μF condenser was so connected in order to suppress the beating with the mains which otherwise occurred. The other curves, 1 kc/s to 1,000 kc/s, were taken with nothing added.

For signals applied to the "D.C." and "mains" terminals, the input resistance of the instrument is, of course, 0.5 MΩ. For signals applied to the "other A.C." terminal it is only about 40 kΩ (measured with 0.5 V at 100 kc/s).

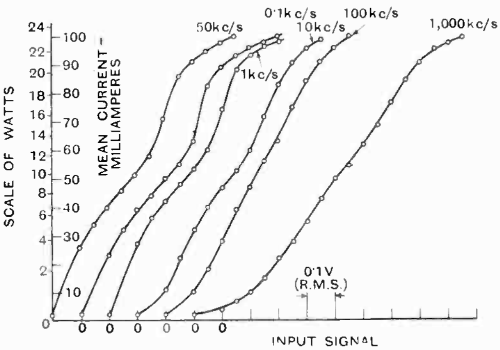


Fig. 16.—*RAC as amplifier for signals of any frequency. Load = resistance 570Ω. Curves separated by successive horizontal displacements through* 0.1 *V*.

6. Compensator C

During the early work on this instrument the author was seeking some device by which a minute change of A.C. mains voltage should produce a large effect.* This led to the inclusion in the present instrument of the parts ringed in Fig. 10, and labelled C_1, C_2, C_3 in Fig. 11. The mains whose fluctuations are to be effective are plugged to C_1, and their r.m.s. p.d. determines the filament temperature, and therefore the saturated emission, of the tungsten-filament valve labelled "B"† (Fig. 10). In this way the grid bias of the amplifier (or relay) input valve is determined with great delicacy by the mains voltage. The rheostat C_2 (Fig. 11) determines what value of the p.d. at plug C_1 shall bring the amplifier or relay on to its working range. In the present instrument the knob of this rheostat is scaled for departures of $\pm$ 10 per cent. from 200 V. When the compensator is in use, i.e., when the strap provided connects the two terminals C_3 together, control of the instrument is transferred from knob *h* to knob C_2.

Fig. 17 shows that a change of 20 or 30 parts in 10,000 in the supply p.d. at C_1

* Possible applications of such a device will suggest themselves to the reader. The particular application contemplated by the author still awaits development.

† An old army "B" transmitting valve, relic of the war of 1914–18.

suffices to cover the whole amplifier range. With relay operation a fraction of this, say, 2 or 3 parts in 10,000, can control the whole output. The curve in Fig. 17 was obtained indirectly by temporarily substituting a battery for the filament transformer, and using a circuit adapted to produce very small calculable changes of p.d. across the filament and its 0.65 Ω resistor.

7. Conclusion

We have seen that with the phase-shifting arrangements of the present instrument the relay action of the gas-filled valve is profoundly modified by the occurrence of grid

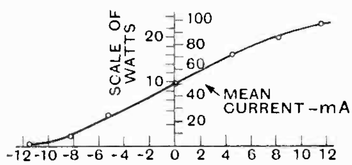


Fig. 17.—*RAC as compensator. Load = resistance 570Ω.*

current. It is customary to suggest that the insertion of a large resistance in the grid circuit of a gas-filled valve removes grid-current effects. In a limited sense this is true, because the grid exerts its control on the anode circuit only while its potential is negative, and then its own resistance is very high. In an all-resistance network fed from a constant A.C. source, the unavoidable plus/minus asymmetry of the grid conductance of a gas-filled valve would not be significant. Given two constant sources, phase-displaced, we could combine them in magnitude proportions determined by an input valve used as a " resistance amplifier." The resultant e.m.f. would be phase-controlled by the signal applied to the input valve, and could be applied to the grid of a gas-filled valve : we should have achieved our aim without resort to reactance. It would be a subject for further research to decide whether some such reactance-free scheme could be given favourable practical shape. The author's present opinion is that it could not.

If phase-shifting circuits employing reactance are used, it is not possible to liberate that part of the cycle when grid current does not flow from effects of the grid current which has flowed during the preceding part of the cycle. (Compare, for instance, the top left curve in Fig. 6 with the top curve in Fig. 6*a*.) For this reason it is suggested that the interest of the foregoing study of the action of a certain constructed relay-amplifier is not confined to this particular instrument or to the particular circuit adopted therein.

Turning again to the actual instrument, its versatility and ease of operation clearly make it a useful tool in a diversity of circumstances. Two applications are here quoted as examples. It has been used to actuate an electromagnetically driven mechanism, under the control of a beam of light incident on a photo-cell, which was connected across the D.C. input terminal and one of the terminals *m* (Fig. 11). With the lamp *d* (Fig. 11) in circuit, no additional apparatus was required beyond a smoothing condenser for the 50 c/s pulses across the electromagnet. A more important application, which has been in intermittent operation for over a year, illustrates the use of the instrument with input signals themselves derived from the mains. A chamber, designed to maintain its temperature constant to 1/1000th of a degree, receives part of its heat supply from the output terminals of the relay, automatically switching this heating power on and off according to the out-of-balance p.d. across a temperature-sensitive Wheatstone bridge which is itself fed from the mains.* In this application the importance of constancy of relay threshold is obvious.

The output of the self-contained instrument is limited to about 30 watts. If for any operation to be controlled a larger power is required, it may be provided, without resort to mechanical switching, by making the output circuit of the present relay-amplifier instrument control the grids of an external bank of gas-filled valves. These may control a power limited only by their capacity. To verify that this could be done, the circuit of Fig. 18 was erected, and was controlled in parallel with the heating circuit of the isothermal chamber referred to above.

* This apparatus will be described in a paper to be read at the Institution of Electrical Engineers on May 5, 1937.

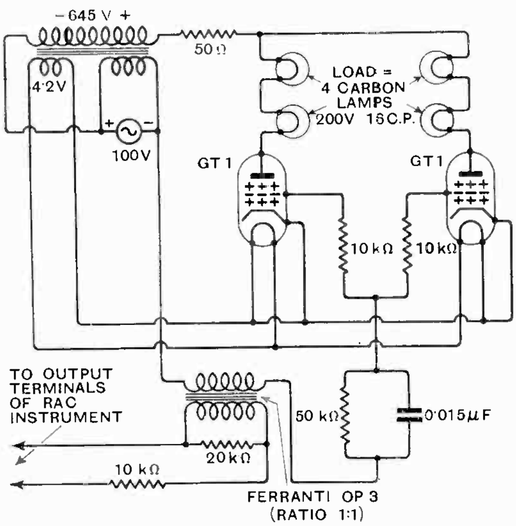


Fig. 18.—*To illustrate control of large power.*

It was found to work well, in both the relay and the amplifier modes; and obviously it could be extended indefinitely by using more and/or larger gas-filled valves in parallel. The power controlled in the demonstration set-up exceeded $\frac{1}{4}$ kilowatt, and it was switched on and off, or alternatively smoothly varied, in sympathy with the demands made by the chamber as it became too hot or too cold by a fraction of a thousandth of a degree.

Acknowledgment

I wish to record my thanks to the General Electric Co. and Mr. C. C. Paterson for kindly providing an argon-filled valve for these experiments; and in the early stages of the work for general advice on gas-filled valves, received especially in conversations with Dr. A. C. Bartlett and Mr. C. R. Dunham.

Book Review

Television Cyclopedia

By Alfred T. Witts. Pp. 151. Published by Chapman and Hall, Ltd., 11, Henrietta Street, London, W.C.2. Price 7s. 6d.

Although television comes as a new subject to many who have hitherto been interested only in radio and sound equipment, it has really been an object of research for many years and a specialised vocabulary has consequently grown up among those engaged on it. This is apt to be rather confusing to the newcomer and a book containing authoritative definitions of the words and phrases employed is to be welcomed.

The Television Cyclopedia sets out to provide such definitions and in large measure it succeeds, although the descriptions are not always as clear as they might be. Unfortunately, a number of errors has crept into the text which considerably mars the book; mis-statements of fact are, of course, always to be deplored, but they are especially serious in a reference book.

Probably the most important error occurs in the description of the Miller effect which is described as "The name given to the action of a thermionic valve that causes the effective input impedance to vary." Miller effect certainly affects the input impedance—but it is not the only factor which can influence it—and it does so because of feed-back through the grid-anode capacity of the valve, which is not even mentioned in this connection! A few lines further on the following surprising statement occurs—" . . . when the load impedance is capacitative the (input) resistance becomes negative . . . ." It is, of course, well known that an *inductive* load impedance is necessary to produce a negative input resistance.

When dealing with the C.R. tube the author states that the deflectional sensitivity is proportional to the voltage difference between the plates when it is clearly the deflection which is proportional to this voltage. His description of diode detection is misleading, partly through over-simplification and partly because he does not take into account the impedance of the load circuit. Some objection might also be made to his definition of the word demodulation, which he lists as an alternative name for detection. Such a meaning is correct in America, but in this country it is more often used in the sense of reducing the depth of modulation (*cf* the apparent demodulation of a weak signal by a strong).

Among the purely television terms the definition of plastic distortion is incorrect. It is "A type of distortion that may occur in a cathode-ray tube reproducer due to a weak reception of the synchronising signal." Actually plastic has rarely, if ever, anything to do with synchronising, and it is caused chiefly by phase distortion, although frequency distortion also exercises an effect.

In spite of these errors the book is on the whole capable of fulfilling its function of providing a ready explanation of the many terms which may puzzle the newcomer to television.

W. T. C.

The Square Law Rectification of Electrical Noise*

By F. R. W. Strafford

SUMMARY.—The r.m.s. value of a noise voltage occupying a discrete frequency spectrum is obtained before and after square law rectification, when it is shown that the process of rectification changes the manner in which the r.m.s. voltage varies with the frequency band width. The effect of adding a carrier voltage is then analysed and it is shown that the manner in which the resultant r.m.s. acoustic output varies with band width is determined by the magnitude of the applied carrier.

Introduction

THE following analysis is concerned with electrical noise which is not sharply tunable by a radio receiver assumed to maintain a constant acceptance frequency band which is capable of being continuously shifted through the radio frequency spectrum.

A broadcast receiver possessing an effective acceptance band of 20 kc/s which may be continuously shifted from 1,500–550 kc/s is a practical example of such a system and it is usually observed that the intensity of most forms of electrical noise is substantially constant over at least 100 kc/s of tuning.

It is therefore permissible to make the simplifying assumption that the amplitude of individual frequency components of electrical noise lying within the acceptance band width of the receiver are equal.

The Noise Spectrum

One may therefore write down the following expression for the disturbing e.m.f. lying within a discrete band width containing N noise components.

$$v = V\{\cos(\omega_1 t + \lambda_1) + \cos(\omega_2 t + \lambda_2) \dots + \cos(\omega_N t + \lambda_N)\}$$
$$= \sum_1^N V \cos(\omega_n t + \lambda_n) \qquad \dots \qquad 1.0$$

where $\omega_n t$ is the angular velocity of any component in the range N and λ_n is its epoch angle relative to the first component of angular velocity $\omega_1 t$, when $t = 0$.

To simplify further the analysis the phase angle λ_n may be omitted until a later stage is reached when its inclusion becomes necessary as will be described.

It is assumed that the voltage represented by Eq. 1.0 has been linearly transferred to the detector terminals. Before rectification the r.m.s. value of the noise e.m.f. will be obtained by evaluating the integral of the squared e.m.f. and writing down the solution for the mean square value in the limit when T is infinitely long.

Thus the r.m.s. value of V is :—

$$V_{RMS} = \left\{\frac{1}{T}\int_0^T \left(\sum_1^N V \cos \omega_n t\right)^2 dt\right\}^{\frac{1}{2}}, \text{ when } T \to \infty.$$

$$= \left\{\frac{V^2}{T}\int_0^T \Big[\frac{N}{2} + \tfrac{1}{2}(\cos 2\omega_1 t + \cos 2\omega_2 t + \dots + \cos 2\omega_N t) + 2\cos\omega_1 t(\cos\omega_2 t + \cos\omega_3 t + \dots \cos\omega_N t) + \dots 2\cos\omega_{N-1} t \cos\omega_N t\Big] dt\right\}^{\frac{1}{2}},$$

when $T \to \infty$.

Now the mean value of all the sinusoidal terms is zero after a complete cycle has been effected, or, classically, as T tends to infinity. This leaves

$$V_{RMS} = \left\{\frac{V^2}{T}\int_0^T \frac{N}{2}\, dt\right\}^{\frac{1}{2}}$$
$$= V\sqrt{\frac{N}{2}} \qquad \dots \qquad 1.1$$

Eq. 1.1 shows that the r.m.s. value of the noise voltage *before* rectification varies as the *square root of* the frequency acceptance band width of the receiver. It can be also

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

shown that the r.m.s. value is independent of any phase differences which might exist between individual components.

The Rectification of v

Let the noise voltage v be applied to a device in which the relationship between input voltage and output current may be expressed by the following trinomial :—

$$i = a_0 + a_1 v + a_2 v^2 \quad \ldots \quad \ldots \quad 1.2$$

It is clear that the substitution of $v = \sum_1^N V \cos \omega_n t$ into the above expression can only yield new sinusoidal components from the third term since the first is independent of v while the second indicates a linear operation.

For the rectified current one therefore writes :—

$$i_1 = a_2 v^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad 1.3$$

$$= a_2 \left(\sum_1^N V \cos \omega_n t\right)^2$$

$$= a_2 V^2 \left\{ \frac{N}{2} + \tfrac{1}{2}(\cos 2\omega_1 t + \cos 2\omega_2 t + \ldots + \cos 2\omega_N t) + 2 \cos \omega_1 t (\cos \omega_2 t + \cos \omega_3 t + \ldots + \cos \omega_N t) + \ldots + (2 \cos \omega_{N-1} \, . \, t \, . \cos \omega_N t) \right\} \quad \ldots \quad 1.4$$

It is interesting to note that the rise in D.C. current due to rectification is equal to $\frac{a_2 V^2 N}{2}$ and is therefore directly proportional to the band width N applied at the input terminals of the rectifier and is quite independent of the type or nature of the rectifier load circuit.

It is now assumed that radio frequency components are suitably by-passed and that an acceptance band containing N terms exists in the same characteristic form as that prior to rectification, but shifted into the acoustic frequency spectrum.

Accordingly the first and second terms of equation 1.4 are excluded together with all the sum components of angular velocity arising from an expansion of the remaining multiple angle terms. It is only the difference components of angular velocity which can lie within the acoustic spectrum and it is of course assumed that $\cos (\omega_2 - \omega_1)t$ $\cos (\omega_3 - \omega_3)t$, etc. satisfies this requirement.

The resultant acoustic current arising from the appropriate expansion of the relevant portion of Eq. 1.4 yields :

$$i_2 = a_2 V^2 \{\sin (N - 1)pt + 2 \sin (N - 2)pt + 3 \sin (N - 3)pt + \ldots + (N - 1) \sin pt\} \quad \ldots \quad 1.5$$

where $p = (\omega_2 - \omega_1) = (\omega_3 - \omega_2)$
$= (\omega_N - \omega_{N-1})$.

The above result is quite obvious when visualised in the following manner. Assume N equally spaced lines of equal height, the distance between lines being pt. There must be $N - 1$ differences between neighbouring components spaced pt apart, $N - 2$ differences between those $2\, pt$ apart, $N - 3$ for the $3\, pt$ spacing and so on.

The Effect of Random Phase Distribution

So far the question of the relative phases between the components representing v have been neglected, but it is now necessary to include them. It is noticed that $N - 1$ components of equal angular velocity pt are produced. Now each of these vectors is of equal magnitude. Assuming that each vector is of equal magnitude it is necessary to ascertain the resultant *instantaneous* value with respect to time of $N - 1$ vectors of equal angular velocity pt. If they were in time phase the instantaneous value would obviously be $(N - 1) \cos pt$. In the case of the noise spectrum which must be regarded as possessing a random phase distribution, the amplitude must be less than $(N - 1)$. According to a theorem associated with the classical study of light, the resultant of N equal vectors of identical angular velocity but random epoch angle tends to $\sqrt{N}$ of that of a single vector.

Eq. 1.5 may now be written in a modified form to include the effect of random phase distribution, whence :—

$$i_3 = a_2 V^2 \{\sin (N - 1)pt + \sqrt{2} \sin (N - 2)pt + \sqrt{3} \sin (N - 3)pt + \ldots + \sqrt{N - 1} \sin pt\} \quad \ldots \quad \ldots \quad 1.6$$

which has now taken into account the random time phase distribution of the noise voltage v.

The r.m.s. value of the acoustic spectrum represented by Eq. 1.6 is :—

$$\bar{i}_3 = \left\{ \frac{1}{T} \int_0^T i_3^2 \, dt \right\}^{\frac{1}{2}} \text{ as } T \to \infty.$$

C

By the same manipulations leading to Equation 1.1.

$$\bar{i}_3 = \frac{a_2 V^2 \sqrt{N(N-1)}}{2} \quad \ldots \quad \ldots \quad 1.7$$

or, since $N >> 1$ for all practical purposes, one may write without sensible error

$$\bar{i}_3 = \frac{a_2 V^2 N}{2} \quad \ldots \quad \ldots \quad \ldots \quad 1.8$$

The process of square law rectification therefore modifies the manner in which the r.m.s. noise voltage varies with the acceptance band width. Before rectification this is proportional to $\sqrt{N}$ while after rectification a direct proportionality is observed.

The Effect of Adding a Sinusoidal Carrier Voltage

Let the rectifier terminal voltage now become

$$e = E \cos \frac{N}{2} \omega t + \sum_1^N V \cos \omega_n t \quad \ldots \quad 1.9$$

This represents a single frequency of amplitude, E located in the centre of the noise spectrum.

Before rectification the r.m.s. value of e is :

$$\bar{e} = \left\{ \frac{1}{T} \int_0^T e^2 \,.\, dt \,.\right\}^{\frac{1}{2}} \text{ as } T \rightarrow \infty \quad \ldots \quad 2.0$$

The expansion of e^2 is very lengthy, but after neglecting all sinusoidal terms and cross products the mean square value is

$$\left(\frac{V^2 N}{2} + \frac{E^2}{2} + EV \right).$$

The r.m.s. value is thus

$$\bar{e} = \left(\frac{V^2 N}{2} + \frac{E^2}{2} + EV \right)^{\frac{1}{2}},$$

or by slight rearrangement.

$$\bar{e} = V \sqrt{\frac{N}{2}} \left(1 + \frac{2E}{VN^2} + \frac{E^2}{V^2 N} \right)^{\frac{1}{2}} \quad \ldots \quad 2.1$$

Square law rectification of e yields, by similar analysis employed to derive Eq. 1.6, the following expression for the acoustic current :

$$i_e = a_2 \Big[V^2 \Big\{ \sin (N-1) pt + \sqrt{2} \sin (N-2) pt + \ldots + \sqrt{N-1} \sin pt \Big\} + \sqrt{2}\, EV \Big\{ \sin pt + \sin 2pt + \sin 3\, pt + \ldots + \sin \frac{N}{2} pt \Big\} \Big] \quad \ldots \quad \ldots \quad 2.2$$

The Effect of Shifting the Carrier Frequency

An interesting point is indicated by this equation. In the absence of the carrier N components of noise voltage produce $N - 1$ acoustic components after rectification. The presence of the carrier adds another $\frac{N}{2}$ terms to the acoustic output if it is located in the centre of the noise spectrum. As the carrier frequency is shifted through the noise spectrum towards either end, the contribution to the higher acoustic terms increases and becomes $N - 1$ in the limit. While the r.m.s. value must remain constant the acoustic pitch will rise, an effect noticed in practice.

The r.m.s. value of i_e is not simply determined and certain mathematical manipulations must be shown in detail.

The r.m.s. value of i_e is fundamentally derived from :—

$$\bar{i}_e = \left\{ \frac{1}{T} \int_0^T i_e^2 \, dt \right\}^{\frac{1}{2}} \text{ as } T \rightarrow \infty$$

the somewhat lengthy Eq. 2.2 must therefore be expanded. Remembering that all sinusoidal cross products of differing angular velocity vanish in the limit, the following results are obtained :—

$$\bar{i}_e = a_2 \left\{ \frac{V^4}{2} (1 + 2 + 3 + \ldots + N - 1) + E^2 V^2 N + \frac{\sqrt{2}\, EV^3}{2} \left(\sqrt{N-1} + \sqrt{N-2} + \ldots + \sqrt{\frac{N}{2}} \right) \right\}^{\frac{1}{2}} \quad \ldots \quad \ldots \quad \ldots \quad 2.3$$

The difficulty lies in summing the terms in the second bracket but a close approximation which may be checked by numerical values is given in the appendix. As a result the r.m.s. value may be written with negligible error as :—

$$\bar{i}_e = a_2 \left(\frac{V^4 N^2}{4} + E^2 V^2 N + \frac{E V^3 N^{\frac{3}{2}}}{6} \right)^{\frac{1}{2}} \quad \ldots \quad 2.4$$

$$\text{or } \bar{i}_e = \frac{a_2 V^2 N}{2} \left(1 + \frac{4E^2}{V^2 N} + \frac{2E}{3VN^{\frac{1}{2}}} \right)^{\frac{1}{2}} \quad \ldots \quad 2.5$$

It is quite obvious that from any practical viewpoint :—

$$\frac{2E}{3VN^{\frac{1}{2}}} << \frac{4E^2}{V^2 N}$$

$$\therefore \bar{i}_e \doteqdot \frac{a_2 V^2 N}{2} \left(1 + \frac{4E^2}{V^2 N} \right)^{\frac{1}{2}} \quad \ldots \quad 2.6$$

In the absence of the carrier voltage E the r.m.s. noise voltage is the same as that given by Eq. 1.8 when it is seen to be proportional to the square of the amplitude V of individual noise components and to be directly proportional to the band width N.

When the carrier amplitude E is such that

$$\frac{4E^2}{V^2N} >> 1$$

$$\bar{i}_e = a_2 VE\sqrt{N} \quad \ldots \quad 2.7$$

In this case the r.m.s. noise output is only directly proportional to V and proportional to the square root of the band width N. This result indicates the desirability of working with large carrier voltages and again supports the statement which requires that most of the gain should precede the detector.

In all of the foregoing it has been tacitly assumed that the rectification is square law. In the absence of a carrier voltage it is thought that any rectifying system whether diode or triode will behave in a sufficiently non-linear manner to assume a power law characteristic approaching the square law used in the analysis. The presence of the carrier, however, particularly when strong compared with the noise, will, in practice, tend to linear rectification on most rectifying characteristics at present known in the art. Demodulation of the noise then results, but whether the resultant r.m.s. noise will be less than that produced by the square law rectifier is open to some doubt and must form the basis for further comparative analysis.

Appendix

$$S_r = \sqrt{N-1} + \sqrt{N-2} + \ldots + \sqrt{\frac{N}{2}}$$

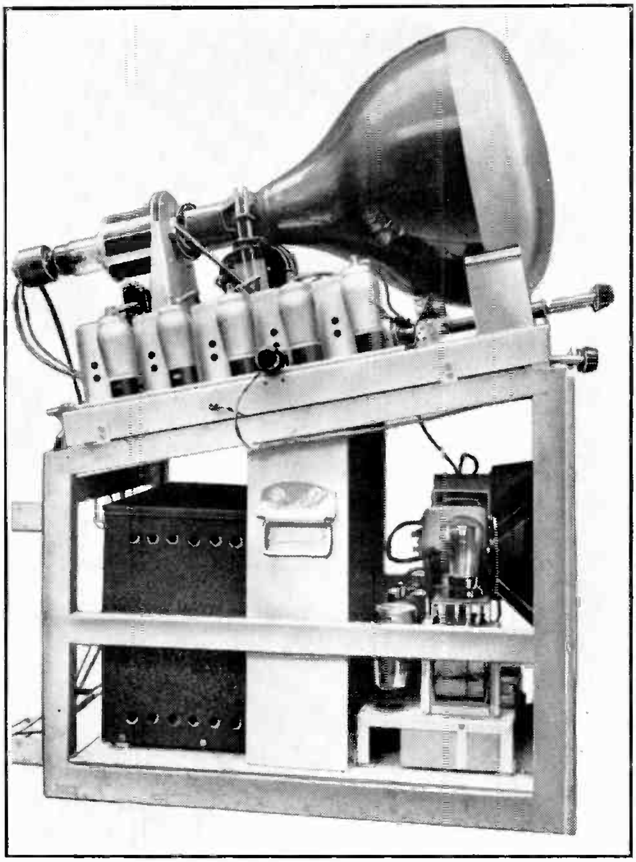
where there are r terms.

$$\therefore \; S_r = \sum_{r}^{2r-1} r^{\frac{1}{2}} = \sum_{1}^{2r-1} N^{\frac{1}{2}} - \sum_{1}^{r-1} N^{\frac{1}{2}}$$

when r is vastly large compared with unity one may write :—

$$S_r = \int_{r-1}^{2r-1} N^{\frac{1}{2}} dN = \frac{2r^{\frac{3}{2}}}{3}$$

$$= \tfrac{2}{3}\left(\frac{N}{2}\right)^{\frac{3}{2}}.$$



In this Ferranti experimental television receiver electromagnetic focussing and deflection are used. The receiver is visible alongside the cathode-ray tube and the mains equipment is fitted into the lower deck.

Superheterodyne Padding Capacities*

The Use of Fixed Padding Condensers

By W. T. Cocking

IN order to obtain single-control tuning in a superheterodyne it is necessary to employ values for the constants of the oscillator circuit which are different from those of the signal-frequency circuits, for the oscillator must function at a frequency higher or lower than that of the signal by the intermediate frequency. There are two ways of achieving ganging—the vanes of the oscillator section of the variable condenser may be shaped differently from those of the others or a standard condenser with identical sections may be used and connected in the "padding" circuit. This latter arrangement is the one usually adopted, for the use of the "shaped-plate" variable condenser seems to offer little advantage where more than a single waveband must be covered. In multi-band receivers the padding system is universal.

The choice of circuit constants for this system was very fully treated by Sowerby,[1] and it is only necessary to remark here that it is not essential to include the padding in the oscillator circuit; in some cases, it may prove advantageous to pad the signal-frequency circuits. The oscillator then operates on a frequency lower than that of the signal and the tuning range is restricted. This makes it difficult to depart from the usual practice of padding the oscillator circuit on the medium and long wavebands, but it is quite feasible on short waves and it has the advantage of permitting somewhat easier adjustment of the ganging. It is worthy of note that Sowerby's formulae can be made applicable to this unusual case by the simple expedient of using the "oscillator" constants for the signal circuits and the "signal" constants for the oscillator. The signal-frequency tuning range will then be that calculated as "oscillator."

Whichever course be adopted, every circuit requires a parallel trimming condenser of the adjustable type and the padded circuits need also a padding condenser which is usually made adjustable also. In a receiver having two signal-frequency circuits and a padded oscillator circuit, there are consequently three parallel trimmers and one series padding condenser for each waveband—four adjustable condensers in all. Modern multi-band receivers may have five bands, so that there may then be as many as twenty trimmers. The use of trimmers where they are not essential is to be deprecated for each additional trimmer means an increase in cost as compared with a fixed condenser and it cannot be relied upon to hold its capacity indefinitely, with the result that the receiver may require more frequent servicing.

It seems commercially impossible to avoid the use of parallel trimmers for each circuit, but this is not always the case with the padding condenser. It does not seem to be generally realised that it is sometimes possible to use a fixed padding condenser of ordinary commercial tolerance.

Ordinary fixed condensers are rated for capacity to no greater accuracy than $\pm$ 15 per cent. and at first sight it seems absurd to think of introducing such a condenser into a tuned circuit in which the permissible total error in capacity may be $\pm$ 1 per cent. or even less. The padding capacity is, however, in series with the tuning condenser, and in consequence the percentage variation in the total capacity is less than that of the padding condenser. When the ratio of padding capacity to variable capacity is large, an error of 15 per cent. in the padding condenser may change the total capacity by as little as 1 per cent.! It is, therefore, clearly of importance to determine the conditions under which a fixed padding condenser can safely be used, for each condenser of this type saves an adjustment, is cheaper than a trimmer, and saves the designer the need for mounting it in an accessible position.

The usual padding circuit is shown in Fig. 1, in which L_1 is the tuning coil and C_1 the parallel trimmer, while C_2 is the variable

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

[1] Ganging the Tuning Controls of the Superheterodyne Receiver, by A. L. M. Sowerby, M.Sc. *Experimental Wireless*, February, 1932.

and C_3 the padding condenser. Only the capacity C of C_2 and C_3 in series is of importance for present purposes. Now

$$C = \frac{C_2 C_3}{C_2 + C_3} = C_2 \frac{1}{1 + C_2/C_3} \quad \ldots \quad (1)$$

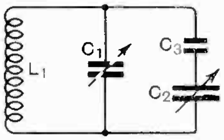


Fig. 1.

Now if C_3 is changed in value by x per cent. it becomes

$$C_3' = C_3 (1 \pm x/100) \quad \ldots \quad (2)$$

and C acquires a new value.

$$C' = C_2 \times \frac{1}{1 + C_2/C_3 (1 \pm x/100)} \quad \ldots \quad (3)$$

and the percentage change y, in C is such that

$$C' = C(1 \pm y/100) \quad \ldots \quad (4)$$

$$= C_2(1 \pm y/100)/(1 + C_2/C_3) \quad \ldots \quad (5)$$

The relationship between x and y can be found by writing

$$\frac{1 \pm y/100}{1 + C_2/C_3} = \frac{1}{1 + C_2/C_3(1 \pm x/100)} \quad \ldots \quad (6)$$

and solving for y. This gives

$$y = 100\left(\frac{1 + C_2/C_3}{1 + C_2/C_3(1 \pm x/100)} - 1\right) \ldots \quad (7)$$

For a constant value of x it is easy to see that as C_2/C_3 increases in value, y also increases; it is consequently necessary to consider only the value of y at the maximum capacity of the tuning condenser C_2, for the error y in total capacity will be greatest at this point. Now maximum values of C_2 greater than 500 $\mu\mu$F. or less than 100 $\mu\mu$F. are not commonly employed, while C_3 usually lies between 200 $\mu\mu$F. and 0.05 μF. The ratio C_2/C_3 may in practice vary from 2.5 to 0.002, and fixed condensers are available at various tolerances, usually $\pm$ 1 per cent., $\pm$ 2 per cent., $\pm$ 5 per cent., $\pm$ 10 per cent., $\pm$ 15 per cent., and $\pm$ 20 per cent. The effect of different values of x upon y for various ratios is most readily seen by plotting curves, one for each arbitrary value of x, of C_2/C_3 against y, and this is shown by the family of curves in Fig. 2. Negative values of x are taken, since they lead to slightly greater values of y; the curves thus show the maximum error.

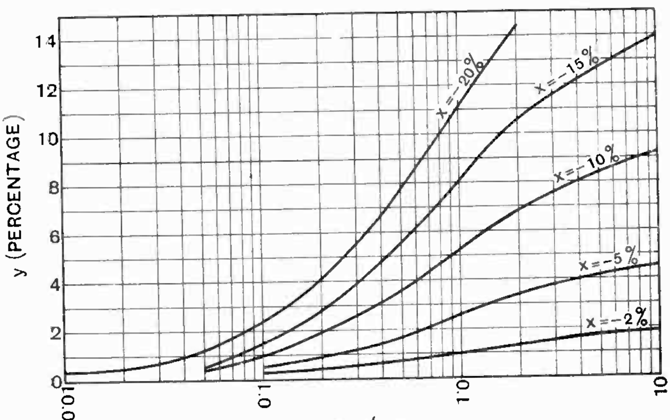


Fig. 2.

As an example of their utility, the writer recently had the case of a short-wave superheterodyne having four bands and a tuning condenser of 160 $\mu\mu$F. maximum capacity. Calculation showed that the padding capacities should be 8,500, 3,230, 796, and 983 $\mu\mu$F., giving ratios C_2/C_3 of 0.0188, 0.0495, 0.201, and 0.163. The curves of Fig. 2 show that for the first two ranges fixed condensers of $\pm$ 15 per cent. tolerance will make a total error in capacity of under $\pm$ 0.5 per cent., while ratings of $\pm$ 5 per cent. will permit the errors to be less than $\pm$ 1 per cent. for the two ranges giving higher valuas of C_2/C_3.

On the medium waveband, C_2 is commonly 500 $\mu\mu$F. and C_3 may be about 250 $\mu\mu$F. giving $C_2/C_3 = 2$. The use of a fixed condenser is then hardly permissible for its accuracy must be greater than $\pm$ 2 per cent. if the total capacity variation is to be held below $\pm$ 1 per cent. This is not necessarily the case on the long waveband, however, for then the padding condenser is often introduced in series with the medium waveband condenser. With an intermediate frequency of 465 kc/s; C_2/C_3 is then quite small and a fixed condenser of $\pm$ 5 per cent. tolerance can generally be used.

It is, therefore, clear that there are many cases in which it is permissible to replace the usual adjustable padding condenser by a fixed condenser, and that it is not always even necessary to specify one of unusually accurate capacity rating.

Voltage Measurements at Very High Frequencies*

Using a Diode with Adjustable Electrode Distance

By Manfred von Ardenne

THERE appeared recently in this journal (*Wireless Engineer*, February, March and April, 1936) a very thorough investigation by E. C. S. Megaw of the properties of the diode voltmeter at ultra-high frequencies, which allowed quantitative estimates of the sources of error inherent in this method of measurement to be obtained. Acquaintance with this work will be assumed in order to avoid repetition.

With the diode voltmeter the available range in the direction of high frequencies is limited by the error due to the connecting leads and the error due to the electron transit time; these will be referred to as "leads error" and "transit-time error" respectively. The former is due to the voltage "drop" in the predominantly inductive resistance of the connecting leads. For given lengths of lead—which must of course always be small compared with the wavelength—the too-high voltage reading thus produced will deviate less from the true value the smaller we keep the self-capacitance of the diode.

The transit-time error—the most important error in work at extremely high frequencies—produces a too-small reading on the instrument. The percentage error, if less than 20, is according to Megaw, for the idealised electrode form of two parallel plates, equal to $6.8 \cdot f \cdot A/10^7\sqrt{V_{max.}}$, where f is the frequency in cycles per second, A the distance in millimetres between the anode surface and the emission surface of the cathode, and $V_{max.}$ the peak value of the voltage under measurement. This relation shows that for a given frequency and a given value of voltage the transit-time error can be reduced only by decreasing the electrode distance A. Hitherto, in view of the tolerances necessary in manufacture and of gap variations due to thermal expansion of the

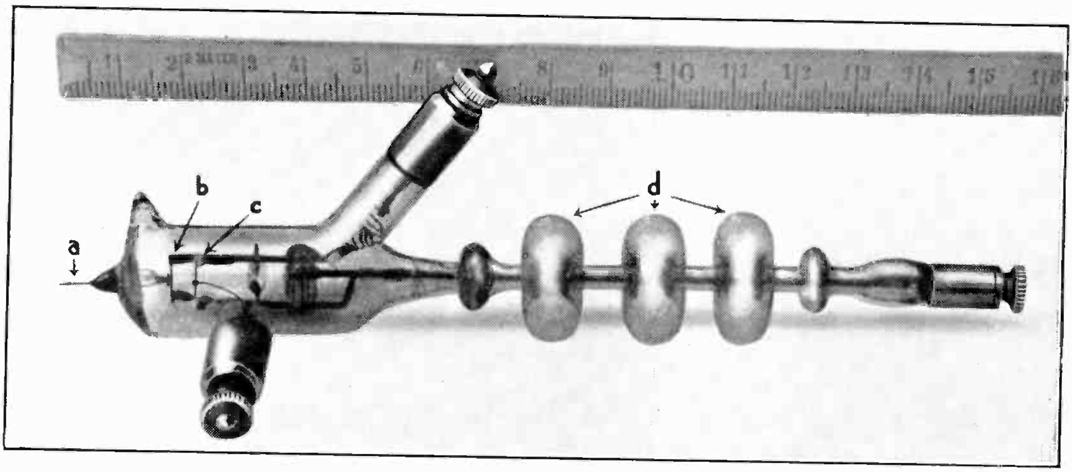


Fig. 1.—*Design of diode with adjustable electrode gap: (a) anode lead, (b) cathode, (c) potential divider with centre tap, and (d) compressible glass extension.*

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

cathode, electrode distances smaller than 0.3 mm have hardly been available in practice; only by the special selection of particular valves has it been possible to obtain distances down to 2×10^{-2} mm. In the following pages a new type of diode is described in which the anode-cathode distance can be adjusted down to an exact value between 5×10^{-3} and 10×10^{-3} mm.

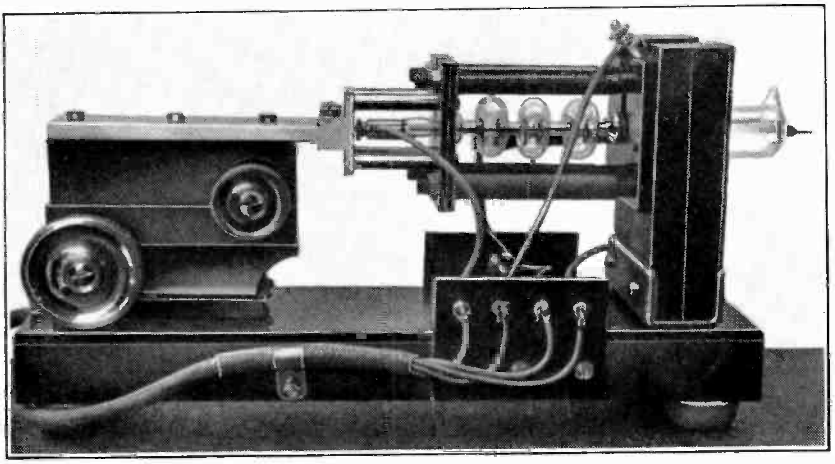


Fig. 2.—*Arrangement of diode and microscope drive for adjusting the anode-cathode gap.*

Elimination of Transit-Time Error by the Use of a Diode Construction with Adjustable Electrode Distance

Fig. 1 shows the construction of this diode, with the compressible glass extension *d* of its bulb; with the help of an adjusting device the electrode gap can be varied from outside within the limits of 0.3 mm to actual contact between cathode and anode. The anode is led out by the shortest possible path, the anode lead *a* being only 1.4 cm long. The cathode *b* is formed by a tungsten wire (heating current about 2.2 amperes) which is tightly stretched even when hot. Special precautions are taken, during the sealing-in, to ensure that the cathode is parallel to the anode surface. Close to the cathode is mounted the resistance wire *c* forming a potential divider; its mid-point tapping serves as the cathode connecting point. The A.C. heating current is led in by the second terminal seen at the side of the bulb and by the connection running inside the compressible glass extension.

The mounting of the diode is shown in Fig. 2. The glass extension[1] is compressed by means of the microscope drive seen on the left. In spite of the fairly massive design of the mounting, the movement is divided equally between the mounting and the glass extension, so that the travel indicated on the drum of the microscope drive is about twice as large as the actual change in the gap between anode and cathode.

The adjustment is carried out as follows: with the cathode heated, the glass extension is gradually compressed by the fine adjustment of the drive, until the cathode just touches the anode. The moment of contact is immediately made obvious by the sudden decrease in the glow of the filament, due to the conducting away of heat. No damage is done to the cathode by the contact with the anode, provided that an increase of heating current is prevented by an iron-in-hydrogen barretter connected in the heating circuit. The anode material is so chosen

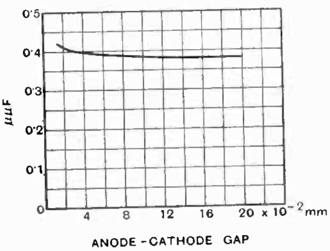


Fig. 3.—*Effect of gap variation on diode capacitance (length of anode lead 1.4 cm).*

[1] The glass extension in a new type of diode is moved laterally to reduce elastic compression, the diode differing from that shown in Fig. 1 only by anode and cathode being located side by side. The arrangement of the mounting with the microscope drive at 90° then becomes more compact.

that there is no marked adhesion between the anode and the hot cathode. Tests show that the back-lash caused by adhesion is always smaller than $2 - 5 \times 10^{-3}$ mm. Adjustment to the smallest possible gap is easily accomplished by turning the fine adjustment back a few divisions, until the recovery of the filament glow indicates that separation has taken place. Practical tests on the model illustrated have shown that an anode-cathode gap of 5×10^{-3} mm can thus be obtained and maintained. With this gap, and a peak voltage of 10 volts to be measured, the transit-time error does not exceed 1% until a frequency of over 10^9 c/s has been reached. At this frequency of 10^9 c/s the leads error, for the particular diode shown, is greater than the transit-time error. When it is remembered that the self-capacitance of the diode is, as the measurements of Fig. 3 indicate, chiefly due to the capacitance to small value to its maximum. This results in a very desirable constancy of behaviour in the region of initial current, since there is no marked dependence of the initial voltage (which has to be subtracted from the condenser voltage) on the electrode gap.

The Circuit of the Equipment and Some Results

The circuit of a factory-made equipment embodying the diode just described is shown in Fig. 4. The value of the D.C. condenser voltage is given by a valve-voltmeter[2] with three ranges, obtained by different cathode-circuit resistances. By the use of a very sensitive pointer instrument in the anode circuit, and the selection of a particularly highly evacuated valve, the ion current in the grid circuit can be kept so small that it does not damage the necessary very high grid-leak resistance (10^8–10^9 ohms).

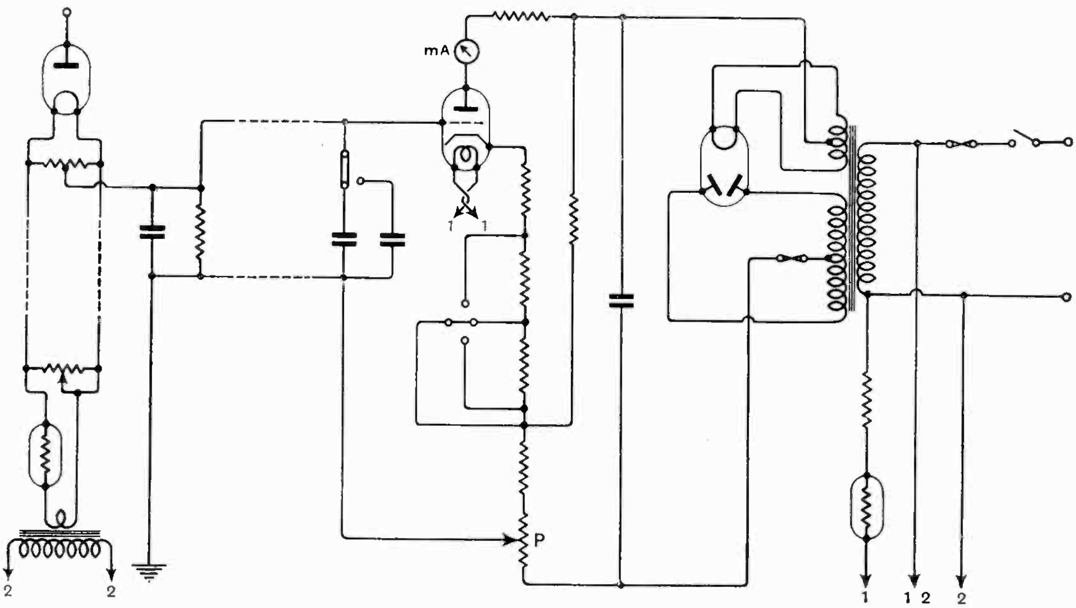


Fig. 4.—*Circuit of diode voltmeter.*

earth of the leads, an error of 7% may be expected with the given diode and a frequency of 10^9 c/s. If the anode lead were further reduced to about 0.7 cm—and such a shortening appears practicable—this error also could be reduced to about 1%.

It is to be noted that the static characteristic of the diode here described alters very little as the electrode gap is varied from a

Even when no voltage is applied to the diode, a small current passes due to the initial velocity of the electrons emitted by the hot filament. This current, however, is cancelled out by the procedure of beginning each measurement by adjusting the working point, by the potentiometer P, to the same

[2] In a special equipment for lower sensitivity the diode-unit is combined with a pointer-electrometer.

point of the triode characteristic, and taking the difference of the readings with and without the voltage under measurement.

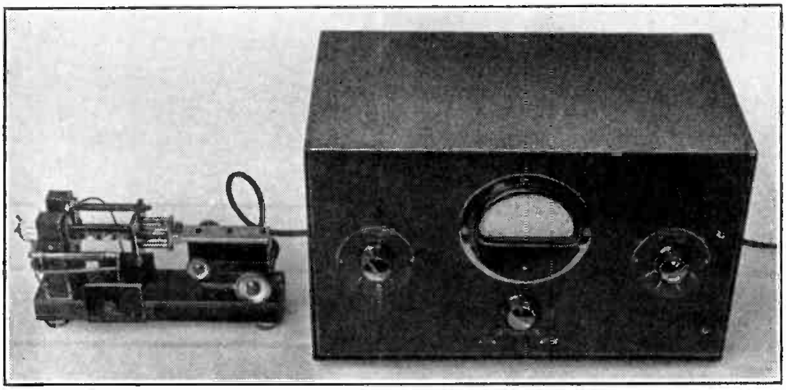
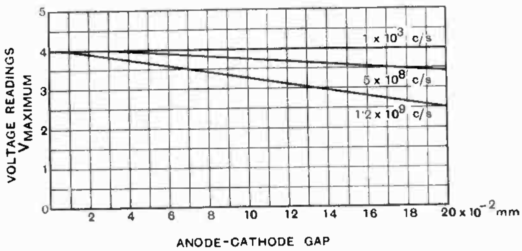


Fig. 5.—*The diode voltmeter for measurements of peak voltages of* 0.5 *to* 140 *volts, at frequencies up to* 1.5×10^9 *c/s (made by the Leybold & von Ardenne Oscillograph Company).*



(*Below*) Fig. 6.—*Effect of electrode-gap variation on the voltage readings, at various frequencies.*

The external appearance of the apparatus is shown in Fig. 5. On the most sensitive range, voltages of about 0.5 to 7.0 volts, peak values, are measured. The second range reaches to about 35 volts, peak value, and the fourth to about 140 volts, peak value. The effect of the length of electrode gap on the voltage readings, for three different typical frequencies and a peak voltage value of 4 volts, is shown by the measurements represented by Fig. 6. At an audio-frequency of 1,000 c/s the reading is entirely independent of the electrode gap, but at high radio frequencies there is a variation with gap, and this is very marked for a wavelength of 25 cm. The correct reading, for this wavelength, is only given with the smallest gap of 5×10^{-3} mm. The measured curves show a fair agreement with the theoretical values calculated from the formulae referred to earlier in this article, but it is to be noticed that the actual error found amounts only to about half the calculated error. This difference may be attributed to the transit-time shortening (not taken into account in the calculation) resulting from the non-linear field distribution, and above all to the shortening due to the initial velocity of the electrons.

The Industry

STANDARD Telephones and Cables have recently installed Lorenz Blind Approach receiving equipment on five Lockheed Electra aircraft for British Airways. Lorenz ground apparatus has been installed at Gatwick and Croydon airports.

La Société Française Radio-electrique has produced an attractive brochure containing a technical description of the apparatus employed for the recently inaugurated radio-telephonic link between France and the U.S.A.

Much useful information on the use of metal rectifiers in conjunction with electrical measuring instruments is contained in a booklet issued by the Westinghouse Brake and Signal Co., 82, York Road, London, N.1.

The G.E.C. Portable Level Meter, produced by the company's Salford instrument works, embodies an amplifier and a log-scale voltmeter including a rectifier. A wide audio-frequency range is covered.

Measurement of the Self-Capacity of Iron-Cored Coils*

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

THE measurement of the self-capacity of an iron-cored coil is not as straightforward as that of an air-cored coil because the inductance of the former varies appreciably with frequency except in those cases where the eddy current losses are negligible. With the exception of such cases, therefore, it is impossible to measure the self-capacity by the standard intercept method† which involves tuning the coil by a condenser to a number of different frequencies and then plotting the square of the wavelength against the corresponding tuning capacity. In the following it is shown that in spite of the variation of the inductance of an iron-cored coil with frequency, its self-capacity can still be measured by resonance methods. Including the standard intercept method there are three such methods available, and the choice of method is decided by the behaviour of the coil at the test frequencies. It is convenient, therefore, to classify the coils under the three following headings :—

(1) Coils whose natural frequency is much lower than the test frequencies.

(2) Coils which have negligible eddy current losses at the test frequencies.

(3) Coils of high natural frequency and appreciable eddy current losses at the test frequencies.

These three cases will now be considered in detail.

Case I.—Coils of Low Natural Frequency

It is well known that a circuit which consists of a coil having an inductance L and resistance R connected in parallel with a condenser C will behave, for all practical purposes, like a condenser of capacity C for all frequencies which exceed, say, 10 times the natural frequency of the system which is given by $f = \frac{1}{2\pi\sqrt{LC}}$. If the condenser corresponds to the self-capacity of the coil then its value can be measured by choosing a test frequency which is greater than $10 f$ and noting the change in capacity required to retune a circuit to this frequency after the coil has been shunted across the tuning condenser.

In the case of a coil having an iron-core the problem is somewhat complicated by the fact that L and R are both functions of the frequency, the former falling and the latter increasing with increase of frequency, so that it may not be possible to estimate a suitable value for the test frequency. In practice, this difficulty can be overcome by repeating the above measurement for a number of test frequencies and increasing their value until a series of consistent readings is obtained.

As a check, the self-capacity of a 20 henry choke, of the type employed for smoothing a D.C. mains supply, was measured at a number of frequencies in the way indicated above. The results obtained are given in Table I.

TABLE I

Frequency in Mc/s.	Tuning Capacity without choke.	Tuning Capacity with choke.	Difference in $\mu\mu F$.
2.5	2787	2740	47
3.0	1964	1917	47
3.5	1448	1399	49
4.0	1094	1045	49
4.5	852	304	48
5.0	692	643	49

Average reading = 48 $\mu\mu$F.

This capacity is actually made up of the self-capacity of the choke in parallel with the stray capacity of the choke to earth.

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

† G. W. O. Howe, *Proc. Phys. Soc.*, London. XXIV., p. 251, 1912.

The latter was measured by disconnecting the choke terminal from the earthy side of the measuring condenser and noting the change in tuning capacity when the other choke terminal was connected and then disconnected from the non-earthy side of the condenser.

For the choke under test the stray capacity to earth was 11 $\mu\mu$F, which makes the self-capacity of the choke 37 $\mu\mu$F.

Case II.—Coils with Negligible Eddy-Current Losses

If we ignore copper losses, hysteresis losses* and the fraction of the total inductance which is due to the non-magnetic portion of the core cross-section, the resistance and inductance of an iron-cored coil whose core is built up of thin laminations of rectangular section are given by equations (1) and (2) respectively†

$$\frac{R_0}{\omega L_N} = \frac{1}{mt}\,\frac{\sinh mt - \sin mt}{\cosh mt + \cos mt} \quad \ldots \quad (1)$$

$$\frac{L_0}{L_N} = \frac{1}{mt}\,\frac{\sinh mt + \sin mt}{\cosh mt + \cos mt} \quad \ldots \quad (2)$$

Where L_N = inductance of the coil when free from all losses;

$m = 2\pi\sqrt{\frac{f\mu}{10^9\rho}}$;

f = frequency in cycles/sec. = $\omega/2\pi$;

μ = permeability;

ρ = resistivity in ohms/cm.^{3};

t = thickness of stampings in cms.

Equation (2) can be expressed as

$$\frac{L_0}{L_N} = \frac{1}{mt}\,\frac{\left\{mt + \frac{(mt)^3}{\underline{|3}} + \frac{(mt)^5}{\underline{|5}} + -\right\} + \left\{mt - \frac{(mt)^3}{\underline{|3}} + \frac{(mt)^5}{\underline{|5}} + \ldots\right\}}{\left\{1 + \frac{(mt)^2}{\underline{|2}} + \frac{(mt)^4}{\underline{|4}} + -\right\} + \left\{1 - \frac{(mt)^2}{\underline{|2}} + \frac{(mt)^4}{\underline{|4}} + -\right\}}$$

$$= \frac{120 + (mt)^4 + \ldots}{120 + 5\,(mt)^4 + \ldots} \quad \ldots \quad \ldots \quad (3)$$

Equation (3) shows that if $mt < 0.7$ the inductance of the coil at the given frequency will not differ from L_N by more than 1 per cent. For a range of frequencies which satisfies this condition the inductance of the coil can therefore be regarded as constant, and its self-capacity can be measured by the standard intercept method.

When the core is not made up of rectangular laminations, equations (1) and (2) no longer apply and the constancy of the inductance must be checked over the range of test frequencies.

Case III.—Coils with Appreciable Eddy-Current Losses

The coils which come under this heading are those which can only satisfy the requirements of Case I at frequencies which are too high to make the carrying out of the measurement practical, and which, at the same time, can only satisfy the requirements of Case II at frequencies which are too low for a reliable measurement to be made by the standard intercept method.

For such coils, however, an intercept method based on the following theoretical considerations can be employed. From equations (1) and (2) we obtain

$$\frac{\omega L_0}{R_0} = \frac{\sinh mt + \sin mt}{\sinh mt - \sin mt} \quad \ldots \quad (4)$$

For $mt > 5$, $\sinh mt >> \sin mt$, so that equation (4) simplifies to $\frac{\omega L_0}{R_0} = 1$. This means that the magnification factor of the coil is a constant for all frequencies which satisfy the condition $mt > 5$. In practice, a constant value is generally not obtained until mt is considerably greater than 5 when the frequencies are usually too high for practical purposes. It is found, however, that, so long as $mt > 5$, the value remains sufficiently constant for the purposes of the test when the ratio of maximum to minimum frequency employed does not exceed about 3. The value of $\frac{\omega L_0}{R_0}$ so obtained is usually less than unity. This departure from the simple theory arises from the fact that the laminations are rarely homogeneous, the inhomogeneity taking the form of a thin surface layer which has a permeability much less than that of the interior.‡

* This is justified because resonance measurements can usually be made with very low magnetising currents.

† Scott, *Proc. I.R.E.*, Oct. 1930, p. 1757.

‡ Peterson and Wrathall, *Proc. I.R.E.*, Feb. 1936, p. 275.

For $mt > 5$ it would therefore be more accurate to write

$$\frac{\omega L_0}{R_0} = k \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

where k is a constant.

Consider now the circuits of Fig. 1 (*a*) and (*b*).

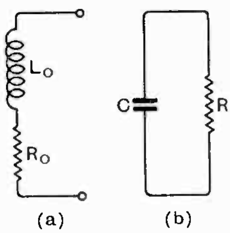


Fig. 1.

The first represents the iron-cored coil which is made up of an inductance L_0 in series with a resistance R_0. At any frequency $f = \omega/2\pi$ this circuit is equivalent to the one of Fig. 1 (*b*) when

$$\frac{\omega L_0}{R_0} = \tan\theta = \omega CR \quad \ldots \quad \ldots \quad (6)$$

$$R_0 = R\sec^2\theta$$

$$\omega L_0 = \frac{R}{2}\sin 2\theta$$

The appropriate values for C and R can be obtained by the following substitution method. The circuit of Fig. 2 (*a*) is first tuned with the coil connected across the tuning condenser C and the reading, say, C_1 noted.

The coil is then removed and the circuit is re-tuned, the new value of C being, say, C_2. A resistance R is then shunted across the tuning condenser as in Fig. 2 (*b*), its value being adjusted to give the same deflection in the meter M as was obtained in the case of Fig. 2 (*a*). We have then from equation (6) that

$$\frac{\omega L_0}{R_0} = \omega(C_1 - C_2)R \quad \ldots \quad \ldots \quad (7)$$

Actually, the coil under test has shunted across it an additional capacity made up of its self-capacity in parallel with the capacity

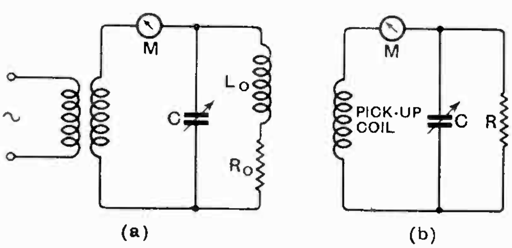


Fig. 2.

of the coil to earth. The value of C_1 should therefore be increased by this capacity, so that, if we call the extra capacity C_s, equation (7) can be written

$$\frac{\omega L_0}{R_0} = R\omega\{(C_1 + C_s) - C_2\}$$
$$= R\omega(C + C_s) \text{ where } C = C_1 - C_2 \quad \ldots \quad (8)$$

For frequencies which satisfy the condition $mt > 5$, we have from equations (5) and (8) that

$$C + C_s = \frac{k}{\omega R} \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

C_s can therefore be evaluated by carrying out the above test for a series of frequencies which satisfy the condition $mt > 5$ and plotting C against $1/\omega R$ in the way indicated by Fig. 3. The value of C_s is then given by the intercept on the capacity axis.

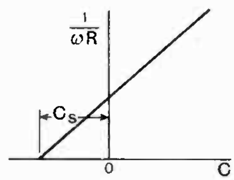


Fig. 3.

Table 2 gives the details of a test carried out on a coil consisting of 42 turns of 23 S.W.G. wire wound with uniform spacing on a stalloy core made up of 50 rings having the following dimensions :—

External diameter = 2.75in.
Internal diameter = 1.75in.
Thickness = 0.014in.

The permeability of stalloy can be taken as 500 and the resistivity as 50 microhms/cm³.

TABLE 2

Frequency in Mc/s.	C in $\mu\mu$F.	R in ohms.	$\frac{1}{\omega R}$
3.5	43.5	770	59.2×10^{-12}
4.0	32.5	834	47.8
4.5	26.0	886	40.0
5.0	21.1	910	35.0
5.5	16.45	954	30.4
6.0	12.9	1000	26.6

Fig. 4 shows C plotted again $1/\omega R$ and it is seen that the value of the shunting capacity is 11.4 $\mu\mu$F. The coil has a capacity to earth of 8 $\mu\mu$F, which makes the self-capacity of the coil 3.4 $\mu\mu$F.

There are two possible sources of error

in the above method of measuring self-capacity which arise from

(1) The inductance of the tuning condenser.

(2) The inductance due to the lines of force which do not pass through the iron.

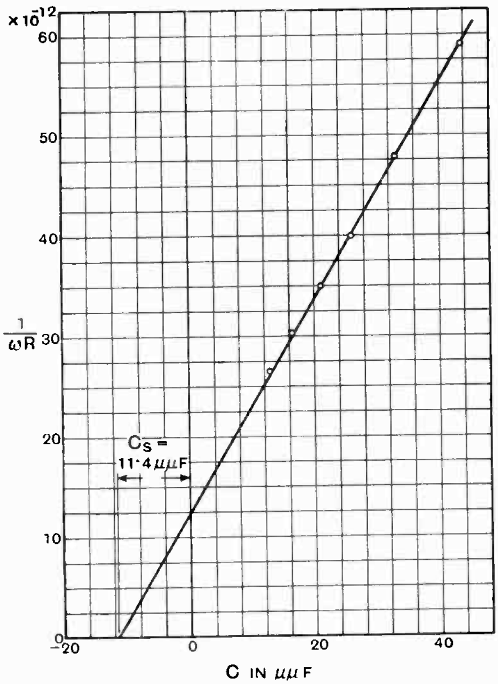


Fig. 4.

The first error can be accounted for in the following way. If the inductance associated with the condenser is L_c, then the actual tuning capacity for a given reading C is

$$C_t = \frac{C}{(1 - \omega^2 L_c C)} \doteq C(1 + \omega^2 L_c C).$$

L_c can be measured by noting the change required in the condenser reading of the arrangement of Fig. 2 (*b*) to restore the circuit to resonance when a small unknown condenser is shunted across it (the resistance R having been previously removed). By altering the value of the pick-up coil another set of readings can be obtained for a different initial setting of the tuning condenser, and from the resulting two equations the unknown capacity can be eliminated and the value of L_c deduced.

The second error arises from the fact that the inductance of the coil due to the lines which pass through the iron falls with frequency whereas the inductance due to the lines which pass through the air remains constant. At very high frequencies, therefore, the latter inductance may form an appreciable part of the total inductance, in which case equation (5) no longer holds and the curve relating to C and $1/\omega R$ will not be a straight line. As a rule, errors arising from this cause can easily be avoided because it is generally possible to select a range of frequencies for the test which are high enough to satisfy the condition $mt > 5$ and low enough to make the ratio of air to iron inductance negligible.

B.B.C.'s Annual Survey

A Summary of the Corporation's Work during 1936

THE 1937 Annual of the B.B.C., which has just been published, is, besides being a survey of the past year's work, an excellent book of reference on the activities of the Corporation. Organisation, finance, engineering and public and foreign relations are all dealt with. In the technical section a particularly interesting article on studio design is included. The studio described is acoustically "live" at one end and "dead" at the other. Maps showing the measured field strength at roof level (10–15 metres above ground) of the sound transmitter of the Alexandra Palace television station are also included.

The Annual is priced at 2/6 or 3/- by post from the B.B.C. Publications Department, 35, High Street, Marylebone, London, W.1.

Television Lectures

A COURSE of four lectures on television is to be given at the Polytechnic, Regent Street, London, W.1, on Mondays at 7.30, commencing on May 31st.

These lectures are to be delivered by Mr. H. J. Barton-Chapple. Demonstrations of reception of the B.B.C. transmissions will be included each week.

The Oxford University Arctic Expedition, 1935-36, to North East Land*

A Report on the Radio Communications

By a Member of the Expedition

Introduction

VERY little information has been published with regard to the conditions for Radio reception and transmission which are experienced in the far North, and what there is is almost entirely confined to summer conditions, which might be expected to be very different from those found in winter, when ionisation by ultra-violet light will be very small. The following paper is an attempt to remedy that lack of information. It describes the apparatus and experiences of the Oxford University Arctic Expedition to North East Land, and, while it must be realised that conditions change from year to year, in it are drawn certain conclusions, which it is thought might be of use to anyone planning a radio-telegraph service of a similar nature.

The Base Station

Site.—The Base Station, whose call-sign was GVX, was situated at 80° 23′ N, 19° 31′ E, a few feet above sea-level on a rocky promontory, backed by high cliffs, which rose to a mountain 1,500ft. high. There were no metallic deposits in this mountain. The site was open from S.E., through S.W. to N.W., in which directions there were no mountains closer than five miles, and none of these greater than 2,000ft., except the mountains of Spitsbergen, which were about 80 miles away. The site was therefore good for communicating with all the stations concerned.

Aerial Equipment.—Observations made by previous summer expeditions had led to the expectation of gales of great force, and the deposition of large amounts of ice on the aerials. For these reasons, high masts were not taken, 30 ft. sectional steel masts being used. Each mast was guyed with 8 rope guys, which were made fast to pegs driven into cracks in the rocks, or to baulks of driftwood buried 3 ft. down into the boulders. Heavy cadmium copper wire (7/069) was used, and each of the three horizontal dipoles was supported by three masts. The wire was allowed a large dip between masts, in order to minimise the horizontal tensions. Rubber insulators of long leakage path were used to prevent undue leakage when ice formed on the aerials. To compensate for the low effective height of the aerials a relatively large power input was made available for the senders.

The highest wind experienced was one which averaged 53 m.p.h. for five hours, but winds of over 30 m.p.h. were common. Probably the cliffs sheltered the site, and these values of wind velocity may therefore be below those usual for North East Land. The only aerial failure was one halyard.

Only on three occasions was there much ice deposit on the aerials, and one of these was due to frozen spray. The ice never exceeded in thickness twice the wire diameter on the windward side, and always fell off after a few days, irrespective of the air temperature.

The conclusions reached are as follows. If it is possible to use relatively high-powered senders, the policy of having low aerials is a sound one, but, to reduce the maintenance to a minimum, it is desirable to use guys of wire, and not rope, because the latter require an adjustment of tension with every change of humidity. Ice formation is rare, and causes no trouble, and much lighter wire should be used for the aerials. This would allow a smaller horizontal tension for a given dip, or a smaller dip for the same tension.

Earthing.—The soil was expected to consist of rocks, and did consist of rocks. Earth mats and a counterpoise were used for earthing, and proved satisfactory.

Receivers.—(*a*) An Eddystone All-world Four, frequency range 0.15 to 25.0 Mc/s, gave adequate sensitivity, but was not very good for reception of Broadcast entertainment because it was not fitted with Automatic Volume Control.

(*b*) A Gambrell 3-valve time-signal receiver gave loud signals from Rugby, Nauen, Croix d'Hins and other long wave stations. A very satisfactory receiver for its purpose.

Senders.—(*a*) A 1 kW M.O.P.A. sender, frequency range 2.0 to 15.0 Mc/s. Power supply was from generators driven by an internal combustion engine, which was housed in a hut made of single plank. The greatest difficulty was experienced in keeping the engine room warm, but the engine itself gave little trouble.

It is concluded, however, that water-cooled

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

engines are unsuitable for use in the Arctic, owing to the ever-present danger of freezing and the difficulty of obtaining water throughout the greater part of the year.

(*b*) A 15 watt self-excited sender made by Gambrell Bros., suitable for telephony, I.C.W. and C.W. Power supply was from a pedal-driven generator lent by Haslam and Newton, Ltd. The frequency range was 1.5 to 3.0 Mc/s. This installation showed great reliability, and the pedal-driven generator must be regarded as extremely useful for supplying power up to 50 watts in inaccessible places.

The aerial used with this sender was a T type, made by paralleling the twin feeders of a horizontal dipole. A single wire counterpoise was used for earthing.

The "A" Ice-Cap Station

Site.—The "A" Ice-cap station, whose call-sign was GVY, was situated approximately 30 miles south of GVX, at a height of 2,000 ft. on the ice-cap, a substantially level area of snow-covered ice many miles in extent.

Aerial Equipment.—Only one 30 ft. mast was used at this station, the guys being made fast to pegs buried into the ice, and the second mast consisted of a 10 ft. bamboo pole. Higher wind velocities were experienced than at the Base, but no damage was caused to the aerial. After mid-winter, when temperatures were generally below zero F, large deposits of hoar frost occurred on the aerial and guys, and had to be shaken off about once in three days. This was easy owing to the lowness of the aerial.

Earthing.—Earthing was by means of earth mats buried in the ice.

Sender and Receiver.—The sender was the same as sender (*b*) above, and the receiver the same as receiver (*a*) above, but the frequency range of the latter was curtailed between 0.6 and 3.0 M/cs. Power supply for the sender was by means of a pedal-driven generator loaned by Mortley, Sprague and Co., Ltd.

The "B" Ice-Cap Station

Site.—The "B" Ice-cap station, whose call-sign was GVZ, was situated on the ice-cap at a height of 2,500 ft. and some 10 miles North of GVY.

Aerial Equipment.—Two bamboo poles were used as masts, and the earthing was by earth mats.

Receiver.—This station had no sender. The receiver was the same as that at GVY.

Schedules

GVX, the Base station, carried out communication with the following stations as under :—

1.—Monthly with the General Post Office Station at Portishead and Highbridge, Somerset, whose call-signs were GKC, GKT, and GKU.

2.—Monthly with Mr. D. H. Johnson's private station at Kingston Hill, Surrey, whose call-sign was G6DW.

3.—Daily with GVY from September to June.

4.—Daily with GVZ (one-way only) from September to February.

5.—Thrice daily with the Meteorological station at Bear Island, situated approximately 400 miles south of GVX. The call-sign of this station is LJB. After April this communication was made weekly instead of thrice daily.

6.—Weekly with Advent Bay coast station, situated 200 miles S.S.W. of GVX, and whose call-sign was LGS. This was discontinued shortly after Christmas.

Frequencies Used. In Megacycles per Second

GKC/GKT	8.2.
GKU	0.15.
G6DW	3.7 from December to February.
	7.2 from March till July.
LJB	0.53
LGS	0.50.
GVY	2.00.
GVX	2.0 to GVY and LGS, and 2.0 or 3.0 to LJB, using sender (*b*). 3.8 to GKC/GKU and G6DW from October to March. 7.2 or 8.2 ditto, April to July, using sender (*a*).

Summary of Sending Results

To England.—Fairly good apart from interference. An all-dark route is best, but communication is quite possible over an all-light route. The frequencies must be adjusted to suit the conditions. A magnetic storm produces fading and even complete absorption.

To Bear Island.—Very good from September to March. Unreliable after March. An all-dark route is best, but communication is possible over an all-light route.

To Advent Bay.—Never satisfactory, and often impossible, probably due to the high mountains which surround it.

To the Ice-Cap.—Always perfect at any time of day or night throughout the year.

Summary of Receiving Results

From Portishead.—Except during time of magnetic storm the Portishead stations, between them, always produce a 100 per cent. readable signal at GVX.

From Kingston Hill.—Good over a limited period of the day.

From Bear Island, Advent Bay and the Ice-cap.—Always perfect at any time of day or night throughout the year.

N.B.—The power input at Bear Island and Advent Bay is 300 watts.

The conclusions reached are as follows :—

The most reliable communication with a regular telegraph service would be obtained by using an input of 500 watts on 0.5 Mc/s. This would give 100 per cent. readability at any time of day or night throughout the year, and communication would be with LJB, LGS, other "coast" stations and ships. Communication with England can never have the reliability of the more local channels. The sender should have a power of not less than 500 watts input, and for communicating at all times the frequency range should be 3.0 to 10.0 Mc/s approximately. If communication is only desired for a few hours each day the frequency range might be reduced to between 4.0 and 8.0 Mc/s.

Communication with the ice-cap stations was perfect with the arrangements described.

Reception of Broadcast Entertainment

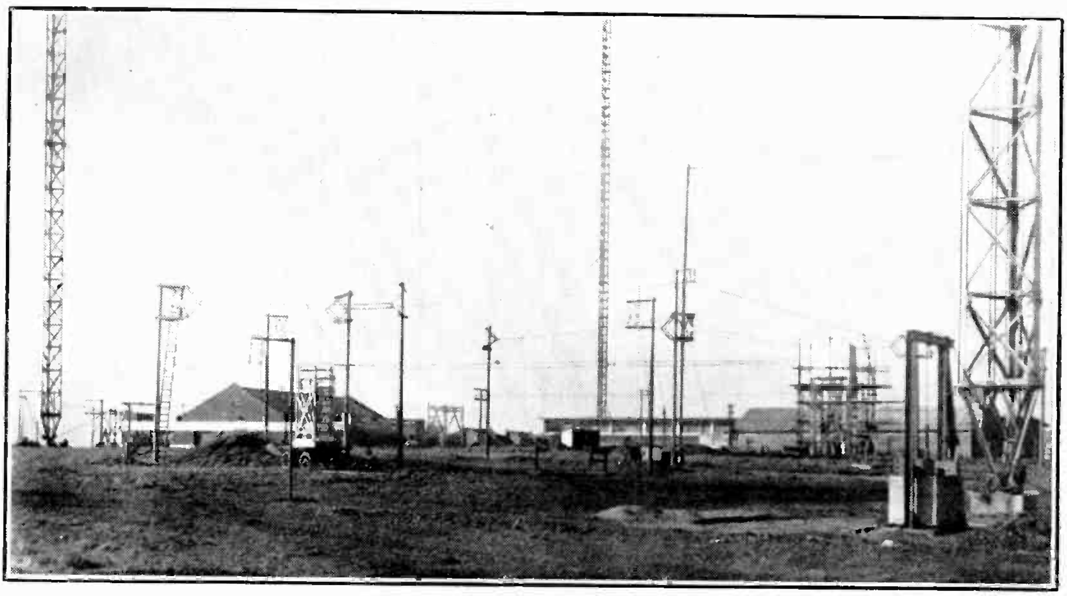
Reception of British Broadcasting stations is possible throughout the year, using the medium- and long-wave stations between October and March, and the short-wave Empire stations between April and September. For the medium waves an all-dark route is best, signal strength increasing noticeably towards mid-winter and midnight. Fading is usually troublesome, and for entertainment a receiver employing A.V.C. is desirable, but atmospheric disturbance is seldom bad. Reception of other European broadcast stations, both long, medium and short wave, is similar to that of British stations. U.S.A. stations are best received rather on the mid-winter side of the two equinoxes. Reception of some form of broadcast entertainment is often possible throughout the twenty-four hours at all times of the year, and eight hours may be relied upon. A comparison between the notes made on reception of medium-wave broadcast at GVX and GVY shows agreement within the limits of the somewhat rough estimation possible.

Acknowledgements

The writer expresses his gratitude to Colonel Crawley and Mr. Greenland of the General Post Office, for their help in arranging the schedules, to the operators of the various stations for handling his traffic, to Mr. Moss for the loan of his notes made at GVY, to Celestion, Ltd., for packing all the communications apparatus, and to the firms who supplied the apparatus, as shown below.

Automatic Coil Winder Co. ...	36 range Universal Avometer.
Celestion	Loud speaker.
Chloride Electrical Storage Co.	Lead accumulators and acid.
Edison Swan Electric Co. ...	Headphones.
Ever Ready Co.	Low-tension batteries and torches.
Ferranti	Fuses for meter.
Gambrell Bros.	Time-signal receiver and small senders.
Haslam and Newton	Pedal-driven generator.
Hellesens	High-tension batteries.
Henley's Telegraph Works Co.	Aerial wire, cut-outs and cables.
High Vacuum Valve Co. ...	Valves.
Marconi's W.T. Co.	Earth mats.
Mortley, Sprague & Co. ...	Pedal-driven generator.
Mullard Wireless Service Co. .	Transmitting valves.
Sorbo	Headphone pads.
Stratton & Co. ...	Receivers, valves, loud speaker, etc.
Tyzack & Son	Tools.

The New Empire Station



This "Wireless World" photograph shows some of the feeders which run from the twenty-three aerial arrays of the B.B.C. Empire station at Daventry. Three new transmitters, two of which have been supplied by Standard Telephones and Cables and the other by Marconi's Wireless Telegraph Company, have all been accommodated in a new building. Each of the new transmitters has a rated power of 50 kilowatts.

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

Distortion in Negative Feedback Amplifiers

To the Editor, The Wireless Engineer.

SIR,—In the theory of distortion in negative feedback amplifiers* it has been usual to assume that distortion appearing in the output is fed back to the input and amplified without further distortion. This assumption is not involved in the following theory. Since doing this work I have found that results similar to mine have been published† but do not seem to be well known.

Let δv, δE be input and output voltages of an amplifier, the characteristic of which is

$$\delta E = f(\delta v) \text{ or } \delta v = F(\delta E) \qquad \ldots \ldots \quad (1)$$

Let δv consist of a signal, δe, and a negative feedback component, $-\beta\delta E$.

$$\delta v = \delta e - \beta\delta E \qquad \ldots \ldots \ldots \quad (2)$$

Then $\delta e = F(\delta E) + \beta\delta E \qquad \ldots \ldots \ldots \quad (3)$

and the problem is to solve (3) to give δE as a function of δe.

By Tayler's theorem

$$\delta E = \left[\frac{dE}{de}\right]_0 \delta e + \tfrac{1}{2}\left[\frac{d^2E}{de^2}\right]_0 \delta e^2 + \qquad \ldots \quad (4)$$

whence, by the relationships

$$\left.\begin{aligned} \frac{dy}{dx} &= \frac{1}{\dfrac{dx}{dy}} \\ \frac{d^2y}{dx^2} &= -\frac{1}{\left(\dfrac{dx}{dy}\right)^3}\frac{d^2x}{dy^2} \\ \frac{d^3y}{dx^3} &= \end{aligned}\right\} \qquad \ldots \ldots \ldots \quad (5)$$

$$\delta E = \frac{1}{\left[\dfrac{de}{dE}\right]_0}\delta e - \tfrac{1}{2}\frac{1}{\left[\dfrac{de}{dE}\right]_0^3}\left[\frac{d^2e}{dE^2}\right]_0 \delta e^2 + \ldots \quad (6)$$

From (2)

$$\frac{de}{dE} = \frac{dv}{dE} + \beta, \ \frac{d^2e}{dE^2} = \frac{d^2v}{dE^2}, \ldots \qquad \ldots \ldots \quad (7)$$

Substituting (7) in (6) and again using (5) we find

$$\delta E = \frac{\left[\dfrac{dE}{dv}\right]_0 \delta e}{1 + \left[\dfrac{dE}{dv}\right]_0 \beta} + \tfrac{1}{2}\frac{\left[\dfrac{d^2E}{dv^2}\right]_0 \delta e^2}{\left(1 + \left[\dfrac{dE}{dv}\right]_0 \beta\right)^3} + \ldots \quad (8)$$

If β be zero (no feedback)

$$dE_1 = \left[\frac{dE}{dv}\right]_0 \delta e_1 + \tfrac{1}{2}\left[\frac{d^2E}{dv^2}\right]_0 \delta e_1^2 + \qquad \ldots \quad (9)$$

so that, to obtain the same output with feedback as without, the input must be increased

$$\left(1 + \left[\frac{dE}{dv}\right]_0 \beta\right)$$

times. Equation (8) then becomes

$$\delta E_1 = \left[\frac{dE}{dv}\right]_0 \delta e_1 + \tfrac{1}{2}\frac{1}{1 + \left[\dfrac{dE}{dv}\right]_0 \beta}\left[\frac{d^2E}{dv^2}\right]_0 \delta e_1^2 +$$

Thus, if only the second term of the various series need be considered, the distortion for a given output is reduced by feedback in the ratio

$$\frac{1}{1 + \left[\dfrac{d^2E}{dv^2}\right]_0 \beta}$$

The third term of (8) is

$$\frac{1}{6}\left\{\frac{\left[\dfrac{d^3E}{dv^3}\right]_0}{\left(1 + \left[\dfrac{dE}{dv}\right]_0 \beta\right)^4} - \frac{3\left[\dfrac{d^2E}{dv^2}\right]_0^2 \beta}{\left(1 + \left[\dfrac{dE}{dv}\right]_0 \beta\right)^5}\right\}\delta e^3$$

which may or may not be less than

$$\frac{1}{6}\left[\frac{d^3E}{dv^3}\right]_0 \left(\frac{\delta e}{1 + \left[\dfrac{dE}{dv}\right]_0 \beta}\right)^3$$

Therefore, the corresponding distortion may or may not be reduced by feedback. Higher terms may be treated similarly.

The above process is equivalent to obtaining a new characteristic for the operation of the amplifier with feedback by adding the abscissae of the graphs

$$E = f(v)$$

and

$$E = \frac{v}{\beta}$$

Some details of graphical methods have been published‡.

Wembley, Mddx.

ROBT. W. SLOANE (Research Laboratories of the General Electric Co., Ltd.).

* Black. *Bell System Tech. Journ.* Vol. XIII, p. 1.
† Feldtkeller. *Telegr. u. Fern. Tech.* Vol. XXV, p. 217.
‡ Bartels. *Elek. Nach. Tech.* Vol. XI, p. 319.

"Wireless Engineering"

To the Editor, The Wireless Engineer

SIR,—I can only apologise to Professor Palmer for the errors in my review of his book. My omission to look up "Grid-bias" in the index was inexcusable, but the index must share the blame for my mis-statement about the omission of the screen-grid tetrode, for the only reference given is to page 162, the dynatron application which I mentioned.

But I cannot agree that the review as a whole was "misleading." C. R. C.

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.

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PROPAGATION OF WAVES

1660. ULTRA-SHORT-WAVE REFRACTION AND DIFFRACTION [Extension of Watson's Analysis to take into Account the Finite Resistivity of the Earth : Curves derived from Mathematical Results].—T. L. Eckersley. (*Journ. I.E.E.*, March, 1937, Vol. 80, No. 483, pp. 286–304.)

The results for a range of wavelength between 2 and 10 m and for heights up to 4000 m and distances up to 400 km are given in the curves. "Although, as stated above, the major factor controlling u.s.w. propagation is diffraction, there is not wanting evidence of variation of signal intensity at extreme distances, which the author considers can only be caused by variation in the gradient of the refractive index of the air near the surface of the ground. The alternative hypothesis that the variations are due to reflections from the ionosphere seems very doubtful, for, although there is evidence of reflections at normal incidence of waves well above the critical frequency, the reflections occur in sporadic bursts and are very unlike the slow fadings observed in u.s.w. propagation. On the other hand, the extreme ranges, recently recorded, of police-car signals on 9 m from America, and television signals from Germany, are evidence of reflection from the ionosphere at glancing incidence. These reflections are likely to occur at the upper limit of the u.s.w. band. With the approach of sun-spot maximum conditions, waves of this kind are likely to be propagated over long distances and so may interfere with local reception on these waves. . . ."

1661. ULTRA-HIGH-FREQUENCY WAVE PROPAGATION OVER PLANE EARTH AND FRESH WATER [Measurements on 59–98 Mc/s : $E = IKA/d^2$: Little Difference between Plane Earth and Fresh Water].—R. C. Colwell & A. W. Friend. (*Proc. Inst. Rad. Eng.*, Jan. 1937, Vol. 25, No.1, Part 1, pp. 32–37.)

1662. DISCUSSION ON "AN URBAN FIELD STRENGTH SURVEY AT THIRTY AND ONE HUNDRED MEGACYCLES" [Doubts on Rate of Attenuation being Much Higher on the Higher Frequency : Authors' Reply].—C. R. Burrows : Holmes & Turner. (*Proc. Inst. Rad. Eng.*, Jan. 1937, Vol. 25, No. 1, Part 1, pp. 146–147.) *See* 2507 of 1936.

1663. WIRELESS AND THE ATMOSPHERE [Possible Effects on Television, and other Ultra-Short-Wave Services, of the Newly Discovered Electrified Layers].—R. A. Watson Watt. (*Wireless World*, 5th March, 1937, Vol. 40, pp. 220–222.)

1664. PROPOSAL FOR COMBINED STUDY [by Amateurs and Others] OF THE PROPAGATION OF WAVES AROUND 10 METRES AND OF THE ULTRA-SHORT WAVES [and a Correlation between Stoye's German Results and Some French Observations].—P. Labat. (*L'Onde Élec.*, March, 1937, Vol. 16, No. 183, pp. 200–203.) For Stoye's work *see* 446 of February.

1665. THE REFRACTIVE INDEX OF WATER FOR ELECTROMAGNETIC WAVES EIGHT TO TWENTY-FOUR CENTIMETRES IN LENGTH.—Goldsmith. (*See* 1900.)

1666. SOME PROBLEMS OF ATMOSPHERIC PHYSICS [Cobb Lectures : Ozone, Electricity in the Lower Atmosphere, Electricity in the Higher Atmosphere].—E. V. Appleton. (*Journ. Roy. Soc. Arts*, 12th, 19th and 26th Feb. 1937, Vol. 85, pp. 299–307, 321–330, and 338–346.)

1667. INTERACTION OF RADIO WAVES [with Bailey's Letter inviting Combined Effort to obtain Data on 100–400 m Waves : with Form for Use by Members of Soc. des Radioélectriciens].—Bailey. (*L'Onde Élec.*, March, 1937, Vol. 16, No. 183, pp. 205–207.) For Bailey's letter on the enhanced Luxembourg effect at the "gyro-frequencies" *see* 840 of March.

1668. THE "GYRO-INTERACTION" EFFECT.—Thompson. (*See* 1758.)

1669. MOTION OF ELECTRONS IN MAGNETIC FIELDS AND ALTERNATING ELECTRIC FIELDS.—L. G. H. Huxley. (*Phil. Mag.*, March, 1937, Series 7, Vol. 23, No. 154, pp. 442–464.)

For previous work, in which the effect of an electric field on the time spent between collisions of electrons with gas molecules was considered, *see* 1287 of April. Here "the same methods are used to investigate the motion of electrons in gases under the action of simple harmonic electric fields either with or without an accompanying constant magnetic field." A general formula is found for the mean rate of dissipation of energy in collisions with the molecules; it contains as special cases several formulae previously used by various writers.

1670. THE EQUATIONS OF MOTION OF ELECTRONS IN GASES [Deduction of General Form for Any Distribution of Energies of Agitation of Electrons].—J. S. Townsend. (*Phil. Mag.*, March, 1937, Series 7, Vol. 23, No. 154, pp. 481–486.) *See* also 3285 of 1936.

1671. THE POLARISATION OF RADIO ECHOES [is Elliptical: Magneto-Ionic Effects in E Region].—D. F. Martyn, J. H. Piddington, & G. H. Munro. (*Proc. Roy. Soc.*, Series A, 3rd Feb. 1937, Vol. 158, No. 895, pp. 536–551.)

Authors' summary:—The paper describes a relatively simple and flexible method of determining the polarisation ellipse of downcoming radio echoes. The method employs pulse emissions, and is therefore applicable when more than one echo is receivable, but avoids the difficulty of radio-frequency phase instability by a partial employment of the frequency-change technique. . . . A simple method of determining the sense of rotation of the vectors in the polarisation ellipse, employing defocusing of the cathode-ray beam, is described. The results obtained afford strong evidence of magneto-ionic effects in the E region of the ionosphere. These effects are found to be due to electrons and not to heavy ions. Further evidence is obtained of the occasional presence of a thin layer of electrons at the level of the E region. It is found that the polarisations of echoes are elliptical, in accordance with Baker & Green's theory of limiting polarisation (1933 Abstracts, pp. 385, 614).

1672. SOME PECULIARITIES OF IONOSPHERIC ECHOES [Widened Image of Short-Wave Echo, obtained by Its Recording during the Oscillograph Fly-Back Instant, shows Continuous Change of Form, with Period of Some Seconds: Deductions].—Jouaust, Abadie, & Joigny. (*L'Onde Élec.*, March 1937, Vol. 16, No. 183, pp. 185–188.)

"All these rapid variations prove that the ionosphere is in a perpetual state of variation, in the vertical sense as well as the horizontal. But the dissociation of the echo remains to be explained. It could be attributed to a stratification of the ionosphere . . . but, apart from the difficulty of admitting such a stratification in a medium so agitated, a doublet in the first echo ought to be followed by a corresponding quadruplet in the [twice reflected] second: this we have never observed. The existence of a doublet can be explained—as Appleton has shown—by the action of the earth's magnetic field. . . . The Appleton theory allows for the existence of a triplet, and the occurrence of a triple reflection has already been announced (Harang, *Terr. Mag.* 1936, pp. 143–160). The theory of the action of the earth's magnetic field would similarly, perhaps, allow a quadruplet [as observed by the writers and shown in Fig. 3, trace c] to be envisaged (Rai, 841 of March).

"If the dissociation of the echo is to be attributed to the earth's magnetic field, the phenomena we have observed seem to indicate that the displacements of the ionised layers of the upper atmosphere are accompanied in this region by important variations of the terrestrial field: variations too localised to act on the magnetographs."

1673. AROUND-THE-WORLD RADIO ECHOES [Average Intensity varies approximately with Percentage Illumination: Measured Delays correspond to Path Length about 3.3% greater than Earth's Circumference].—A. C. Peterson, Jr. (*Bell Lab. Record*, March, 1937, Vol. 15, No. 7, pp. 216–220.)

1674. THE PROPAGATION OF WIRELESS WAVES IN THE IONOSPHERE.—H. G. Booker. (*Abstracts of Dissertations for the Ph.D. and other Degrees*, Cambridge, 1935–1936, pp. 76–78.)

The abstract of Part I was given in 3277 of 1936. In Part II "Appleton's magneto-ionic theory, which is only suitable for investigating vertical propagation in the ionosphere, is generalised so as to be capable of dealing with the case of oblique incidence." It is shown that the critical electron density required for the reflection of a magneto-ionic component, which must be calculated by expressing the condition that the direction of energy-propagation is horizontal, can be as much as 20% in excess of that calculated by expressing the condition that the direction of phase-propagation is horizontal. In Part III it is shown that "vertical propagation in the ionosphere may, with due care, be described fairly completely with the aid of the quasi-longitudinal and quasi-transverse approximations only." A region of absorption exists below the deviating region, and for propagation through it at quite large angles to the magnetic field only the component of that field in the direction of propagation is effective. Near the magneto-ionic frequency there is never an appreciable extra-ordinary reflected wave.

1675. ANNUAL VARIATION OF THE CRITICAL FREQUENCIES OF THE E AND F_2 LAYERS.—L. Harang. (*Nature*, 20th Feb. 1937, Vol. 139, pp. 328–329.)

Noon observations of the critical frequencies recorded at Tromsö during the last two years form the basis of "a hypothesis explaining the dependence of the critical frequencies of the F_2 layer on, and the independence of the critical frequencies of the E layer of, the annual temperature (and therefore pressure) variations." The annual variations in critical frequency are found to be "due to different absorption of the solar radiation producing ionisation. . . . In the F_2 layer the ionising agency is only slightly absorbed when passing through the layer; a variation of pressure will therefore strongly influence the production of ions. In the E layer the ionising rays are completely absorbed and the maximum electron production is fixed by the limited spectral energy and is independent of pressure variations."

1676. THE DAYLIGHT VARIATION OF SIGNAL STRENGTH.—R. C. Colwell & A. W. Friend. (*Journ. of Applied Phys.* [formerly *Physics*], Feb. 1937, Vol. 8, No. 2, pp. 141–143.)

Automatic records of medium waves from KDKA, WMMN, and WLW. Rapid variation of daytime signals from the stations was found, with wide fluctuation from day to day; night signals showed a relationship depending on the barometric pressure, in agreement with Martyn's observations (1934 Abstracts, p. 199). The daylight signal strength increased during the autumn of 1936. "If the newly discovered D and C regions of the ionosphere are regarded as the absorbing layers of the E region, the observations given . . . are in agreement with Martyn's theory."

1677. ON RELATIONS OF THE IONOSPHERIC LAYERS TO METEOROLOGICAL INFLUENCES.—G. Leithäuser & B. Beckmann. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 18, 1937, pp. 59–61 and Plate facing p. 58.)

The steepness of slope of the observed evening rise of the layers must be influenced by the intensity and direction of the winds in the upper atmosphere. Such is the theoretical deduction drawn from the authors' statement (*see* 1279 of April and back references) that the ionosphere does not participate in the earth's rotation (or that at any rate there is a large phase lag between the two motions), when all the implications as to the effects of such a state of affairs are taken into account: as regards, particularly, the bringing into position, at the spot where the height measurements are made, of new supplies of charge carriers. In this connection it must be remembered that apparent movements of the F layer may be caused by processes occurring not at heights of 200–300 km but in the lower E and D layers, for such apparent F-layer movements may be due either to ionisation changes in the F layer or to changes in the lower layers producing alterations to the group velocity, and thus apparent alterations to the height of the upper layers: occasionally the two actions counterbalance one another and the layer height appears to remain constant.

Thus it would be expected that the apparent evening rise of the layers would be quick and pronounced if there were a strong upper wind blowing from east to west, whereas with a west wind the ascent would be slow. Comparison of the writers' observations with the Lindenberg Observatory charts of winds at heights of 3–4 km confirms these theoretical conclusions, as is seen from Figs. 2–4, where the top curves represent the mean steepness of the measured evening rise and the two lower curves (in each figure) represent the direction and strength of the wind at 8.00 and 17.00: the rise of the layers occurred between 19.00 and 23.00. The layer and wind curves agree throughout, except at the isolated points marked with small squares, which represent sudden bursts of ionisation confirmed by independent observations. The correlation factor is 6 to 7 times the mean error, and a change in the direction of the wind produced a characteristic change in the steepness of the ascent.

The final paragraph discusses available data and opinions as to the strength and direction of winds at still greater heights.

1678. EFFECT OF METEORIC SHOWER ON THE IONISATION OF THE UPPER ATMOSPHERE [Increase of Ionisation of E_1 and E_2 Regions by Leonid Shower of Nov. 1936: Doubtful Increase in F_1 Region].—J. N. Bhar. (*Nature*, 13th March, 1937, Vol. 139, pp. 470–471.)

1679. ATMOSPHERIC OSCILLATIONS [Theoretical Work with Bearing on Temperature Distribution in Upper Atmosphere and "Dynamo" Theory of Diurnal Variation of Earth's Magnetic Field].—C. L. Pekeris. (*Proc. Roy. Soc.*, Series A, 3rd Feb. 1937, Vol. 158, No. 895, pp. 650–671.)

1680. AURORAL DISPLAY AND RADIO DISTURBANCE [observed on 7.1.1937 in Scotland: 27 Days before Display on 3.2.1937: Simultaneous Magnetic Unrest].—(*Nature*, 20th Feb. 1937, Vol. 139, p. 318: short note only.) For further details of these disturbances *see* also J. P. Rowland, *Nature*, 27th Feb. 1937, Vol. 139, pp. 375–376, where it is suggested that "the aurora is chiefly manifest whilst a current of negatively charged ions is traversing the upper atmosphere in a direction with a south to north component."

1681. EFFECT OF PRESSURE ON THE EXCITATION FUNCTION OF THE BANDS OF THE MOLECULE OF IONISED NITROGEN [Experimental Curves show Maximum].—R. Bernard. (*Comptes Rendus*, 15th Feb. 1937, Vol. 204, No. 7, pp. 488–490.)

1682. RELATION BETWEEN THE INTENSITY VARIATIONS OF ULTRA-VIOLET SOLAR RADIATION, MEASURED AT SOIL LEVEL, AND THE POLLUTION OF THE LOWER ATMOSPHERE [Pollution an Important Cause of Ultra-Violet Intensity Variation].—L. Herman & F. Bernstein. (*Comptes Rendus*, 1st March, 1937, Vol. 204, No. 9, pp. 708–710.)

1683. MEASUREMENTS OF IONISATION IN THE IONOSPHERIC LAYERS DURING THE PARTIAL SOLAR ECLIPSE OF JUNE 19TH, 1936, AT SHANGHAI.—Ts'en, Chu, & Liang. (*Chinese Journ. of Phys.*, Dec. 1936, Vol. 2, No. 2, pp. 169–177: in English.)

Pulse observations, on fifteen frequencies from 3.16 to 6.12 Mc/s, indicate that the ionisation of the F_1 layer is almost entirely due to ultra-violet light or similar high-speed radiation, agreeing with Appleton; that of the E layer cannot be explained by this hypothesis alone, a considerable part of it being apparently due to some other agent, probably corpuscular bombardment in accordance with Chapman.

1684. Radio Fade-Outs through 1936.—J. H. Dellinger. (*QST*, Feb. 1937, Vol. 21, No. 2, pp. 35 and 86, 88.)

"As there is reason to suppose that radio fade-outs (and the associated magnetic and other phenomena) are caused by one type of ultra-violet solar radiation, and that ordinary magnetic disturbances, auroras, etc., are caused by a solar emanation of different character, these phenomena present powerful means of keeping track of two different and very interesting types of event on and in the sun."

1685. Intrinsic Properties of Light and Corpuscles from Distant Sources [Nebular Light and Terrestrial Light: Corpuscular Rays].—F. Zwicky. (*Proc. Nat. Acad. Sci.*, Feb. 1937, Vol. 23, No. 2, pp. 106–110.)

1686. Storms on the Sun's Surface at Times of Total Eclipse.—S. A. Mitchell. (*Science*, 19th Feb. 1937, Vol. 85, Supp. p. 8.)

1687. Comparison of Data on the Ionosphere, Sunspots, and Terrestrial Magnetism.—Judson. (*Proc. Inst. Rad. Eng.*, Jan. 1937, Vol. 25, No. 1, Part 1, pp. 38–46.) *See* 7 of January.

1688. Cosmic Data to be Broadcast Daily from W1XAL, Boston.—(*Sci. News Letter*, 13th Feb. 1937, p. 100.)

1689. The Moon and Reception [English Observations on American Short-Wave Stations].—C. G. Hayes. (*World-Radio*, 26th Feb. 1937, p. 6.)

1690. The Physical Reality of Zenneck's Surface Wave [Vertical Dipole does Not generate Surface Wave behaving at Great Distances like Zenneck's Plane Surface Wave: Success of Wave Antennas Not Dependent on Zenneck Wave].—W. H. Wise. (*Bell S. Tech. Journ.*, Jan. 1937, Vol. 16, No. 1, pp. 35–44.)

The evidence against the Zenneck wave is presented. It is then shown that a plane electromagnetic wave, polarised with the electric vector in the plane of incidence and in the wave front, impinging on a plane solid at nearly grazing incidence, produces a total field in which the horizontal electric field near the solid has very nearly the same ratio to the vertical electric field as in the Zenneck surface wave; and that the wave tilt near the ground at a great distance from a vertical dipole is almost the same as that found for the plane wave at nearly grazing incidence. *See* also Rice, 1691, below.

1691. Series for the Wave Function of a Radiating Dipole at the Earth's Surface.—S. O. Rice. (*Bell S. Tech. Journ.*, Jan. 1937, Vol. 16, No. 1, pp. 101–109.) "Two convergent series and one asymptotic series are obtained. A remainder term for the latter series is given which enables one to set an upper limit to the amount of error obtained by stopping at any particular stage in the series."

1692. Radio Propagation over Plane Earth—Field-Strength Curves [Part I—Aerials on the Surface of the Earth: Part II—Aerials above It].—C. R. Burrows. (*Bell S. Tech. Journ.*, Jan. 1937, Vol. 16, No. 1, pp. 45–75.)

In Part I the results obtained by Sommerfeld and by Rolf are corrected, and certain approximations introduced by Rolf to reduce the number of variables to a workable number are eliminated (*see* also Burrows, 1693, below). In Part II the complete equation giving the field strength for aerials at any height above the earth is reduced to a simple equation which allows the calculation of the field under conditions of practical interest.

1693. The Surface Wave in Radio Propagation over Plane Earth [Experimental Disproof of Zenneck-Sommerfeld Surface Wave from Simple Aerial].—Burrows. (*Proc. Inst. Rad. Eng.*, Feb. 1937, Vol. 25, No. 2, pp. 219–229.)

For a preliminary letter *see* 3661 of 1936. "As a result . . . it follows that the asymptotic series development of the received field strength is a true asymptotic expansion and does not require the addition of an exponential term. Hence the series development of the problem by Strutt and Wise may be used with confidence." *See* also 1690.

1694. Absence of Fresnel's "Most Useful Effect" in the Hyperbolic Reflector.—L. E. Dodd. (*Journ. Opt. Soc. Am.*, Feb. 1937, Vol. 27, No. 2, pp. 92–94.)

1695. The Diffusion of Light at the Surface of Separation of Two Liquids [Experimental Confirmation of the $1/\lambda^2$ Law].—Barichanskaia. (*Physik. Zeitschr. der Sowjetunion*, No. 5, Vol. 10, 1936, pp. 666–672: in French.)

1696. On the Anomalous Diffraction Gratings: II [Summary of Results of Theoretical Work by Sommerfeld's Method explaining Anomalies in Diffraction Spectra].—U. Fano. (*Phys. Review*, 15th Feb. 1937, Series 2, Vol. 51, No. 4, p. 288.) For previous work *see* 29 of January.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

1697. Some New Forms of Electroconvective Eddies [with (1) Parallel Rectilinear and (2) Coaxial Cylindrical Electrodes].—Avsec & Luntz. (*Comptes Rendus*, 8th March, 1937, Vol. 204, No. 10, pp. 757–759.) *See* also 1297 of April.

1698. The Diameter of the Lightning Channel.—B. F. J. Schonland. (*Phil. Mag.*, March, 1937, Series 7, Vol. 23, No. 154, pp. 503–508.)

"A lightning photograph is discussed which shows the first and last separate strokes of the discharge to have had their channels shifted a distance exceeding 3.7 m by the wind. It is found that the average diameter of the lightning-stroke channel is about 16 cm . . . Consideration is given to the question whether this diameter represents that of the electrical core of the discharge."

1699. Apparatus for Photographing Lightning Flashes [with Wide Range and High Resolving Power].—Albright. (*Review Scient. Instr.*, Jan. 1937, Vol. 8, No. 1, pp. 36–37.) Consisting of eight whirling and three fixed box cameras on tripod head.

1700. Lightning [General Phenomena: Direct Strokes to Transmission Circuits and Their Prevention, etc.].—B. L. Goodlet. (*Nature*, 13th March, 1937, Vol. 139, pp. 478–479: abstract of recent I.E.E. paper.)

1701. Protection of Powerful Transmitters in Thunderstorms.—W. Peters. (*E.N.T.*, Jan. 1936, Vol. 14, No. 1, pp. 24–33.)

A protective device is described in which the h.f. voltage in the output circuits, power leads and aerial is quickly switched off by locking the grids of the amplifying valves. The emitter starts working again automatically after the disturbance. The arrangement of a protective spark gap and choke in the aerial and tuning hut is shown in Fig. 2. The statistics of thunderstorm disturbances (§ 2) and the danger of lightning striking the aerial (§ 3) are analysed. Fig. 3 illustrates a calculation of the danger zone of a vertical aerial for lightning flashes. A calculation of overvoltages produced by electrostatic induction in the field of a thundercloud is given in § 4 (Fig. 6). The dimensions required for the spark gap and choke are deduced from this. Fig. 7 shows the spark gap, with an arrangement for measuring the lightning current. A spark causes an h.f. arc, which short-circuits the power leads. The stabilisation and de-ionisation of this arc are investigated; the de-ionisation is done by quickly switching off the h.f. voltage. The switch is set going by an indicator which responds to the reflected wave arising in various types of disturbance. The whole protective circuit is shown in Fig. 14; it is effective against any overvoltages and breakdowns which may arise through faulty switching, tuning, etc., as well as against thunderstorm phenomena. It also provides a means of economising on insulation. Receivers may be protected from disturbances by this short-period locking.

1702. Indirect Lightning Overvoltages on Power Lines.—H. Norinder. (*Teknisk Tidskrift*, 6th March, 1937, Vol. 67, Supp. pp. 33–39.)

1703. Investigations of Klydonograph Brush-Discharge Figures by Current and Potential Measurements with the Cathode-Ray Oscillograph [Symmetrical Brush-Discharge Figures with Point/Dielectric/Plate Arrangement: Voltage Measurements: Variation of Figure Form with Steepness and Voltage of Surge: Spreading Velocity, etc.].—G. Dragu. (*Arch. f. Elektrot.*, 18th Feb. 1937, Vol. 31, No. 2, pp. 131–139.) *See* also 891 of March.

1704. The Measurement of the Maximum Current Strength of Short-Period Surges [and a New Technique using Iron-Powder Rods instead of Steel-Wire Bundles, with Several Advantages].—E. Blum & W. Finkelnburg. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 18, 1937, pp. 61–65.)

1705. The Effect of the Capacities of the Masts on the Propagation of Surges along Groups of Conductors.—H. Schwenkhagen. (*Arch. f. Elektrot.*, 18th Feb. 1937, Vol. 31, No. 2, pp. 73–92.)

The effect of the discontinuity in a conductor caused by the presence of an extra capacity to earth is investigated theoretically for various waveforms. In general the wave-front is found to be flattened and the peak voltage decreased. An anomalous wave of opposite sign is found with coupled conductors. Qualitative agreement with experimental results is obtained.

1706. Field Investigations using Controlled Surges [Reflections, Attenuation, Propagation Velocity, etc.].—K. B. McEachron & E. J. Wade. (*Gen. Elec. Review*, Feb. 1937, Vol. 40, No. 2, pp. 72–83.)

1707. The Absolute Intensity of the Ionisation by Cosmic Radiation at Sea Level [1.10 ± 0.04 Ions/cc/sec.]—Clay & Jongen. (*Physica*, March, 1937, Vol. 4, No. 3, pp. 245–255.)

1708. Magnetic Storms recorded at Tsingtao Observatory since 1924.—C. Y. Liu. (*Chinese Journ. of Phys.*, Dec. 1936, Vol. 2, No. 2, pp. 178–186: in English.)

1709. "The Earth's Magnetism" [Book Review].—S. Chapman. (*Proc. Inst. Rad. Eng.*, Jan. 1937, Vol. 25, No. 1, Part 1, p. 151: *Wireless Engineer*, Feb. 1937, Vol. 14, No. 161, p. 62.)

PROPERTIES OF CIRCUITS

1710. Distortion of "Kipp" Oscillations by a Quadripole.—M. von Ardenne. (*Hochf:tech. u. Elek:akus.*, Feb. 1937, Vol. 49, No. 2, pp. 37–40.)

The frequency spectrum of "kipp" oscillations is first analysed for various durations of the return stroke; the decrease in the amplitude of the overtones (Fig. 1) is given by eqn. 2, which shows that for non-zero durations the amplitude becomes periodically zero. Fig. 2 shows the distortion of a "kipp" oscillation with zero return-stroke duration when all overtones above the tenth are cut out; it is found that low distortion of the "kipp" curve with non-zero return-stroke duration can only be expected if the Fourier series is not cut off before the first term with zero amplitude. Fig. 3 illustrates the synthesis of a "kipp" oscillation from sinusoidal overtones when all frequencies are cut out whose oscillation time is less than the duration of the return stroke. In § III the *degree of distortion* of "kipp" oscillations is defined as the ratio of the largest to the smallest recording velocity present on the rising part of the curve; it gives at once the ratio of the scales of reproduction of various parts of the image. Fig. 4 shows the "kipp" voltage distortion when charging takes place across an ohmic resistance; it illustrates the percentage of the charging curve which may be cut out without producing too much distortion. The distortions of "kipp" curves are discussed which are produced in elements with linear properties by frequency variations or phase rotations. Fig. 5 shows the distortion due to change in phase or amplitude of the fundamental oscillation, Fig. 6 the degree of distortion as function of a phase displacement of the fundamental relative to all the other spectral components, Fig. 7 the phase rotation and variation with amplitude of an over-damped resonance system. It is found that the resonance frequency must be brought to the centre of gravity of the " kipp " spectrum ; the value of the attenuation can be deduced which produces exactly the critical phase displacement of the fundamental oscillation. This solves the problem of the economic design of transmission circuits or amplifiers for " kipp " oscillations.

1711. THE CALCULATION OF THE RELAXATION-OSCILLATION [" Kipp "] FREQUENCY OF SIMPLE GLOW-DISCHARGE-TUBE CIRCUITS.—F. Bergtold. (*Funktech. Monatshefte*, Jan. 1937, No. 1, pp. 30–31.)

1712. THE CORRECTION OF THE INPUT CIRCUIT OF A [Wide-Band] AMPLIFIER, *and* ON THE CORRECTION OF RESISTANCE COUPLED AMPLIFIERS AT LOW FREQUENCIES.—Weisbrut : Kreutzer. (*See* 1869 and 1870.)

1713. PUSH-PULL RESISTANCE-COUPLED AMPLIFIERS [Usual Push-Pull Cancellation of In-Phase Signal absent with Resistance Coupling : a Successful Circuit giving Cancellation by In-Phase Degenerative Feed-Back].—F. Offner. (*Review Scient. Instr.*, Jan. 1937, Vol. 8, No. 1, pp. 20–21.)

1714. [Thermal] NOISE VOLTAGES IN OSCILLATORY CIRCUITS [depend on Value of Capacity only, Not of Inductance or Resistance].—R. Feldtkeller. (*Veröff. a. d. Geb. d. Nachr:tech., Siemens*, No. 2, Vol. 6, 1936, Sec. VII, 2 pp.)

1715. FLUCTUATIONS OF POTENTIAL AT THE ENDS OF A METALLIC CONDUCTOR OF SMALL VOLUME TRAVERSED BY A CURRENT [Mathematical and Experimental Investigation].—J. Bernamont. (*Ann. de Physique*, Jan. 1937, Vol. 7, pp. 71–140.) Continuation of the work dealt with in 1968 of 1936 and back references.

1716. A CONTRIBUTION TO THE THEORY OF FORCED OSCILLATIONS IN A GENERATOR WITH TWO DEGREES OF FREEDOM.—A. Mayer. (*Tech. Phys. of USSR*, No. 12, Vol. 3, 1936, pp. 1056–1071 : in English.)

For the writer's treatment of the coupled vibrations of two self-excited generators, also using the van der Pol method of " slow variation of coefficients ", *see* 1724 of 1936. Particular attention is paid to the questions of the existence and stability of the so-called " biharmonic motions " of the generator in the condition far from resonance, and of the switching from one " normal " frequency to another (in the " Ziehen " loop) by turning the external force on and off.

1717. A STABLE NEGATIVE-RESISTANCE OSCILLATOR OF SMALL HARMONIC CONTENT [" Roberts " Circuit employing Resistance Neutralisation enables Amplitude to be kept near Threshold].—H. J. Reich. (*Proc. Inst. Rad. Eng.*, Feb. 1937, Vol. 25, No. 2, pp. 156–157 : summary only.)

Giving total harmonic content below one-half per cent. and high frequency stability, without the " objectionable features " of oscillators depending on secondary emission. Automatic amplitude control is used to keep the oscillations at the required low amplitude over the frequency range.

1718. THE THEORY OF THE TRANSFORMATION FROM CONSTANT CURRENT TO CONSTANT VOLTAGE.—H. Pieplow. (*Arch. f. Elektrot.*, 23rd Jan. 1937, Vol. 31, No. 1, pp. 64–72.)

General conditions for the construction of Boucherot circuits are deduced from quadripole theory. The asymmetrical, symmetrical, and bridge quadripoles are discussed, with their vector diagrams and efficiences. The practical use and economy of these circuits for high voltage supply are considered.

1719. TWO-MESH TUNED COUPLED CIRCUIT FILTERS [" Reasonably Simple Analysis " of Use to Design Engineers : Free from Restrictions such as " Circuits are Identical," " Coupling is by Pure Reactance "].—C. B. Aiken. (*Proc. Inst. Rad. Eng.*, Feb. 1937, Vol. 25, No. 2, pp. 230–272.)

" The results include, and collect into a correlated whole suitable for application to practical problems, many relations which have been derived before, as well as a number of new ones." The analysis is limited to filters with a pass-band width only a few per cent. of the centre frequency.

1720. TRANSIENTS OF RESISTANCE-TERMINATED DISSIPATIVE LOW-PASS AND HIGH-PASS ELECTRIC WAVE FILTERS.—W. Chu & C. K. Chang. (*Chinese Journ. of Phys.*, Dec. 1936, Vol. 2, No. 2, pp. 154–168 : in English.)

Extension of the work dealt with in 3707 of 1936 to include Π-type low-pass and T- and Π-type high-pass filters. With the same network constants, transients die out faster in Π-type filters. The cut-off frequency of a Π-type filter varies with the number of sections : when only two sections are used (high- or low-pass) the variation is a maximum and amounts to nearly 26% from the theoretical value.

1721. THE BAND-PASS–LOW-PASS ANALOGY [leading to a Simple Method of deriving the Former from the Latter].—V. D. Landon. (*Proc. Inst. Rad. Eng.*, Dec. 1936, Vol. 24, No. 12, pp. 1582–1584.)

1722. THE DESIGN OF A MECHANICAL ANALOGY FOR THE GENERAL LINEAR ELECTRICAL NETWORK WITH LUMPED PARAMETERS [Theoretical Analysis].—M. Pawley. (*Journ. Franklin Inst.*, Feb. 1937, Vol. 223, No. 2, pp. 179–198.)

1723. THE GRAPHICAL DETERMINATION OF BAND-FILTER CURVES.—F. Stejskal. (*Funktech. Monatshefte*, Jan. 1937, No. 1, pp. 15–16.) For previous work on band filters *see* 932 of 1936.

1724. ELECTRICAL FILTERS IN THEORY AND CALCULATION.—W. Kautter. (*Funktech. Monatshefte*, Jan. 1937, No. 1, pp. 1–11.)

1725. Nomograms for the Design of Band-Pass R.F. Circuits [Uehling Mixed Coupling Circuits acting as Band-Pass Filters: as in Western Electric 10-A Receiver].—C. P. Nachod: Uehling. (*Rad. Engineering*, Dec. 1936, Vol. 16, pp. 13–16.) For Uehling's work *see* Abstracts, 1930, p. 210; 1931, p. 95 & 148.

1726. Design of Resistance Pads [*T*, *L*, *H* and *U* Types: for Impedance Matching with Minimum Attenuation: etc.].—C. F. Nordica. (*Comm. & Broadcast Eng.*, Nov. 1936, Vol. 3, No. 11, pp. 12–14 and 21.)

1727. Calculation of the Self-Inductance of Plane Polygonal Circuits.—P. L. Kalantaroff & V. I. Worobieff. (*Proc. Inst. Rad. Eng.*, Dec. 1936, Vol. 24, No. 12, pp. 1585–1593.) Extension of Bashenoff's methods (Abstracts, 1929, p. 111 & 398) to circuits with re-entrant angles.

1728. On the Resonance Phenomena in a Lecher System loaded at the End with Capacity.—Volpert. (*See* 1899.)

TRANSMISSION

1729. A New Source of Long-Wave Infra-Red Rays [Experiments with H.T. 3-Electrode Tube (Magnesium-Oxide Anticathode with Embedded Grid) with Calculated Micro-Wavelength of 9×10^{-2} cm].—M. Lewitskaja. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 10, 1936, pp. 697–702: in German.)

The aluminium cathode was put at a negative potential of 45 kv: the anticathode was earthed, and the grid given a positive potential of 280–300 v. "A simple calculation shows . . . that the electrons can carry out oscillations at the grid which will lie in the further infra-red region. . . . In the tests with this tube, however, not simply these oscillations were obtained but a special type of radiation. . . ." On applying the potential to the cathode, a glow appeared at the anticathode, and a thermojunction screened in a metal box, placed at the focus of the second of two mirrors giving an optical path of nearly 2 metres' total length, yielded a galvanometer deflection of 1 cm which persisted almost unchanged when the tube was switched off. Three sheets of black paper placed over the quartz window of the tube had practically no effect on the deflection, which however vanished for a wooden plate or metal sheet. Various tests confirmed the long-wave infra-red nature of these after-glow rays. To produce an equal energy by heat would require a temperature round 23 000 degrees, whereas throughout the tests the anticathode remained dark. "We have here a kind of phosphorescence by means of long waves, in which the electrons spring from one grain of the magnesium oxide to another." The publication of those incompleted researches is prompted by Malter's work on the electron radiation in casesium oxide (3418/9 of 1936).

1730. The Influence of Gas Pressure on the Energy and Efficiency of Magnetron Oscillations.—Maidanov. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 10, 1936, pp. 718–740.)

English version of the Russian paper dealt with in 530 of February. "All difficulties which are experienced when the vacuum is not very high are due *not* to the decrease in the oscillatory energy but to the surplus heating [of the filament: probably through bombardment by positive ions] . . . Vacua as high as 10^{-6} mm Hg . . . cannot guarantee the absence of surplus heating [*cf.* Wigdorchik, 1731, below]; therefore we think that the rational construction of a magnetron valve should not be based on the improvement of the vacuum but on the study and development of new effective methods for regulating the stabilisation of the cathode heating" [*cf.* Gwyer & Megaw, 1733, below].

1731. A Study of the Surplus Heating of a Cathode in a Magnetron: Corrections.—Wigdorchik. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 10, 1936: correction slip.) *See* 1318 of April. In Table 2 on p. 640 the magnetic field is in "relative units," not gauss: this applies also to the last line of p. 647.

1732. On the Modulation of a Magnetron Oscillator.—M. T. Grekhova & V. I. Sapozhnikov. (*Izvestiya Elektroprom. Slab. Toka*, No. 12, 1936, pp. 5–7.)

There are certain difficulties in applying anode modulation to a magnetron oscillator, when this is operated on wavelengths of the order of 10 to 40 cm. In the present paper a brief description is given of two types of oscillator which were developed in order to obviate these difficulties. In the first type, use is made of two discs at the ends of the anode similar to Linder's end plates (2611 of 1936), and modulation is effected by applying the modulating voltage to the discs (Fig. 1). It is stated that very little distortion is introduced by this method of modulation. In the second type, additional electrodes in the form of gauze discs are interposed between the end plates and the anode, and the modulating voltage is applied to these discs (Fig. 4). The advantage of this method is that practically no extra power is required for modulation, although the amplitude of the modulating voltage must be high.

1733. Automatic Stabilisation of Temperature-Limited Currents in Thermionic Valves [particularly for Ultra-Short-Wave Oscillators where Space-Charge Limitation of Anode Current is Detrimental].—R. G. B. Gwyer & E. C. S. Megaw. (*Journ. Scient. Instr.*, March, 1937, Vol. 14, No. 3, pp. 76–83.)

"The problem is essentially that of keeping the anode current of a saturated diode within some specified limit of an assigned value. The solution adopted makes use of a small change in the anode current, acting through a control device, to alter the cathode temperature in such a direction as to oppose the original change."

1734. The Influence of the Transit Time of Electrons in Vacuum Tubes [with Table of Approximate Times: may produce Useful Negative-Resistance Effects: etc.].—A. Clavier. (*L'Onde Élec.*, March, 1937, Vol. 16, No. 183, pp. 145–149.)

As not infrequently occurs, the originally tiresome effects may be turned to good use, for if the lag between the effects of the electron motion and the voltage producing them is sufficiently large compared with the period, it produces negative-resistance effects. "This phenomenon is used for the production and detection of oscillations corresponding to wavelengths of the order of a decimetre and of a centimetre."

1735. Note on the Useful Power which can be furnished by Ultra-Short-Wave Transmitters [of Adequate Stability].—Y. Rocard. (*L'Onde Élec.*, March, 1937, Vol. 16, No. 183, pp. 150–155.) Without out-of-the-way measures, but taking necessary precautions, useful powers of 50–500 w between 1.80 m and 9 m can be obtained without water-cooled valves. Magnetrons give useful powers of hundreds of watts on 2 m, 30 w on 30 cm, and 2 w on 16 cm.

1736. Micro-Waves: Part III—Transmitting Apparatus and Its Coupling to Aerials, Its Modulation, and Systems for Concentrating the Radiation: Part IV—Detection and Amplification.—Carrara. (*Alta Frequenza*, Feb. 1937, Vol. 6, No. 2, pp. 104–141.) Further to the papers dealt with in 937 of March. Future parts will consider propagation, components, commercial apparatus, and measuring technique.

1737. On the Design of a Modulator for a Television Transmitter [on Ultra-Short Waves].—Ivanov & Solov'ev. (*See* 1867.)

1738. A Variometer for an Oscillator of Wide Frequency Range [Concentric Spheres, Inner rotating about Axis always Perpendicular to Electromagnetic Axes of Both].—J. A. Pierce. (*Review Scient. Instr.*, Jan. 1937, Vol. 8, No. 1, pp. 24–27.)

Used as the "tank" inductance in a Hartley oscillator, and maintaining a constant excitation ratio over a wide frequency range (for ionosphere pulse transmitter). Basic design applicable to oscillators of lower power and much wider frequency range.

1739. Vacuum Tube Modulation Meter [giving Value by noting Ratio of Two Readings].—P. M. Honnell. (*Electronics*, Jan. 1937, Vol. 10, pp. 18–20.)

1740. Application of Dry-Plate Rectifiers to Modulation [in Carrier-Current Telegraphy and Telephony].—A. Pagès. (*Génie Civil*, 2nd Jan. 1937, Vol. 110, p. 24: summary only.)

1741. The Mode of Action of "Ring" Modulators [for Carrier-Current Single-Sideband Suppressed-Carrier Working].—A. Schmid. (*Veröff. a. d. Geb. d. Nachr:tech.*, *Siemens*, No. 3, Vol. 6, 1936, pp. 145–163.)

1742. Determining the Optimum L/C Ratio for Transmitter Tank Circuits.—J. L. Reinartz. (*QST*, March, 1937, Vol. 21, No. 3, pp. 25–26 and 116, 118.)

1743. The Doherty High-Efficiency Amplifier applied to Amateur 'Phone [on 3.95 Mc/s].—B. E. Montgomery. (*QST*, Feb. 1937, Vol. 21, No. 2, pp. 30–34 and 118, 122.) For Doherty's paper *see* 4020 of 1936.

1744. Corrections to "Transmitter Adjustments" [for Broadcasting].—Sperling. (*Electronics*, Jan. 1937, Vol. 10, p. 56.) *See* 3729 of 1936.

1745. Stabilised Feedback for Radio Transmitters.—L. G. Young. (*Bell Lab. Record*, Feb. 1937, Vol. 15, No. 6, pp. 182–186.)

1746. Radio Progress during 1936. Part V—Report by the Technical Committee on Transmitters and Antennas.—(*Proc. Inst. Rad. Eng.*, Feb. 1937, Vol. 25, No. 2, pp. 211–218.)

RECEPTION

1747. The Single-Anode Magnetron in Receiving Circuits for Micro-Waves.—A. Giacomini. (*Alta Frequenza*, Feb. 1937, Vol. 6, No. 2, pp. 75–103: long English summary at end of journal.)

From author's summary:—"The characteristic curves $I_a = f(V_a)$ found experimentally with a [single-anode] magnetron are examined in detail. Studying the functions of the type $\Delta I_a = f(V_a)$, with H constant, where ΔI_a is the increase of I_a when an oscillating voltage of constant amplitude is superposed on the direct anode voltage, the following conclusions are reached:—(1) when the direct voltage is near the value resulting in a negative differential resistance, the magnetron is a sensitive relay for alternating voltages of any frequency; (2) the magnetron lends itself to the detection of oscillatory voltages of period T_f considerably longer than T_r, the time of revolution of the electrons; (3) if T_f is much less than T_r, detection is possible but of low efficiency; if T_f is about equal to T_r, the magnetron is in the best possible condition for the detection of micro-waves; in this case ΔI_a has negative values, contrary to what the form of the static characteristic would suggest. This last result is obtained by a study of the variations of the damping of the receiving circuit when, for a fixed micro-wave period T_f, changes are made to H, V_a, or the cathode temperature θ_c."

Other conclusions relate to the existence of values of H and of V_a which, independently, give rise to maximum damping: if the time of revolution of the electrons, in the condition of max. damping, is calculated, T_r is found to be very near both to the period of the micro-waves which maintain the circuit in forced oscillation and to the period T_g of the micro-waves which the same magnetron could generate; it seems however unlikely that an identity $T_f = T_g$ should exist. Finally, if H is very near the value giving max. damping, the dielectric constant of the medium between the cathode and the anode may take on values either greater than or less than unity. It appears from experiments now in progress that these phenomena may be regarded as a special case of Hollmann's "inversion of characteristics."

1748. MICRO-WAVES: DETECTION AND AMPLIFICATION.—Carrara. (*See* 1736.)

1749. ON AUDION ["Leaky-Grid"] AND DIODE DETECTION [Examination of Accepted Superior Linearity of Latter].—R. Tamm. (*Veröff.a.d.Geb.d.Nachr:tech., Siemens,* No. 2, Vol. 6, 1936, Sec. VII, 3 pp.) The same degree of linearity is found theoretically, but in practice the audion is more subject to adverse conditions liable to lead to non-linear distortion.

1750. ARRANGEMENT FOR SIMULTANEOUSLY REGISTRATING THE FIELD-INTENSITIES OF THREE TRANSMITTERS [on Neighbouring Short-Wave Frequencies: for Special Receiving Tests by Dutch State Telegraphs].—J. J. Vormer. (*Wireless Engineer,* March, 1937, Vol. 14, No. 162, pp. 113–116.) With approximately logarithmic scale and other special provisions to allow for the triple recording of widely varying values on a photographic strip of limited width.

1751. A VERY SIMPLE AUTOMATIC CONTRAST EXPANDER [Crosley Light-Bulb-Bridge Circuit ("Auto-Expressionator") and Its Defects: Suggested Improvement].—Th. Sturm. (*Funktech. Monatshefte,* Jan. 1937, No. 1, pp. 12–14.)

Discussion of the device dealt with in 2153 and 2585 of 1936. Its "defects" might be removed by the use of iron-wire barretter tubes in place of the small incandescent lamps, and by the use of a *differential* bridge circuit which (to make up for the low efficiency of the whole device) is introduced before the output stage and fed by a push-pull pre-amplifier stage (Fig. 8).

1752. STUDY OF LEVEL REGULATORS AND "ANTI-FADING" DEVICES.—Espinasse. (*L'Onde Élec.,* March, 1937, Vol. 16, No. 183, pp. 189–199: to be continued.) *See* 1418 of 1936, which is the same paper "with some modifications."

1753. VARIABLE FIDELITY CONTROL [Available Methods of Automatic Selectivity Control], *and* AUTOMATIC SELECTIVITY CONTROL.—A. W. Barber: H. F. Mayer. (*Rad. Engineering,* Jan. 1937, Vol. 17, pp. 5–8: *Electronics,* Dec. 1936, Vol. 9, pp. 32–34.)

1754. AMERICAN ASC [Automatic Selectivity Control] CIRCUITS.—(*Wireless World,* 26th March, 1937, Vol. 40, pp. 296–298.)

1755. A MATHEMATICAL ANALYSIS OF A METHOD FOR REGULATING SELECTIVITY.—V. O. Bukler. (*Izvestiya Elektroprom. Slab. Toka,* No. 12, 1936, pp. 1–5.)

A theoretical investigation is presented of the well known method for regulating the selectivity of a radio receiver by interposing an inductance in parallel with a resistance R between two stages of the intermediate-frequency amplifier. It is shown that when R is small in comparison with the effective self-inductance of the coupling circuits, varying R changes the band width abruptly but also detunes the circuits considerably. With high values of R, on the other hand, only small changes in the band width can be obtained. It is also pointed out that in this, as well as in other methods in which the selectivity regulation is not effected by a direct alteration of the inductive coupling, the variation of the band width is not symmetrical.

1756. "TOUCH" TUNING [Correct Tuning indicated by Sudden Braking of Tuning Knob].—van Loon. (*Rad. Engineering,* Jan. 1937, Vol. 17, pp. 20–21.) From a paper in *Philips Tech. Review.*

1757. INTERACTION OF RADIO WAVES [and the Gyro-Frequency Effect: Request for Collaboration].—Bailey. (*See* 1667.)

1758. ATHLONE AS A BACKGROUND TO DROITWICH: A "GYRO-INTERACTION" EFFECT, AS DISTINCT FROM LUXEMBOURG EFFECT, *and* ATHLONE AND THE SHORT WAVES.—Thompson: Watkins. (*World-Radio,* 12th March, 1937, p. 7.) But see also *ibid.,* 19th & 26th March, pp. 10 & 6.

1759. MULTIPLE STATION RECEPTION ON SINGLE DIAL-SETTING TRACED TO POOR CONTACTS ON HOUSE WIRING [Rectifying Contacts act as Transmitters, emitting Sum and Difference Frequencies, etc.].—Crosley Corporation: Rockwell. (*Sci. News Letter,* 27th Feb. 1937, p. 135.)

See also Rockwell, "Cross Modulation in Radio Receivers" (including "tunable hum" and its cause), summarised in *Proc. Inst. Rad. Eng.,* Jan. 1937, Vol. 25, No. 1, Part 1, pp. 4–5. Such effects are often erroneously attributed to "Luxembourg effect."

1760. THE SPECTRUM OF DEMODULATED INTERFERENCE FROM VARIOUS SOURCES.—K. Hagenhaus. (*Veröff. a. d. Geb. d. Nachr:tech., Siemens,* No. 2, Vol. 6, 1936, Sec. V, 4 pp.)

1761. AIR MOISTURE IS CAUSE OF LOWER INSULATOR EFFICIENCY [and Radio Interference: Result of Tests with the Dawes H. V. Bridge].—Dawes & Reiter. (*Sci. News Letter,* 27th Feb. 1937, p. 140.)

1762. HIGH-FREQUENCY APPARATUS FOR MEASUREMENTS IN INTERFERENCE-SUPPRESSING TECHNIQUE.—Schuchmann & Sammer. (*Veröff. a. d. Geb. d. Nachr:tech., Siemens,* No. 2, Vol. 6, 1936, Sec. V, 4 pp.)

1763. INTERFERENCE-SUPPRESSING METHODS FOR BROADCAST RECEPTION IN MOTOR CARS.—Mezger & Schneider. (*Veröff. a. d. Geb. d. Nachr:tech., Siemens,* No. 2, Vol. 6, 1936, Sec. V, 5 pp.)

1764. TACTICS IN THE FIGHT AGAINST BROADCAST INTERFERENCE [Neither Interference Suppression during Manufacture only, nor after Installation only, Satisfactory.]—R. Feldtkeller. (*Veröff. a. d. Geb. d. Nachr:tech., Siemens,* No. 2, Vol. 6, 1936, Sec. V, 5 pp.) Suppression must be applied in the Works to such an extent that if, after installation, interference is found to be caused, it can be cured very cheaply.

1765. QUANTITATIVE INFORMATION ON THE INTERFERENCE-PREVENTING EFFICIENCY OF SCREENED AERIAL LEADS.—B. Ehlermann. (*Veröff. a. d. Geb. d. Nachr:tech., Siemens*, No. 2, Vol. 6, 1936, Sec. V, 4 pp.)

1766. THE RCA MULTIPLEX ANTENNAPLEX SYSTEM [of All-Wave Radio Distribution for Blocks of Flats, etc.].—V. D. Landon. (*Rad. Engineering*, Jan. 1937, Vol. 17, pp. 10–12 and 14.)

1767. HIGH-FREQUENCY DISTRIBUTION FOR RADIO RECEPTION IN BLOCKS OF FLATS.—I. Ahlgren. (*Teknisk Tidskrift*, 6th March, 1937, Vol. 67, Supp. pp. 40–44.)

1768. ABNORMAL ADJUSTMENTS AND WHISTLES IN SUPERHETERODYNES.—M. Lambrey. (*Génie Civil*, 6th Feb. 1937, Vol. 110, pp. 144–145.) From a lecture to the Société des Radio-électriciens.

1769. NOMOGRAMS FOR THE DESIGN OF BAND-PASS MIXED-COUPLING CIRCUITS, AS IN WESTERN ELECTRIC 10-A RECEIVER.—Nachod. (*See* 1725.)

1770. [Negative] FEEDBACK AMPLIFIER DESIGN.—F. E. Terman. (*Electronics*, Jan. 1937, Vol. 10, pp. 12–15 and 50.)

1771. THE BAND-SPREAD PROBLEM [Earlier Work of Landon & Sveen extended to Computation of Circuits for All-Wave Superheterodynes].—R. C. Woodhead: Landon & Sveen. (*Electronics*, Jan. 1937, Vol. 10, pp. 29 and 48.) *See* 1932 Abstracts, p. 639.

1772. NOTE ON THE ALIGNMENT OF SUPERHETERODYNE RECEIVERS WITH SINGLE-KNOB TUNING [Method of Design Calculation successfully applied to Many Different Types].—G. Lehmann. (*L'Onde Élec.*, Feb. 1937, Vol. 16, No. 182, pp. 132–142.)

The only case where the method partly fails is when the i.f. is higher than the signal frequency (*e.g.* long-wave reception with an i.f. of 450 kc/s). The technique is summarised in the table on p. 142.

1773. AMATEUR RECEIVERS OF ADVANCED DESIGN.—B. Dudley. (*Electronics*, Dec. 1936, Vol. 9, pp. 20–24.)

1774. RADIO PROGRESS DURING 1936. PART III—REPORT BY THE TECHNICAL COMMITTEE ON RADIO RECEIVERS.—(*Proc. Inst. Rad. Eng.*, Feb. 1937, Vol. 25, No. 2, pp. 185–198.) With bibliography of 72 items.

1775. WHAT DOES THE PUBLIC WANT? [in Its Broadcast Receivers].—(*Rad. Engineering*, Dec. 1936, Vol. 16, pp. 22 and 25.)

1776. HOW ARE RADIOS USED? [Some Secondary Uses easily provided for by Small Additions during Manufacture].—(*Rad. Engineering*, Jan. 1937, Vol. 17, pp. 15–16.) Such as the provision of headphone and microphone jacks for deaf people.

1777. SILENT RADIO [Receiver giving either Loud-speaker or Bone-Conduction Reproduction].—Dictograph Company. (*Electronics*, Dec. 1936, Vol. 9, p. 58.)

1778. "TESTING RADIO SETS" [Book Review].—J. H. Reyner. (*Wireless Engineer*, Feb. 1937, Vol. 14, No. 161, pp. 72–73.)

1779. PRINCIPLES OF "CONTROL" OF BROADCAST RECEIVERS [Discussion of the Curves necessary to represent the Performance of a Receiver, and of the Technique for obtaining Them: Necessity for Standardisation of Scales of Such Curves, to protect Buyers: Desirability of an "Office of Control"].—G. Lubszynski. (*L'Onde Élec.*, Jan. 1937, Vol. 16, No. 181, pp. 45–57.) For corrections see *ibid.*, Feb. 1937, p. 142.

1780. CAN THE MERIT OF BROADCAST RECEIVERS BE MEASURED? [and a Suggested List of 15 Tests].—R. Feldtkeller & W. E. Steidle. (*Veröff. a. d. Geb. d. Nachr:tech., Siemens*, No. 2, Vol. 6, 1936, Sec. I, 4 pp.)

1781. STANDARD TESTS FOR RADIO RECEIVERS. I—THE R.M.A. SPECIFICATION. II—THE ELECTRICAL TESTS. III—ACOUSTIC TESTS.—(*Electrician*, 26th Feb., 5th & 12th March, 1937, Vol. 118, pp. 297, 327–328, & 357–358.)

AERIALS AND AERIAL SYSTEMS

1782. DIRECTIONAL AERIALS [Driven and Parasitic Arrays: Transmitting and Receiving: Theoretical and Experimental Treatment: Methods and Curves for Practical Design: Method of Measuring Mutual Impedance: Systematic Method of Adjusting a Complicated Array].—G. H. Brown. (*Proc. Inst. Rad. Eng.*, Jan. 1937, Vol. 25, No. 1, Part 1, pp. 78–145.)

Among other results, "in the case of a single parasitic reflector it is found that the mysterious something that is supposed to happen when the spacing is one-quarter wavelength fails to materialise. Closer spacings are found to be desirable in both the transmitting and receiving case. It is found that the parasitic antenna functions equally well as a director or a reflector." In the case of the aerial parallel to an infinite sheet acting as a reflector, it is desirable to space the aerial very much less than a quarter wavelength from the sheet.

1783. MORE ON THE DIRECTIVITY OF HORIZONTAL ANTENNAS: HARMONIC OPERATION: EFFECTS OF TILTING.—Grammer. (*QST*, March, 1937, Vol. 21, No. 3, pp. 38–40 and 92, 94, 98.) Continued from 526 of February.

1784. SERIES FOR THE WAVE FUNCTION OF A RADIATING DIPOLE AT THE EARTH'S SURFACE.—Rice. (*See* 1691.)

1785. CONCERNING NEW METHODS OF CALCULATING RADIATION RESISTANCE, EITHER WITH OR WITHOUT GROUND [Use of Simple, Exact Formulae (given in Previous Papers) illustrated by Practical Cases].—W. W. Hansen & J. G. Beckerley. (*Proc. Inst. Rad. Eng.*, Dec. 1936, Vol. 24, No. 12, pp. 1594–1621.) *See* 1431 of 1935 and 3382 of 1936. A number of errors in the latter paper are here corrected. Various time-saving graphical methods are given.

1786. WJZ's NEW TOWER "PROVES IN" [640-Ft Tower Antenna more than doubles Non-Fading Radius and increases Signal by 5 Decibels].—(*Electronics*, Jan. 1937, Vol. 10, p. 21.)

1787. THE ECONOMICS OF VERTICAL RADIATORS [for Broadcasting].—V. J. Andrew. (*Comm. & Broadcast Eng.*, Nov. 1936, Vol. 3, No. 11, pp. 22–23.)

1788. RADIO PROGRESS DURING 1936. PART V—REPORT BY THE TECHNICAL COMMITTEE ON TRANSMITTERS AND ANTENNAS.—(*Proc. Inst. Rad. Eng.*, Feb. 1937, Vol. 25, No. 2, pp. 211–218.)

1789. TERMINATING R-F [Transmission] LINES.—J. L. Potter. (*Comm. & Broadcast Eng.*, Dec. 1936, Vol. 3, No. 12, pp. 5–7 and 23.)

1790. TERMINATING CONCENTRIC LINES.—C. G. Dietsch. (*Electronics*, Dec. 1936, Vol. 9, pp. 16–19 and 36.)

1791. SINGLE AND COMMUNAL AERIALS IN THEIR LEGAL ASPECT.—Pridt-Guzatis. (*Funktech. Monatshefte*, Jan. 1937, No. 1, pp. 31–32.)

1792. ANTI-STATIC ANTENNA [coiled in Circular Copper Tube mounted on Nose of Aeroplane].—(*Comm. & Broadcast Eng.*, Dec. 1936, Vol. 3, No. 12, p. 18.)

1793. THE EFFECT OF THE CAPACITIES OF THE MASTS ON THE PROPAGATION OF SURGES ALONG GROUPS OF CONDUCTORS.—Schwenkhagen. (*See* 1705.)

VALVES AND THERMIONICS

1794. THE INFLUENCE OF GAS PRESSURE ON THE ENERGY AND EFFICIENCY OF MAGNETRON OSCILLATIONS [and the Future Improvement of Design].—Maidonov. (*See* 1730.)

1795. MOTION OF ELECTRONS IN MAGNETIC FIELDS AND ALTERNATING ELECTRIC FIELDS, *and* THE EQUATIONS OF MOTION OF ELECTRONS IN GASES.—Huxley: Townsend. (*See* 1669 & 1670.)

1796. A HALF-METRE TUBE [Western Electric 316A Triode giving 8.5 W at 300 Mc/s and 4.0 W at 600 Mc/s].—C. E. Fay. (*Bell Lab. Record*, Feb. 1937, Vol. 15, No. 6, pp. 178–181.)

1797. ACORN PENTODE RCA-956 [giving Voltage Gain of 4 or more at 1 Metre].—(*Electronics*, Dec. 1936, Vol. 9, p. 53.)

1798. A POWER AMPLIFIER FOR ULTRA-HIGH FREQUENCIES.—Samuel & Sowers. (*Bell S. Tech. Journ.*, Jan. 1937, Vol. 16, No. 1, pp. 10–34.) *See* 127 of January and 1369 of April.

1799. THE INFLUENCE OF THE TRANSIT TIME OF ELECTRONS IN VACUUM TUBES.—Clavier. (*See* 1734.)

1800. COLD-CATHODE MULTIPACTORS [Farnsworth Electron-Multipliers].—W. C. Eddy. (*Comm. & Broadcast Eng.*, Oct. 1936, Vol. 3, No. 10, pp. 12–13.)

1801. SECONDARY EMISSION AND FATIGUE PHENOMENA IN PHOTOSENSITIVE CAESIUM-OXYGEN ELECTRODES.—Kvartshava. (*See* 1885.)

1802. THE SECONDARY ELECTRON EMISSION FROM OXIDISED SILVER AND MOLYBDENUM SURFACES.—Afanas'eva & Timofeev. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 10, 1936, pp. 831–839.) German version of the Russian paper dealt with in 991 of March.

1803. THE 807 [Beam Power H.F. Valve] AS A CRYSTAL OSCILLATOR.—J. Stiles: Wolfskill. (*QST*, Jan. 1937, Vol. 21, No. 1, pp. 18–19 and 42.)

"It does not want to draw as much power as the 6L6 but does give more stable power output to the aerial. It offers definitely greater advantages at the higher frequencies." For the type 807 *see* 539 of February, and for "Operating Notes on Power Crystal Oscillators" by Wolfskill, including beam power tubes, see *QST*, Feb. 1937, pp. 43–46 and 55, 114, 115.

1804. A FEW MORE RECEIVING TUBES [Beam Power Valves 6V6G (particularly for Car Receivers) and 25L6 (110 Volts, Output over 2 Watts): Electron-Ray Indicator Tube 6H5: OZ4G Rectifier for Vibrators].—(*QST*, Jan. 1937, Vol. 21, No. 1, pp. 37 and 112, 114.)

1805. SCREEN VOLTAGE FOR THE 6L6 [Beam Power Valve: Circuit avoiding Necessity for Separate Source].—C. L. Loudon. (*QST*, March, 1937, Vol. 21, No. 3, pp. 48–49.)

1806. DUAL-TRIODE PHASE INVERTERS AS PUSH-PULL AUDIO DRIVERS [particularly for Beam Power Valves].—C. R. Hammond. (*QST*, Jan. 1937, Vol. 21, No. 1, pp. 40–42.)

1807. THE DEFLECTION AMPLIFIER [Deflection-Control "Cathode-Ray" Type of Valve as Amplifier, Rectifier, and Generator].—E. P. Rudkin. (*Wireless World*, 26th March, 1937, Vol. 40, pp. 299–301.) "It is probable that the first development will be in the direction of combined intensity and deflection control to the existing type of valve; later, the more advanced type of deflection valve may be expected to make its appearance."

1808. ELECTRON MICROSCOPE TUBE [Type 889: with 2-Inch Screen: Mains Driven].—Du Mont Laboratories. (*Electronics*, Dec. 1936, Vol. 9, p. 52.)

1809. A 913 OSCILLOSCOPE WITH LINEAR SWEEP.—J. B. Carter. (*QST*, Jan. 1937, Vol. 21, No. 1, pp. 22–24 and 108, 110.) *Cf.* 1368 of April.

1810. THE PERFORMANCES OF CERTAIN TYPES OF FREQUENCY-CHANGING VALVES IN ALL-WAVE RECEIVERS [and the Evolution of the Type EK2 "Modified Octode"].—M. J. O. Strutt. (*L'Onde Élec.*, Jan. 1937, Vol. 16, No. 181, pp. 29–44.)

Author's summary:—The various conditions which should be satisfied by frequency changers in general, and by those working on short waves in particular, are summed up in 11 points. Sections II and III explain and study some of the most important effects occurring in octodes when working on short waves: interaction by electronic coupling, and variation of frequency. Some of the methods by which these inconveniences can be partially corrected are shown. In the next part the general properties of octodes, on the lines of the table of eleven points previously established, are studied. In section V the most recent progress in the construction of octodes is mentioned, figures being given of the short-wave performance of the new types [*e.g.* EK2, where the grid dimensions are so chosen that the positive potentials of the 3rd and 5th grids can be reduced to 50 volts: thanks to this reduction, and to the grid dimensions, the electronic coupling is considerably reduced, and it is still further diminished by the incorporation, in the valve itself, of a small mica condenser between the 1st and 4th grids]. These figures distinguish themselves favourably in comparison with those given by current types.

1811. SOME NUMERICAL DATA ON CONVERTER [Frequency-Changing] VALVES WITH TWO CONTROL GRIDS [Heptodes and Octodes: Experimental Testing of Lambrey's Formulae].—M. S. Krauthamer: Lambrey. (*L'Onde Élec.*, Feb. 1937, Vol. 16, No. 182, pp. 114–131.)

For Lambrey's paper *see* 2144 of 1936. All the valves tested (Triomph, Tungsram, Philips, and Cossor) satisfied the condition of high internal resistance postulated for Lambrey's formulae. Some of them, however, were otherwise unsuited to the theoretical treatment: "we have always been inclined to think that if a conversion conductance is required, the best thing to do is to measure it. The measurements and calculations now made have fortified us solidly in this conviction," although with certain valves the agreement between theory and experiment is quite good.

1812. DESIGN AND MANUFACTURE OF RECEIVING TUBES.—Benjamin, Cosgrove, & Warren. (*Electronics*, Jan. 1937, Vol. 10, pp. 52 and 54.) *Cf.* 988 of March. Full paper in *Journ. I.E.E.*, April, 1937, pp. 401–439.

1813. FACTORS INFLUENCING THE USEFUL LIFE OF VACUUM TUBES.—T. H. Briggs. (*Electronics*, Dec. 1936, Vol. 9, pp. 39–40 and 42, 44.)

1814. CORRECTIONS TO "SUPPLEMENT TO THE VALVE TABLES IN THE ISSUES FOR MAY AND NOVEMBER, 1935."—Decaux. (*L'Onde Élec.*, Jan. 1937, Vol. 16, No. 181, p. 57.) *See* 130 of January.

1815. RADIO PROGRESS DURING 1936. PART II—REPORT BY THE TECHNICAL COMMITTEE ON ELECTRONICS.—(*Proc. Inst. Rad. Eng.*, Feb. 1937, Vol. 25, No. 2, pp. 177–184.) With bibliography of 61 items.

1816. ON THE POSSIBILITY OF ELIMINATING THE FLUCTUATION NOISES IN VALVE AMPLIFIERS.—G. V. Browde [Braude]. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1936, pp. 19–34.) *See* 535 of February.

1817. TECHNIQUE OF TRANSMITTING VALVES [Survey].—R. Warnecke. (*L'Onde Élec.*, March, 1937, Vol. 16, No. 183, pp. 156–184.)

A. Anode dissipation, for radiation- and liquid-cooled types: action of the residual gases: conservation of vacuum in the course of time. B. Grid dissipation. C. Instantaneous max. value of anode current: pure-metal cathodes: monatomic-film cathodes: oxide-coated cathodes: applications of the various types of cathode. D. Anode supply voltage: "Rocky Point Effect" secondary emission.

1818. SIMPLIFIED METHODS FOR COMPUTING PERFORMANCE OF TRANSMITTING TUBES [Pulses split up into Equivalent D.C. and A.C. Components: Optimum Conditions for Various Classes of Service: Deductions].—W. G. Wagener. (*Proc. Inst. Rad. Eng.*, Jan. 1937, Vol. 25, No. 1, Part 1, pp. 47–77.)

1819. AN OPTICAL PYROMETER FOR MEASURING TUBE PLATE DISSIPATION.—A. D. Mayo, Jr. (*QST*, Jan. 1937, Vol. 21, No. 1, pp. 44 and 96, 102.)

1820. THERMIONIC EMISSION INTO DIELECTRIC LIQUIDS [demonstrated for Cathodes in Contact with the Liquids: Current/Voltage Relation a Modified Schottky Law: Effects of Adsorbed Hydrogen & Oxygen, of Surface Irregularities and Work Function: Current Conduction in Toluene is by Electrons thermionically emitted from Cathode].—E. B. Baker & H. A. Boltz. (*Phys. Review*, 15th Feb. 1937, Series 2, Vol. 51, No. 4, pp. 275–282.)

1821. THE TRANSMISSION OF HEAT BY RADIATION: A NEW METHOD OF CALCULATION.—W. Heinze & S. Wagener. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 18, 1937, pp. 75–86.)

DIRECTIONAL WIRELESS

1822. ON A CAUSE OF ERROR IN INTERLOCKED-SIGNAL [Equi-Signal] DIRECTION FINDING.—P. Besson. (*L'Onde Élec.*, Feb. 1937, Vol. 16, No. 182, pp. 81–84.)

Found in service with the author's "associated loop and aerial" system (1932 Abstracts, p. 39), but liable to affect other systems also: close to the axis, a slight change in the tuning of the receiver may produce an apparent swing-over from one side of the axis to the other. A similar effect has been noticed on crossed-loop systems by various workers, and has been attributed to a slight difference in frequency between the two loops, so that close to the axis, where the two signals are almost equal, a slight change in the receiver tuning would favour one signal.

This explanation, however, unexpectedly failed with the loop-and-aerial system, for the most complete precautions to maintain stability did not cause the effect to disappear. The source of the trouble was finally found to be a difference in the relative intensities of the two side-bands according to which signal was being transmitted; this difference was due to the tuning of the plate oscillating circuit of the last amplifying valve (to which the aerial coil was coupled) varying slightly with the position of the signalling key, owing to certain parasitic capacities which are difficult to avoid completely. As a result, although the carrier and side-band frequencies of the two emissions were strictly identical, the *spectra* of the emissions were slightly different (Fig. 3, curves 1 and 2). The trouble disappeared when new precautions were taken to obtain a complete symmetry of the aerial-coupling coil and of the signalling key. On crossed-loop systems with non-sinusoidal modulation, giving numerous side waves, the effect is exaggerated if the modulation percentage is increased and if the system of keying is such as to affect the tuning appreciably. No such trouble would arise if the emissions were on pure c.w.; keying would at most produce only a slight constant displacement of the axis, which could be brought back to its normal position by suitable regulation of the current intensities. But modulated waves have certain advantages over unmodulated, and are much preferred by the users of direction-finding services.

1823. ERROR-FREE BEARINGS WITH THE PULSE DIRECTION FINDING APPARATUS [1/3000 Sec. Pulses at 1/300 Sec. Intervals].—W. W. Diefenbach: Telefunken. (*Funktech. Monatshefte*, Jan. 1937, No. 1, pp. 25–27.) Such pulse transmitters are installed in the "Graf Zeppelin" and the "Hindenburg" (*cf.* 3796 of 1936).

1824. PRINCIPLE AND THEORY OF A NEW DESIGN OF THE AUTOMATIC RADIO-COMPASS FOR AIRCRAFT.—A. B. Damyanovitch: Busignies. (*L'Onde Élec.*, Jan. 1937, Vol. 16, No. 181, pp. 5–28.) Dealing in great detail with the latest commercial model (type R.C.5), "now beginning to come into general service both in the Air Force and in the Navy," of the Busignies revolving frame-and-generator system: *see* also 549 of February.

1825. THE SIMON SYSTEM OF INSTRUMENT LANDING AND COLLISION WARNING [using the Simon Radioguide and Underground Horizontal Transmitting Loops].—H. W. Roberts. (*Comm. & Broadcast Eng.*, Oct. 1936, Vol. 3, No. 10, pp. 14–15 and 27.) *See* also 4082 of 1936.

ACOUSTICS AND AUDIO-FREQUENCIES

1826. A STABILISED AUDIO-FREQUENCY OSCILLATOR UNIT.—I. P. Polevoy. (*Izvestiya Elektroprom. Slab. Toka*, No. 12, 1936, pp. 24–33.)

Author's summary:—"The article states that undamped oscillations can exist only when the mean value of the decrement during one cycle is equal to zero. The oscillator frequency is considered as an average value of the frequency during one cycle. Since the frequency fluctuations are proportional to the square of the fluctuations of the decrement, the most advantageous conditions of operation of the oscillator unit are obtained when the decrement is near zero during the whole cycle. An arrangement of the oscillator unit is described which corresponds to the above-mentioned theoretical requirements for the stabilisation of oscillations." The circuit is given in Fig. 11. The amplitude of the oscillations is kept constant by feeding the output of the oscillator to an amplifier, which in its turn feeds a rectifier controlling the grid potential of the oscillator. In practice, the output valve can also act as the controlling rectifier (Fig. 12). Tests show that a change of anode voltage from 80 to 50 volts produces a frequency change of about 0.1 cycle both in a 760 c/s frequency and a 2048 c/s frequency.

1827. COMBINATION HORN- AND DIRECT-RADIATOR LOUDSPEAKER [Addition of Long Folded Horn (for Low Frequencies) to Back of Small Cone Loudspeaker (for Wide-Angle Distribution of Middle and High Frequencies): with Acoustic Filter for changing Output from Horn to Open Side of Cone].—H. F. Olson & R. A. Hackley. (*Proc. Inst. Rad. Eng.*, Dec. 1936, Vol. 24, No. 12, pp. 1557–1566.)

1828. THE MATCHING OF THE LOUDSPEAKER TO THE OUTPUT VALVE.—H. Pitsch. (*Funktech. Monatshefte*, Jan. 1937, No. 1, pp. 19–24.)

When the a.c. grid voltage is given: when the anode voltage is given: when the max. anode dissipation is given: the taking into account of the curvature of the characteristic curves and the varying distances between them: the influence of the frequency-dependence of the loudspeaker resistance: "the optimum matching is best made for that frequency region in which the most notes occur, since it can be assumed that these notes are likely to occur at the greatest volume and therefore to require the greatest power. This region lies between about 200 c/s and 1000 c/s, in which zone the loudspeaker resistance is approximately constant and about 20% greater than the ohmic resistance of the moving coil." Triodes and pentodes are compared on the last page.

1829. THE DESIGN OF EXPONENTIAL HORNS.—W. S. Duncan. (*Comm. & Broadcast Eng.*, Nov. 1936, Vol. 3, No. 11, pp. 8–9.)

1830. SOUND REPRODUCTION: WESTERN ELECTRIC MIRROPHONIC SYSTEM—A NOTABLE ADVANCE [embodying the Harvey Fletcher "Diphonic" Loudspeaker System, a "Harmonic Suppressor," etc.]—(*Electrician*, 12th March, 1927, Vol. 118, p. 352.) The "important new device known as a harmonic suppressor" makes the amplifier maintain constant quality, free from distortion, over a very large range of volume.

1831. SOUND REINFORCING SYSTEM FOR HOLLYWOOD BOWL [Out-of-Doors Stereophonic Reproduction].—A. R. Soffel. (*Bell Lab. Record*, March, 1937, Vol. 15, No. 7, pp. 225–228.)

1832. SUPER-POWER PUBLIC-ADDRESS INSTALLATIONS.—J. P. Taylor. (*Comm. & Broadcast Eng.*, Dec. 1936, Vol. 3, No. 12, pp. 8–11 and 25.)

1833. PUTTING PUBLIC ADDRESS TO WORK [in Factories: System including Fire Alarm, Work-Period Time Signals, etc., besides Radio and Gramophone Programmes].—H. J. Benner. (*Electronics*, Dec. 1936, Vol. 9, pp. 25–27.)

1834. MEASURING LOUDSPEAKER RESPONSE AUTOMATICALLY [Gain-Control Values required to keep Microphone-Amplifier Output constant are recorded as Measure of Loudspeaker Outputs (exciting the Microphone) at Different Frequencies].—H. F. Hopkins. (*Bell Lab. Record*, March, 1937, Vol. 15, No. 7, pp. 234–237.)

1835. THE FUNDAMENTAL VIBRATION OF A MEMBRANE [Elementary Mathematical Method for finding Upper and Lower Limits to Its Frequency].—J. Barta. (*Comptes Rendus*, 15th Feb. 1937, Vol. 204, No. 7, pp. 472–473.)

1836. CONTRIBUTION TO THE INVESTIGATION OF THE FLEXURAL OSCILLATIONS OF PARALLELOGRAM-SHAPED PLATES WITH FREE EDGES [Experimental Confirmation of Theory].—B. Pavlík. (*Ann. der Physik*, Series 5, No. 4, Vol. 28, 1937, pp. 353–360.) For theory *see* 566 of February.

1837. A DYNAMICAL METHOD FOR THE MEASUREMENT OF YOUNG'S MODULUS FOR IMPERFECTLY ELASTIC METALS, AND THE APPLICATION OF THE METHOD TO NICKEL AND SOME OF ITS ALLOYS [Determination of Resonant Pulsatances of Vibrating Bar: Theory including Eddy-Current and Hysteresis Effects: Results showing Effect of Heat Treatment].—R. M. Davies & I. H. Thomas. (*Phil. Mag.*, March, 1937, Series 7, Vol. 23, No. 154, pp. 361–397.)

1838. THE FREQUENCY OF TRANSVERSE VIBRATION OF A LOADED FIXED-FREE BAR: II—THE EFFECT OF THE ROTATORY INERTIA OF THE LOAD [Theory].—R. M. Davies. (*Phil. Mag.*, March, 1937, Series 7, Vol. 23, No. 154, pp. 464–475.) *See* above reference.

1839. DIRECTIONAL MICROPHONE [the RCA Uni-Directional Microphone, Olson Principle: Single Ribbon, with Upper Half acting as Pressure Type and Lower as Velocity Type].—J. P. Taylor. (*Comm. & Broadcast Eng.*, Oct. 1936, Vol. 3, No. 10, pp. 8–11.)

1840. A NEW TYPE OF TELEPHONE RECEIVER [with Greatly Improved Characteristic between 50 and 6000 c/s].—H. F. Olson. (*Journ. Soc. Motion Picture Eng.*, Nov. 1936: summary in *Alta Frequenza*, Feb. 1937, pp. 146–147.)

1841. SOME PRACTICAL INVERSE FEEDBACK CIRCUITS FOR AUDIO POWER AMPLIFIERS: IMPROVED OUTPUT VOLTAGE REGULATION WITH REDUCED HARMONIC DISTORTION.—RCA. (*QST*, Jan. 1937, Vol. 21, No. 1, pp. 26–27.) Particularly suitable for 6L6 beam power valves.

1842. BALANCED AMPLIFIERS. PARTS IV, V AND VI.—Priesman. (*Comm. & Broadcast Eng.*, Oct., Nov., Dec. 1936, Vol. 3.)

1843. THE *Wireless World* RECORDING AMPLIFIER [for Home Recording: Mains-Driven, Variable Frequency Response, 4–6 Watts Output].—(*Wireless World*, 19th March, 1937, Vol. 40, pp. 268–271.)

1844. FIDELITY OF DISC RECORDING [and Its Measurement].—F. N. G. Leevers. (*Wireless World*, 19th March, 1937, Vol. 40, pp. 272–273.)

1845. CATHODE-RAY TUBE WITH RAY SCANNING GUARD PLATE (WITH SPECIALLY SHAPED PERFORATIONS) IN FRONT OF COLLECTORS: FOR GENERATING MUSIC.—Merlin Davis. (*Electronics*, Jan. 1937, Vol. 10, pp. 38 and 40.) Outline of a recent patent.

1846. THE ACOUSTICS OF WIND INSTRUMENTS.—Struve. (*Tech. Phys. of USSR*, No. 12, Vol. 3, 1936, pp. 1044–1055.) German version of the paper dealt with in 186 of January.

1847. HOW PITCH CHANGES WITH LOUDNESS [Experimental Results].—A. R. Soffel. (*Bell Lab. Record*, Jan. 1937, Vol. 15, No. 5, pp. 145–148.)

1848. AMPLITUDE DISTORTION [Conventional Measuring Methods incapable of evaluating Harmonic Distortion: "Confused Thinking" on Physical Side: Scalar Values, not Vector, are measured, giving Inconsistent Results: Examples: New ("Side-Tones") Method, with Examples of Use: Suggested Standards of Distortion].—J. H. O. Harries. (*Wireless Engineer*, Feb. 1937, Vol. 14, No. 161, pp. 63–72.)

1849. DISTORTION-MEASURING EQUIPMENT FOR BROADCASTING LINES.—Freystedt & Langsdorff. (*Veröff a. d. Geb. d. Nachr:tech., Siemens*, No. 2, Vol. 6, 1936, Sec. VI, 6 pp.)

1850. A MODERNISED HEARING METER, *and* DECIBEL METERS.—R. Nordenswan: F. H. Best. (*Bell Lab. Record*, Jan. 1937, Vol. 15, No. 5, pp. 163–166: pp. 167–169.)

1851. MEASUREMENTS OF SOUNDS RELATIVE TO THE TESTING OF SO-CALLED "SOUND AMPLIFIERS FOR LORRIES."—A. Labrousse. (*Ann. des Postes, T. et T.*, Jan. 1937, Vol. 26, No. 1, pp. 38–58.) Called for by the French regulation that every motor vehicle of loaded weight over 3000 kg must have a "sound amplifier" to ensure that motorists wishing to pass may make themselves heard.

1852. A SPECTROMETER FOR ACOUSTIC FREQUENCIES.—F. Vogel & U. Hennecke. (*Veröff a. d. Geb. d. Nachr:tech., Siemens*, No. 3, Vol. 6, 1936, pp. 165–171.)

1853. HOW LOUD IS SOUND? [with Table of Acoustical Levels].—C. H. Tower. (*Comm. & Broadcast Eng.*, Nov. 1936, Vol. 3, No. 11, pp. 7 and 23, 27.)

1854. THE SOUND FIELD IN THE NEIGHBOURHOOD OF A VERY NOISY FACTORY.—H. J. Menges. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 18, 1937, pp. 73–75.)

1855. METHODS FOR INCREASING THE CROSS-TALK ATTENUATION BETWEEN OVERHEAD LINES [Mathematical Treatment].—Vos & Aurell. (*Ericsson Technics*, No. 6, 1936, pp. 113–149.)

1856. HIGH-FREQUENCY OSCILLATIONS AND SUPERSONIC WAVES [Summarising Account of Technique and Applications].—L. Bergmann. (*Naturwiss.*, 19th Feb. 1937, Vol. 25, No. 8, pp. 113–119.)

1857. MEASUREMENTS WITH ULTRASONICS ON THE VELOCITY AND ABSORPTION OF SOUND AT ORDINARY AND AT LOW TEMPERATURES.—van Itterbeck & Mariens. (*Physica*, March, 1937, Vol. 4, No. 3, pp. 207–215: in English.)

1858. SUPERSONIC EMISSION FROM PIEZOELECTRIC QUARTZ CRYSTALS [measured by Radiation Pressure exerted on Opaque Obstacle: Resonance Curve for Fifth Harmonic].—E. Baumgardt. (*Comptes Rendus*, 8th March, 1937, Vol. 204, No. 10, pp. 751–754.) *See* also 1460 of April.

1859. RADIO PROGRESS DURING 1936. PART I—REPORT BY THE TECHNICAL COMMITTEE ON ELECTROACOUSTICS.—(*Proc. Inst. Rad. Eng.*, Feb. 1937, Vol. 25, No. 2, pp. 165–176.)

PHOTOTELEGRAPHY AND TELEVISION

1860. RADIO PROGRESS DURING 1936. PART IV—REPORT BY THE TECHNICAL COMMITTEE ON TELEVISION AND FACSIMILE.—(*Proc. Inst. Rad. Eng.*, Feb. 1937, Vol. 25, No. 2, pp. 199–210.)

1861. BRITISH TELEVISION [Comparison of Haynes Receiver (Constructional Details in *Wireless World*) with American (Farnsworth) Practice].—(*Rad. Engineering*, Jan. 1937, Vol. 17, pp. 19 and 24.) For the Haynes receiver see *Wireless World* of 18th Dec. 1936, pp. 642–647.

1862. ULTRA-SHORT-WAVE REFRACTION AND DIFFRACTION.—Eckersley. (*See* 1660.)

1863. A TRANSMITTING CATHODE-RAY TUBE FOR TELEVISION [Full Description of Manufacture in Russia of Iconoscope Tubes].—N. M. Romanova & B. V. Krusser: Zworykin. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1936, pp. 56–68.)

1864. THE TELEVISION CATHODE-RAY TRANSMITTER WITH 240-LINE DEFINITION [using the Iconoscope: Amplifier Circuits: Saw-Tooth Currents for Electro-Magnetic Deflection: etc.].—Weisbrut, Gelesov, Kreutzer, & Chashnikov. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1936, pp. 68–76.)

1865. MECHANICAL TELEVISION TRANSMITTER WITH 96-LINE DEFINITION USING PHOTOELEMENTS WITH MULTIPLE SECONDARY-EMISSION AMPLIFICATION.—O. Lourie [Lurje]. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1936, pp. 76–81.)

1866. SOME REMARKS ON "THE CHARACTERISTICS OF TELEVISION" [Adoption, by American Committee, of "Negative" Modulation used by Barthélémy: Criticism of Its Adoption of Interlaced Scanning—Advantages as to Flicker nullified, for Bright Images, by Inter-Line Shimmer: etc.].—R. Barthélémy. (*L'Onde Élec.*, Feb. 1937, Vol. 16, No. 182, pp. 85–88.) For the writer's paper on the advantages of negative modulation *see* 2281 of 1936.

1867. ON THE DESIGN OF A MODULATOR FOR A TELEVISION TRANSMITTER.—B. I. Ivanov & G. F. Solov'ev. (*Izvestiya Elektroprom. Slab. Toka*, No. 12, 1936, pp. 34–43.)

The main technical requirements which are imposed on a modern high-power television transmitter operating on ultra-short waves are discussed, and it is shown that high-power anode modulation is not suitable for this type of transmitter. It is suggested that grid modulation should preferably be used, and a theoretical investigation is presented of the operation of a system proposed by Prof. Minz (Fig. 1). It is pointed out, however, that the conclusions reached in this investigation, and the methods proposed for designing the modulator, are applicable to any other type of grid modulation. Systems using triodes and screen-grid valves are considered separately, and two numerical examples are given. The theoretical results obtained were verified experimentally, and the main conclusion reached is that triodes are more suitable for use both as modulators and as audio-frequency amplifiers.

1868. ON THE PERMISSIBLE PHASE DISPLACEMENT IN TELEVISION APPARATUS.—R. G. Schiffenbauer. (*Izvestiya Elektroprom. Slab. Toka*, No. 12, 1936, pp. 44–45.)

A brief survey of the articles published since 1934 by the author and by Smirnov (*see* 1955/6 of 1935 and 1079, 1080 & 2713 of 1936). The permissible phase displacement at the lowest frequency (frame frequency) is given by the author as 1.5–2° at 80% modulation. The requirement that there should be no displacement at all at 100% modulation, put forward by Smirnov, is incorrect, in the opinion of the author, and is due to the wrong assumption that the general formula derived by Smirnov is also applicable to the case of zero current. For the maximum displacement at the highest frequency (element frequency) of 15 000 c/s, the author specifies 10 to 20 μs, and similar figures are given by foreign writers (10 to

20 μs at 20 000 c/s. The displacement of 0.5° quoted by Smirnov is incorrect and was arrived at by applying, without sufficient justification, the conclusion reached for the frame frequency to all other frequencies, up to the element frequency.

1869. THE CORRECTION OF THE INPUT CIRCUIT OF A [Wide-Band] AMPLIFIER.—A. D. Weisbrut. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1936, pp. 13–19.)

It is shown that while, in order to improve the signal/valve-noise ratio, the input impedance of the amplifier should be raised, this makes the correction of its frequency characteristic difficult. It is therefore suggested that satisfactory results cannot be obtained by modifying the input circuit alone. In the present paper a method is proposed in which the necessary correction is effected in the anode circuit of the valve by connecting an inductance and a resistance in series with the anode (Fig. 3). Formulae (11) and (17) are derived determining the resultant frequency and phase corrections respectively, and a number of curves are given to facilitate the necessary calculations. Methods are also indicated for determining the optimum input impedance.

1870. ON THE CORRECTION OF RESISTANCE COUPLED AMPLIFIERS AT LOW FREQUENCIES.—V. L. Kreutzer. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1936, pp. 3–13.)

The particular case considered is the correction of the frequency and phase characteristics of an amplifier by de-coupling circuits, consisting of resistances and capacities, connected in series with the anodes of the valves (Fig. 1). This method was first proposed by Schiffenbauer (2336 of 1935). In the present paper the determination of the various constants of the amplifier circuits is discussed and an account is given of an experimental verification of the results obtained.

A formula (16) is derived determining the frequency coefficient (the rise of the frequency characteristic) for the lowest frequency when complete phase compensation is obtained. From an inspection of this formula methods are suggested for reducing the frequency coefficient towards unity, and curves are plotted in Fig. 4 from which the required values of the various constants can be determined. In the experimental portion of the paper a description is given of the apparatus used, and some of the oscillograms obtained are shown.

1871. GEOMETRICAL ELECTRON OPTICS, *also* THE CATHODE-RAY TUBE IN TELEVISION TRANSMISSION AND RECEPTION, *and* TELEVISION TRANSMISSION [Three of the VDE Series of Lectures].—Brüche: Knoll: Buschbeck. (*Funktech. Monatshefte*, Jan. 1937, No. 1, Supp. pp. 1–4: 4–8: 8–12.)

1872. TELEVISION RECEPTION [VDE Lecture].—M. von Ardenne. (*Funktech. Monatshefte*, Feb. 1937, No. 2, Supp. pp. 13–18.)

The mixture of frequencies at the receiver input terminals: u.s.w. field strength and the noise level: receiver circuits: separating out the synchronising signals: the time-base circuits (and the frequency spectrum of "kipp" oscillations): design considerations, including the optical system of projecting receivers: table of lines of design of 1936 receivers.

1873. ON THE PROBLEM OF THE CALCULATION OF THE MAGNETIC DEVIATION OF THE ELECTRON RAY IN TELEVISORS [Calculation of Ampere-Turns in Deflecting Coil].—S. I. Kataev & E. S. Bezsonova. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1936, pp. 34–43.)

"The assumptions made when deriving approximate formulae for the calculation of the ampere-turns of deflecting coils are considered. The necessity and possibility of strict derivation, free from simplifications, are pointed out. An exact formula for coils with infinitely small cross-section, and one for those with finite cross-section, are derived. The results of an experimental check are given, and it is seen that calculations using the simple formula 28, derived on natural assumptions, give a more accurate result than known formulae, even when more complicated, derived on other assumptions." Formula 28 is: ampere-turns = $2.68\, y \sqrt{U}/l\{1 - 1/\sqrt{1 + (a/z)^2}\}$, where y is the deflection, U the voltage, l the distance between the common axis of the coils and the screen, and a and z the mean radius of a coil and the distance of its mean plane from the axis of the tube, respectively (Fig. 10). With this equation "the error will not exceed 7%: this can easily be seen by comparing the results obtained by the simplified eqn. 28 with those obtained from eqn. 27 used in conjunction with eqn. 19."

1874. PROBLEMS CONCERNING THE PRODUCTION OF CATHODE-RAY TUBE SCREENS [leading to the Binder-Less Liquid Settling Suspension Method of Preparation, and Its Advantages].—H. W. Leverenz. (*Journ. Opt. Soc. Am.*, Jan. 1937, Vol. 27, No. 1, pp. 25–35.)

1875. THE FLUORESCENT MATERIALS FOR TELEVISION.—V. D. Ivanov. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1936, pp. 81–88.)

"The principal methods for characterising fluorescent materials for c-r tubes are given. The constants and curves for brilliancy, spectral composition, stability, sensitivity threshold, afterglow and other fluorescent properties are given. The methods of production of the most used materials—willemite, zinc sulphide, and calcium tungstate—are described." Many literature references are given.

1876. FLUORESCENCE OF THE BIVALENT RARE EARTHS [Red Fluorescence, at Low Temperatures, of Calcium Sulphate containing Traces of Thulium].—K. Przibram. (*Nature*, 20th Feb. 1937, Vol. 139, p. 329.)

1877. DISTORTION OF "KIPP" OSCILLATIONS BY A QUADRIPOLE.—von Ardenne. (*See* 1710.)

1878. BROAD-BAND TELEVISION CABLES.—G. W. O. H: Siemens & Halske. (*Wireless Engineer*, March, 1937, Vol. 14, No. 162, pp. 111–112.) Editorial on recent German work (*see* Kaden, 1879, below).

1879. CORRECTION [to Formula in "Attenuation and Transit Time of Wide-Band Cables"].—H. Kaden. (*Arch. f. Elektrot.*, 18th Feb. 1937, Vol. 31, No. 2, p. 140.) *See* 596 of February.

1880. INTERNAL INEQUALITIES OF COAXIAL WIDE-BAND CABLES.—M. Didlaukis & H. Kaden. (*E.N.T.*, Jan. 1937, Vol. 14, No. 1, pp. 13–23.)

The internal inequalities discussed are due to variations in the diameter of the external conductor and in the dielectric constant. They are produced while the cable is being made and are distributed throughout its length. Discussion of the electrical behaviour of such a cable is based on the idea that it is composed of elementary pieces of slightly different dimensions, whose impedances differ slightly but whose propagation constants are approximately equal. Small reflection points are thus present along the cable (Fig. 1a); vector addition of their effects causes variations in the input impedance. Double reflection within the cable also gives rise to a disturbance superposed on the signal proper (Fig. 1b). Eqn. 2 gives the amount by which the impedance of a small portion of the cable varies when the diameters of the external and internal conductors and the dielectric constant of the insulation change by small amounts (*see* also 596 of February). The variations of the external conductor are chiefly responsible for the impedance variations; they are connected with changes in the dielectric constant. Fig. 2a shows the diameter of a cable with Styroflex insulation (Fig. 3), measured with the recording arrangement of Fig. 4; Fig. 2b gives the mean dielectric constant of pieces of cable 1 m long (measuring circuit Fig. 5). An elementary calculation of the reflected wave (Fig. 1a) and the superposed disturbance (Fig. 1b) is given for low frequencies; in this the whole cable is divided into N portions of length l (Fig. 6). Fig. 7 shows the equivalent circuit for a portion of the cable; its reflection factor is given by eqn. 7 and the total reflected wave is obtained by summation (eqn. 8). The mean square value is given by eqn. 10, which shows that the reflected wave increases with decreasing attenuation and with increasing frequency. The impedance variations of a long cable are determined by the reflection factor (eqn. 11). The superposed disturbance is similarly calculated (Fig. 9; eqns. 12, 13); it finds expression in the variations of the residual attenuation curve (eqn. 14), which are much smaller than those of the impedance. The result of a more detailed calculation is then given, in which the assumption that the variations of the cable portions are independent of one another is no longer made. The curve in Fig. 11 shows how the mean square value of the impedance variations depends on the length of the cable portions; for long lengths the variations are proportional to the square root of the length. A *correlation range*, r, is determined whose characterisation is that the variations for distances approximately equal to or less than r are more or less dependent on one another, while they are independent for distances large compared with r. From this, eqn. 17 is deduced and is found to agree with the experimental curve of Fig. 11 and its limiting values for short and long cable portions. The correlation range r and the mean square variation S^2 of the impedance for the limiting case of zero portion length are regarded as characteristic constants of the variation statistics of the cables. They provide sufficient information for the calculation of the electrical behaviour of the uneven cable; the theoretical deduction of the reflection factor and superposed disturbance in terms of them is given (Fig. 12). Fig. 13 shows the mean square value of the impedance variations, Fig. 15 that of the superposed disturbance, of a long cable as a function of frequency for various correlation ranges.

The demands made by long-distance telephony and television as to the degree of internal equality of a wide-band cable are discussed; permissible variations of the cable for telephony are deduced from the limiting permissible value of the superposed disturbance, which may be determined either directly or indirectly from the impedance variations. For television, the decay time of the superposed disturbance must be considered (Figs. 16, 17); it may survive through many points of the picture and give a received image in which the contrasts are much reduced. Numerical estimates for a cable in which the superposed disturbance is not detrimental to the image are given. Formulae for the measurement of inequalities in manufactured lengths are derived; the cable is closed with its approximate mean impedance and the variations of input impedance are measured as a function of frequency (Fig. 18).

1881. THE TRANSMISSION OF INFORMATION BY WIDE-BAND CABLES [German Coaxial-Line Network].—Mayer & Thierbach. (*Veröff. a. d. Geb. d. Nachr.tech., Siemens*, No. 4, Vol. 6, 1936, pp. 223–225.)

1882. THE TELEFUNKEN HIGH-FREQUENCY COAXIAL CABLE [Data].—Telefunken. (*Zeitschr. V.D.I.*, 2nd Jan. 1937, Vol. 81, pp. 25–26.)

1883. COLD-CATHODE MULTIPACTORS [Farnsworth Electron-Multipliers].—W. C. Eddy. (*Comm. & Broadcast Eng.*, Oct. 1936, Vol. 3, No. 10, pp. 12–13.)

1884. SECONDARY ELECTRON EMISSION FROM THIN METAL FILMS DEPOSITED ON GLASS.—Afanas'eva, Timofeev, & Ignatov. (*Tech. Phys. of USSR*, No. 12, Vol. 3, 1936, pp. 1011–1019.) German version of the paper dealt with in 605 of February.

1885. SECONDARY EMISSION AND FATIGUE PHENOMENA IN PHOTOSENSITIVE CAESIUM-OXYGEN ELECTRODES.—I. F. Kwarzchawa [Kvartshava]. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 10, 1936, pp. 809–819: in German.)

"Conclusions:—On fatigue of a caesium-oxygen surface the secondary emission decreases. The strong secondary emission of the surface is the result of the ionisation, by primary and secondary electrons, of the caesium atoms adsorbed at the Cs_2O layer. The fact that the secondary emission produces no marked fatigue of the caesium-oxygen surface is explained by the fact that the primary electrons with high velocities penetrate into the interior of the oxide and ionise its molecules. As a result of the ionisation, the electrical conductivity of the oxide increases. Caesium-oxygen surfaces with large coefficients of secondary emission can be prepared by oxidising the thin film of metallic caesium, with which the Ag_2O layer is covered, little by little with oxygen."

The effect of the increasing amount of adsorbed oxygen on the photo-sensitivity (curve 1) and on the secondary-emission coefficient (curve 2) is seen in Fig. 10. As the amount increases, the sensitivity increases and reaches a maximum: the secondary emission also increases, and remains practically constant while the sensitivity diminishes. The process is as follows:—as the oxygen is adsorbed, the surface of the metallic caesium becomes covered with a layer of Cs_2O; a part of the caesium atoms diffuses through the thin oxide layer and is adsorbed at the surface. The sensitivity and secondary emission are thus progressively increased, until all the caesium atoms are either incorporated in the oxide or adsorbed at its surface. On further increase of the amount of oxygen, the oxygen atoms are adsorbed at the surface and increase the work function: a slight increase in this work function strongly decreases the photoeffect, owing to the low initial velocities of the photoelectrons, but has no effect on the secondary electrons, which in all probability possess higher initial velocities. Moreover, the adsorbed oxygen atoms may themselves give up secondary electrons.

1886. THE ELECTRICAL CONDUCTIVITY OF THIN CAESIUM AND POTASSIUM FILMS ON PYREX GLASS SURFACES.—Appleyard & Lovell. (*See* 1940.)

1887. PHOTOELECTRIC EMISSION [from Different Metals: Sensitivity Shift on Reaction with Oxygen due probably to Formation of Sub-Oxide].—H. C. Rentschler & D. E. Henry. (*Journ. Franklin Inst.*, Feb. 1937, Vol. 223, No. 2, pp. 135–145.)

"The advantages of using the method previously described (1932 Abstracts, p. 649) for preparing clean surfaces for the study of photoelectric emission from different metals are briefly discussed. Experiments are described which show that when certain metal surfaces react with oxygen the shift in sensitivity toward the longer wavelength is due to a reaction and not to the physical nature of the surface, and that the similar shift when an alkali metal deposits on another metal is likewise the result of a reaction."

1888. TIME LAG IN THE VACUUM PHOTOCELL [Possible Effect of Differences in Slight Gas Content].—N. R. Campbell. (*Nature*, 20th Feb. 1937, Vol. 139, p. 330.) *See* 1053 of March.

1889. PHOTOCELL CORRECTION FILTER [All-Glass Filter bringing Spectral Sensitivity of Photronic Photocell into Agreement with That of Human Eye].—(*Journ. of Applied Phys.* [formerly *Physics*], Feb. 1937, Vol. 8, No. 2, p. 148: note on "Viscor" filter.) *See* also 831 of February.

1890. AN INVESTIGATION OF THE SHENSTONE EFFECT [Variation of Photoelectric Sensitivity of Metal as Function of Electric Currents passed through It: Experiments showing Effect definitely Attributable to Removal of Occluded Gas: Variation in Photoelectric Sensitivity of Outgassed Molybdenum due to Formation and Evaporation of Adsorbed Electro-Positive Gas Layer].—A. H. Weber. (*Journ. Franklin Inst.*, Feb. 1937, Vol. 223, No. 2, pp. 215–242.)

1891. THE PASSAGE OF CORPUSCLES ACROSS POTENTIAL BARRIERS [Matrix Theory giving Proportions of Reflected and Transmitted Corpuscular Waves].—A. Datzeff. (*Comptes Rendus*, 22nd Feb. 1937, Vol. 204, No. 8, pp. 558–560.)

1892. THE SEARCH FOR HIGH-EFFICIENCY LIGHT SOURCES.—S. Dushman. (*Journ. Opt. Soc. Am.*, Jan. 1937, Vol. 27, No. 1, pp. 1–24.) With bibliography.

1893. CHARACTERISTICS OF SOME NEW MERCURY-ARC LAMPS [including the High-Pressure Quartz Capillary Types, with and without Water Cooling].—Barnes & Forsythe. (*Journ. Opt. Soc. Am.*, Feb. 1937, Vol. 27, No. 2, pp. 83–86.)

1894. THE OPTICAL RELATIONS IN ELECTRICAL ILLUMINATING [Gas-Discharge] TUBES WITH WALLS OF CLEAR LUMINESCENT GLASS WITH AND WITHOUT A COATING OF CLOUDED GLASS [Theory and Experiment: Improvement of Luminosity with Clouded Glass].—Fischer. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 17, 1936, pp. 337–340.)

1895. THE KERR EFFECT OF NITROBENZOL IN BENZOL (PRELIMINARY COMMUNICATION).—H. Friedrich. (*Physik. Zeitschr.*, 1st March, 1937, Vol. 38, No. 5, p. 139.)

A measured curve is given showing a non-linear increase of the resistance to rotation of the molecules with increasing concentration of nitrobenzol in benzol; this is found to explain the corresponding decrease of the molecular Kerr constant for the nitrobenzol molecule.

1896. ELECTRICAL SATURATION IN PURE LIQUIDS AND THEIR MIXTURES [Dipole Association studied by Measurements of Effect of Electric Field on Dielectric Constants of Mixtures of Nitrobenzene & Benzene: Existence of Minimum Value for Dielectric Constant at Certain Proportion of Mixture: Effect of Purifying & Drying Nitrobenzene].—A. & B. Piekara. (*Comptes Rendus*, 3rd Nov. 1936, Vol. 203, No. 18, pp. 852–854.)

1897. NEW POLARISATION FILTER USING DOUBLY REFRACTING CRYSTALS.—M. Haase: Zeiss. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 18, 1937, pp. 69–72.) With test results. *See* also 3857 of 1936 and 232 of January; also (for American "polaroid" filters) 3099 of 1936.

MEASUREMENTS AND STANDARDS

1898. USE OF THE PARALLEL [Lecher] WIRE SYSTEM AS A MEASURING INSTRUMENT IN THE RANGE OF DECIMETRE WAVES.—W. Hempel. (*E.N.T.*, Jan. 1937, Vol. 14, No. 1, pp. 33–43.)

The applicability and accuracy of the Lecher-wire resonance method for the measurement of impedance in the decimetre-wave range were investigated by constructing a Lecher-wire system (Fig. 1) with very loose coupling to the emitter, which was well screened from the space in which the measurements were made. Fig. 2 shows the Lecher system used for determining voltage antinodes (or current nodes), in which the wire could be broken and the break moved along until it was at a current node; this is the only position in which the system is properly tuned. The impedance to be measured was placed across the system at the break; the change in position of the break required for re-tuning could be measured very accurately. An equation (2) for the impedance is deduced from the wave equation; the two methods of measurement by the wave and voltage ratios respectively are discussed theoretically from the point of view of the accuracy attainable by them. A third method is investigated theoretically in which it is only necessary to draw a voltage curve (Fig. 3); the value of the impedance under test is given by eqn. 8 and is simply derived from the maximum and minimum voltage values and the voltage at the point where the Lecher-wire system is loaded with the impedance. The errors involved are discussed; measured curves are given showing the voltage curve along the Lecher system when open (Fig. 4) and closed with a reflector (Fig. 5). It was found that the Lecher system could be regarded as free from end radiation in the impedance measurements (Fig. 6). Figs. 7, 8 show the voltage distributions for loading with a resistance wire and a condenser respectively. Fig. 9 illustrates the measurement of the self-inductance of straight wires. In a critical consideration of the experimental results, it is found that complex impedances give rise to considerable errors, chiefly because of the disturbance of the transverse nature of the field between the wires by the impedance (Fig. 10, which illustrates the abnormal voltage distribution near the impedance). The emitter used for Lecher-wire experiments on decimetre waves must be of considerable power, so that the retroaction can be suitably reduced.

1899. ON THE RESONANCE PHENOMENA IN A LECHER SYSTEM LOADED AT THE END WITH CAPACITY.—A. R. Volpert. (*Izvestiya Elektroprom. Slab. Toka*, No. 12, 1936, pp. 7–16.)

"The condition for obtaining maximum voltage across the condenser is investigated. It is shown that the physical interpretation of the condition found lies in the phenomenon of voltage resonance in systems consisting of distributed and concentrated constants. The deduced formulae allow the determination of the value of resonance voltage across the condenser and the value of the input resistance of the Lecher system at voltage resonance. The design is also given of a loop for tuning, allowing voltage resonance to be obtained for any relations between the Lecher system parameters and the value of the end capacity."

1900. THE REFRACTIVE INDEX OF WATER FOR ELECTROMAGNETIC WAVES EIGHT TO TWENTY-FOUR CENTIMETRES IN LENGTH [Wavelength in Water measured by Interference Method: Refractive Index High but decreases with Increasing Frequency].—T. T. Goldsmith. (*Phys. Review*, 15th Feb. 1937, Series 2, Vol. 51, No. 4, pp. 245–247.)

The interference method used is a modification of that referred to in 1934 Abstracts, p. 492 (Miesowicz).

1901. RESEARCHES ON THE ANOMALOUS DISPERSION OF POLAR LIQUIDS: METHODS AND APPLICATIONS [using Ultra-Short Waves between 17 cm and 6 m, and an Improved Version of Drude's "Second Method": Measurements on Propyl Alcohol and Solutions of Water and Heavy Water in Dioxane].—P. Abadie. (*L'Onde Élec.*, Feb. 1937, Vol. 16, No. 182, pp. 89–113.)

To be continued (not in March issue): the present instalment is taken up by a survey of existing (often contradictory) results, such as the obtaining of negative dielectric constants, and by a description of the principles and apparatus of the writer's technique.

1902. ELECTRICAL SATURATION IN PURE LIQUIDS AND THEIR MIXTURES [Dielectric Constant Measurements].—Piekara. (*See* 1896.)

1903. EXPERIMENTS ON THE MECHANISM OF CONDUCTION IN LIQUIDS OF LOW DIELECTRIC CONSTANT [Mobility Measurements on Hexane carrying Artificial Currents produced Photoelectrically].—K. H. Reiss. (*Ann. der Physik*, No. 4, Vol. 28, 1937, pp. 325–352.)

1904. MEASUREMENTS OF DAMPING IN VERY HIGH FREQUENCY CIRCUITS [of Ultra-Short-Wave Transmitters and Receivers: Description of a Grid-Rectifying Voltmeter for the Purpose].—G. Lehmann. (*L'Onde Élec.*, Jan. 1937, Vol. 16, No. 181, pp. 58–70.)

The qualitative study of 4–8 m transmitters has shown that most of the losses in such circuits are ohmic losses in the inductance coils. A systematic investigation of the causes of damping is thus of capital importance. The chief methods of measuring such damping are the dynatron method, the resistance-substitution method, and the resonance-curve method. The first is found to be unsatisfactory for ultra-high frequencies: of the other two, the resonance-curve method is specially useful as it allows absolute values to be obtained. Both methods require an instrument to measure the relative values of the u.h.f. currents or voltages, and the present paper describes such an instrument, together with the technique of its use, including the suppression of the damping due to the instrument itself. A later paper will describe a systematic investigation, with its help, of the influence of the shape of the conductors, and the nature and structure of their surfaces, on their resistance at these frequencies.

The special voltmeter circuit (using an RCA 955 "acorn" triode—*see*, for example, 1453 of 1935) is such as to give milliammeter readings approximately independent of frequency between the wide limits of 50 c/s and 100 Mc/s.

1905. ULTRA-SHORT AND SHORT-WAVE MEASUREMENTS OF THE CONDUCTIVITY AND DIELECTRIC CONSTANT OF BIOLOGICAL TISSUES AND LIQUIDS [by Barretter Method].—Osswald. (*See* 2030.)

1906. ON ERRORS IN THE MEASUREMENT OF CURRENTS AND VOLTAGES AT RADIO [including Ultra-High] FREQUENCIES.—R. E. Albrandt. (*Izvestiya Elektroprom. Slab. Toka*, No. 12, 1936, pp. 17–24.)

The equivalent circuits of ammeters and voltmeters are derived, and tables compiled showing typical values of constants of these circuits, and also input impedances at 3 and 30 m for various types of instruments. The formation of circuits from a meter to earth through stray capacities and earthed points of the main circuit, to which the meter is connected, is discussed in detail, and a table is given showing typical values of capacities to earth for various types of meter. Methods are indicated for calculating the leakage current, and these are illustrated by a number of numerical examples dealing with different types of circuit.

1907. THERMOCOUPLE AMMETERS FOR ULTRA-HIGH FREQUENCIES [Errors almost entirely due to Skin Effect in Heated Member: Defects of Compensation Methods: Good Results by Use of Tubular Platinum-Alloy Heaters with One-Mil Wall: Calibration Method using Straight-Filament Lamps and Photocell].—J. H. Miller. (*Proc. Inst. Rad. Eng.*, Dec. 1936, Vol. 24, No. 12, pp. 1567–1572.)

1908. THE BOLOMETER, A LITTLE KNOWN H.F. CURRENT-MEASURING DEVICE [Experimental Investigation].—H. Wolff. (*Funktech. Monatshefte*, Jan. 1937, No. 1, pp. 27–29.)

1909. A CALIBRATED SOURCE OF HIGH-FREQUENCY POTENTIAL [*e.g.* 4.75–12.6 Mc/s].—S. Githens, Jr. (*Review Scient. Instr.*, Feb. 1937, Vol. 8, No. 2, pp. 48–50.)

"The difficulties encountered in h.f. potential measurement can be avoided by the use of an oscillator which measures the potential it generates. . . . A portion of the principal oscillatory ('tank') circuit performs the function of potential measurement, rendering unnecessary the attachment of a measuring device."

1910. A NEW BRIDGE CIRCUIT FOR MEASURING THE CURVE FORM [of Voltage Waves from Electrical Generators].—H. E. Linckh. (*Physik. Zeitschr.*, 15th Feb. 1937, Vol. 38, No. 4, pp. 105–111.)

In this bridge circuit (Fig. 1) the harmonics of the wave form are investigated by balancing out the fundamental by a wave obtained from a resonant circuit tuned to the fundamental frequency and fed by the wave under investigation *via* an ohmic resistance. The theory of the bridge is worked out; its errors, sensitivity, current consumption, etc., are calculated. A method of measuring peak values with a circuit (Fig. 4) including a thyratron is described (§ 7). Experimental results and oscillograms are given.

1911. A NEW BRIDGE FOR THE DIRECT MEASUREMENT OF IMPEDANCE [balanced against Variable Non-Inductive Resistance, giving Ohmic Value of Impedance without Calculation: also Phase Angle if required, by Simple Formula].—A. Serner. (*Wireless Engineer*, Feb. 1937, Vol. 14, No. 161, p. 59–62.)

The arm opposite the unknown impedance contains one of the two variable non-inductive resistances (the third is fixed), a variable condenser, and a fixed inductance L, having a variable mutual inductance with a coil in the diagonal. In a simplified version, for routine measurements at a fixed frequency, the mutual inductance and the condenser are both fixed.

1912. USE OF THE "C-tan δ" RECORDER IN COMBINATION WITH THE SCHERING BRIDGE.—Geyger. (*See* 1998.)

1913. HIGH-FREQUENCY CURRENT AND VOLTAGE METERS.—J. Stanek. (*Veröff. a. d. Geb. d. Nachr:tech., Siemens*, No. 2, Vol. 6, 1936, Sec. VI, 4 pp.)

1914. PUSH-PULL STABILISED TRIODE VOLTMETER [Circuit Constants fixed and Valves matched to Them by Adjustment of Shunt Resistors].—C. Williamson. (*Proc. Inst. Rad. Eng.*, Feb. 1937, Vol. 25, No. 2, pp. 162–163: summary only.) Useful down to 10^{-5} v: the supply voltage can be varied by 5% with no loss of precision.

1915. H.F. MEASUREMENTS ON COILS AND CONDENSERS [of Broadcast Receivers: using Various Resonance Methods].—A. Jaumann. (*Veröff. a. d. Geb. d. Nachr:tech., Siemens*, No. 2, Vol. 6, 1936, Sec. VI, 7 pp.)

1916. USE OF RELAXATION OSCILLATIONS IN CAPACITY MEASUREMENT.—R. Guillien. (*Comptes Rendus*, 1st March, 1937, Vol. 204, No. 9, pp. 668–670.)

The writer has devised a method of measuring capacity by means of the relaxation oscillations which occur when a condenser, shunted by an ohmic resistance, is in series with an oscillating circuit between the grid and cathode of an oscillating valve. When the frequency of interruption of the h.f. oscillations is in the audio range, the anode current has an l.f. component which may be filtered out; its resonance curves, given when the capacity of the condenser is varied, have a very sharp crevasse which affords a quick and accurate method of measuring the capacity. The circuit used is described.

1917. HIGH-SPEED PHOTOGRAPHIC METHODS OF MEASUREMENT [General Account].—H. E. Edgerton, J. K. Germeshausen, & H. E. Grier. (*Journ. of Applied Phys.* [formerly *Physics*], Jan. 1937, Vol. 8, No. 1, pp. 2–9.)

1918. INTERNATIONAL COMPARISON OF THE STANDARDS OF FREQUENCY.—A. Wainberg. (*L'Onde Élec.*, Jan. 1937, Vol. 16, No. 181, pp. 71–80.)

By simultaneous measurements of 60 m transmissions from RKF (Moscow) at Brussels, Warsaw, Dollis Hill, Paris, Mojaisk (Russia) and Leghorn, in Dec. 1935 and Jan. 1936. Results are also given of 1936 tests on broadcast wavelengths from Motala, Budapest I, and Breslau, measured by the broadcast control centres of Brussels, Italy, England and Russia. "The mean total effect of the absolute values of all the errors, as well as their maximum effect, is in all cases inferior to $\pm 4 \times 10^{-7}$."

1919. STANDARDS OF RADIO FREQUENCY [Details of Emissions from National Physical Laboratory, Teddington].—(*Nature*, 27th Feb. 1937, Vol. 139, pp. 363–364: *Electrician*, 5th Feb. 1937, Vol. 118, p. 196.)

1920. FREQUENCY STANDARDISING EQUIPMENT [Objections to the D. W. Dye Technique using Multivibrators: Limitations of the Continuously Variable Valve Oscillator: New Technique and Apparatus combining Advantages of Both].—H. J. Finden. (*Wireless Engineer*, March, 1937, Vol. 14, No. 162, pp. 117–126.)

1921. DETERMINATION OF THE SURFACE OF A PIEZOELECTRIC LAMINA AS A FUNCTION OF ITS FREQUENCY.—A. de Gramont & D. Beretzki. (*Comptes Rendus*, 15th Feb. 1937, Vol. 204, No. 7, pp. 459–462.)

The writers have investigated the effect of the area of the lamina on its efficiency and on the ease with which it vibrates. Laminae of constant area were made gradually thinner, and the surfaces of laminae of constant thickness were gradually decreased though kept similar in shape; the h.f. power in milliwatts per mm² of quartz was measured (Figs. 1, 2, 3). The curves show a maximum of power as a function of the ratio of area to thickness, and explain why the usual quartz laminae will not vibrate at very high frequencies; oscillations of frequency 5×10^7 c/s were obtained with a lamina whose side was 2 mm long. Its small capacity, comparable to the grid/cathode capacity in the attached oscillatory circuit, contributed to the ease of maintenance of oscillations.

1922. ON THE CIRCUMFERENTIAL VIBRATION OF A HOLLOW CYLINDRICAL QUARTZ OSCILLATOR.—Ny Tsi-Zé & F. Sun-Hung. (*Chinese Journ. of Phys.*, Dec. 1936, Vol. 2, No. 2, pp. 145–153: in English.)

For previous work on the various modes of vibration *see* 635 of February and 1487 of April. The present paper concentrates on the circumferential vibration: the empirical relation between cylinder dimensions and frequency is derived and the temperature coefficients of frequency are determined. These are practically zero over a wide range of temperature when the ratio internal-radius/external-radius approaches a value very close to 0.5. The necessity for this ratio to be fixed in this way does not limit the use of the quartz cylinder in any way, because the frequency of the circumferential vibration depends on the *sum* of the radii and not on their ratio.

1923. ON THE ANOMALOUS VARIATION WITH TEMPERATURE OF THE ELECTRICAL CONDUCTIVITY OF SOME SILICATE MINERALS AND ESPECIALLY OF *R*-CUT QUARTZ.—Saegusa & Matsumoto. (*Jap. Journ. of Phys., Transactions & Abstracts*, Dec. 1936, Vol. 11, No. 2, Abstracts p. 61.)

1924. THE MAGNETOSTRICTIVE OSCILLATION OF QUARTZ PLATES.—R. C. Colwell & L. R. Hill. (*Journ. of Applied Phys.* [formerly *Physics*], Jan. 1937, Vol. 8, No. 1, pp. 68–70.)

Sand figures are shown of the nodal lines of vibration of small quartz plates, produced by mechanical impact from magnetostrictive rods cut to the proper lengths. Electrical vibrations of the plates, in a field produced by the same circuit which was used to set the magnetostrictive rods in vibration, give exactly similar patterns for identical frequencies.

1925. INFLUENCE OF ELASTIC TENSION ON MAGNETOSTRICTION.—B. K. Girenchin. (*Physik Zeitschr. der Sowjetunion*, No. 5, Vol. 10, 1936, pp. 689–693: in English.)

1926. A NOTE ON MAGNETOSTRICTION IN DEGENERATE ELECTRON GAS [Formula for Magnetostriction derived by Quantum-Theoretical Reasoning].—D. V. Gogate. (*Phil. Mag.*, March, 1937, Series 7, Vol. 23, No. 154, pp. 487–490.)

1927. WIDE-RANGE RESONANCE-TYPE FREQUENCY METERS WITH SENSITIVE VACUUM-TUBE INDICATORS [including a Model for 1–600 m].—W. M. Smith. (*QST*, Jan. 1937, Vol. 21, No. 1, pp. 35–37.)

Essentially, the highly sensitive indicator is a triode voltmeter: the variation from standard practice lies in the control of the initial electron current, by cathode or filament temperature control rather than by variation of grid bias or plate voltage. Acorn triodes are particularly suitable.

1928. NOMOGRAM FOR COIL CALCULATIONS [based on Nagaoka Formula for Inductance of Single-Layer Solenoid].—C. P. Nachod. (*Electronics*, Jan. 1937, Vol. 10, pp. 27–28.)

1929. CALCULATION OF THE SELF-INDUCTANCE OF PLANE POLYGONAL CIRCUITS.—Kalantaroff & Worobieff. (*See* 1727.)

1930. FORMULAS FOR SHIELDED COILS.—Harris: RCA Radiotron. (*Rad. Engineering*, Dec. 1936, Vol. 16, p. 17.) Based on the work of Harris (1932 Abstracts, p. 417) and RCA Radiotron Application Note No. 48.

1931. AN ABSOLUTE DETERMINATION OF THE AMPERE.—P. Vigoureux. (*Phil. Trans. Roy. Soc. Lond.*, Series A, 15th Dec. 1936, Vol. 236, No. 762, pp. 133–154.)

1932. "BRITISH STANDARD GLOSSARY OF TERMS USED IN ELECTRICAL ENGINEERING" [Book Review].—G.W.O.H. (*Wireless Engineer*, Feb. 1937, Vol. 14, No. 161, pp. 57–58.)

1933. THE PHYSICO-THEORETICAL LIMITS OF MEASURABILITY.—W. Gerlach. (*Zeitschr. V.D.I.*, 2nd Jan. 1937, Vol. 81, pp. 2–7.)

SUBSIDIARY APPARATUS AND MATERIALS

1934. THE EDDY-CURRENT LOSSES IN IRON-POWDER CORES [Derivation of Formulae for Calculation: etc.].—M. Kornetzki & A. Weis. (*Veröff. a. d. Geb. d. Nachr.tech., Siemens*, No. 3, Vol. 6, 1936, pp. 101–117.)

For the broadcast band the chief source of loss in a well-insulated core is found to be the eddy-current losses in the individual iron particles. If these coalesce, the specific resistance of the core falls considerably, while the dielectric constant and the dielectric loss-angle of the core increase correspondingly. In this case the capacity eddy currents, occurring throughout the whole core cross section, increase so much that they reach the same order of magnitude as the eddy currents in the particles. Finally, a special type of loss is discussed, arising in the core as a result of the electric field of the winding.

1935. THE MAGNETIC STABILITY OF FERROMAGNETIC ALLOYS OF IRON: I—Messkin & Margolin. (*Zeitschr. f. Physik*, No. 7/8, Vol. 101, 1936, pp. 456–477.)

The effects of concentration, formation, and dissolution of solid solutions on the magnetic stability of iron alloys are investigated experimentally. "Some complex iron alloys are given which have small instability, low hysteresis losses, high electric resistance and satisfactory technical properties" as specified for telephone engineering by Dahl, Pfaffenberger, & Sprung (1933 Abstracts, p. 637) and Goldschmidt & Pfaffenberger (1933 Abstracts, p. 281).

1936. THE MAGNETIC SUSCEPTIBILITY OF THE SILVER/LEAD, SILVER/ANTIMONY, AND THE SILVER/BISMUTH SERIES OF ALLOYS [Measurements].—Stephens & Evans. (*Phil. Mag.*, Sept. 1936, Series 7, Vol. 22, No. 147, pp. 435–445.)

1937. NEW DETERMINATIONS OF GYROMAGNETIC RATIOS FOR FERROMAGNETIC SUBSTANCES.—Barnett. (*Phys. Review*, 15th Aug. 1936, Series 2, Vol. 50, No. 4, p. 390: abstract only.) For previous work *see* 2882 of 1935.

1938. CONTROLLED GRAIN SIZE IN STEEL.—Swinden & Bolsover. (*Engineering*, 16th & 30th Oct. 1936, pp. 432–434 & 488–489.) "The effect on mechanical properties and some suggestions concerning the theory involved."

1939. FLUCTUATIONS OF POTENTIAL AT THE ENDS OF A METALLIC CONDUCTOR OF SMALL VOLUME TRAVERSED BY A CURRENT.—Bernamont. (*See* 1715.)

1940. THE ELECTRICAL CONDUCTIVITY OF THIN METALLIC FILMS. II—CAESIUM AND POTASSIUM ON PYREX GLASS SURFACES [Measurements].—Appleyard & Lovell. (*Proc. Roy. Soc.*, Series A, 3rd Feb. 1937, Vol. 158, No. 895, pp. 718–728.) For I *see* 1123 of March.

1941. AUTOMATIC STABILISATION OF TEMPERATURE-LIMITED CURRENTS IN THERMIONIC VALVES.—Gwyer & Megaw. (*See* 1733.)

1942. A VARIOMETER FOR AN OSCILLATOR OF WIDE FREQUENCE RANGE.—Pierce. (*See* 1738.)

1943. A SIMPLE COMPENSATION MEASURING AMPLIFIER.—Geyger. (*Arch. f. Elektrot.*, 23rd Jan. 1937, Vol. 31, No. 1, pp. 57–63.)

Known automatic d.c. compensators are first reviewed. A simple induction amplifier is then described in which the regulation of the comparison compensating current is achieved with a transformer by means of a continuously variable mutual inductance controlled by a moving-coil null instrument. Fig. 1 shows the circuit for voltage measurements when the voltage to be measured does not change its direction; Fig. 2, the circuit when the voltage to be measured can change its direction; Fig. 4, the circuit for loss-free current measurements. Small currents and voltages can be measured without energy consumption and registered with an ink recorder. *See* 1998.

1944. AN INSTRUMENT FOR MEASURING IONISATION CURRENTS [by Townsend Method, with Automatic Balancing].—Lea. (*Journ. Scient. Instr.*, March, 1937, Vol. 14, No. 3, pp. 89–94.) For currents of 10^{-10} to 10^{-14} ampere; it will also function as an integrating meter.

1945. WHEN METERS BLOW: EDGERTON PHOTOGRAPHS SHOW HOW INSTRUMENT FUSES PROTECT AGAINST OVERLOAD.—Fohr. (*Electronics*, Jan. 1937, Vol. 10, pp. 22–23.) From the Littlefuse Laboratories.

1946. THE RAPIDITY OF HIGH-SPEED CINEMATOGRAPHY.—Labarthe. (*Génie Civil*, 2nd Jan. 1937, Vol. 110, p. 24: summary only.) Including a plan for 500 000 pictures per second, by a ray of light scanning a battery of photocells.

1947. THE COORDINATE OSCILLOGRAPH [Optical Arrangement showing on Screen the Relationship between Two or More Quantities measured separately by Oscillograph Loops].—Bader. (*Arch. f. Elektrot.*, 18th Feb. 1937, Vol. 31, No. 2, pp. 108–115.)

1948. ELECTRON-OPTICAL ARRANGEMENT FOR MULTIPLE CATHODE-RAY TUBES WITH INCANDESCENT CATHODES.—Knoll. (*Arch. f. Elektrot.*, 23rd Jan. 1937, Vol. 31, No. 1, pp. 41–42.)

Cold-cathode multiple tubes using the principles of anode and cathode stopping (*see* resp. 1933 Abstracts, p. 111—Knoll—& p. 283—Boekels & Dicks) have proved to be of practical use. These principles, when applied to tubes with incandescent cathodes, give rise however in general to very small currents, or involve the use of large incandescent surfaces or heating power. This paper describes two electron-optical arrangements using anode stopping which give currents in the electron beams of magnitude about ten times that given by known devices, for the same cathode surface. They are both based on the production and stopping of a filament electron beam. The two types of cathode used are shown in Fig. 1: (a) a pencil-shaped cathode surrounded by a Wehnelt cylinder; the emission takes place from a ring-shaped section of the cylindrical surface of the cathode: (b) a cone-shaped cathode surface surrounded by a "skull-cap" or a Wehnelt cylinder. In each case the electrons are gathered into a filament with circular ring cross-section, which is split up by the anode stop into a number of smaller filaments.

1949. HIGH-VACUUM MULTIPLE-BEAM CATHODE-RAY OSCILLOGRAPH.—A. Bigalke. (*Arch. f. Elektrot.*, 23rd Jan. 1937, Vol. 31, No. 1, pp. 43–48.)

The historical development and required properties of the multiple-beam oscillograph are first summarised. An experimental tube for measuring the path of the beam is shown in Fig. 1; it has a spiral cathode surrounded by a cap (Fig. 2), an anode stop giving four electron beams, and an electric lens system. The path of the beam (shown in Fig. 4) is shown up by three pieces of fluorescent molybdenum wire gauze placed at intervals across the tube. Fig. 5 shows a cylinder used as a stop for two-beam tubes; it contains deviating plates which are thus placed in front of the lens system. Figs. 6 and 7 show oscillograms illustrating the practical utility of the tube. Proposed directions of further development are indicated.

1950. CONVERGENCE OF ELECTRONS BY MEANS OF MAGNETIC COILS [Derivation of Formulae for Focal Distance and Angle of Rotation: Difference between Lens Actions of Short and Long Coils: etc.].—Bouwers. (*Physica*, March, 1937, Vol. 4, No. 3, pp. 200–206: in English.)

1951. THE EIGHT IMAGE ERRORS, OF THIRD ORDER, OF MAGNETIC ELECTRON LENSES [Experimental Demonstration].—Diels & Wendt. (*Zeitschr. f. tech. Phys.*, No. 3, Vol. 18, 1937, pp. 65–69.) Namely spherical aberration, isotropic and anisotropic coma, astigmatism and field curvature, isotropic and anisotropic distortion (differing scale for different distances from axis), and anisotropic field curvature (Fig. 15: a point far from the axis is imaged as a circle).

1952. ON VARIOUS METHODS FOR DESIGNING ELECTRON LENSES.—Yanchevski, Buchinski, & Eremeev. (*Izvestiya Elektroprom. Slab. Toka*, No. 11, 1936, pp. 43–56.)

For previous work *see* 2353 of 1936. The electron lens considered in this paper consisted of two coaxial cylinders of different diameters, placed end to end (Fig. 1) and having a certain potential difference. The following methods were used to determine the position of the principal foci and planes of this lens: (a) graphical method (which is explained in the paper); (b) approximate method of Picht (Abstracts, 1933, p. 224); (c) similar method of Polotovski (3553 of 1935); (d) exact method of Picht; (e) method of Scherzer (Abstracts, 1933, p. 224); (f) optical method in which the path of the ray from surface to surface is calculated from a knowledge of the refractive indices and adii of curvature of the surfaces; and (g) experimental method of Wetthauer (*Zeitschr. f. Phys.*, Vol. 46, 1924).

In order to use any of the above methods it is necessary to know the shape and distribution of the equipotential surfaces in the lens, and for this investigation the necessary information was obtained by laborious experiments of which a detailed description is given. The results obtained are shown in a comparative table and it is considered as a preliminary conclusion that the optical method and the exact method of Picht are the most satisfactory.

1953. A NEW ELECTRON MICROSCOPE [Two-Stage: with Focusing Coils mounted in Vacuum: embodying also Optical Microscope].—Martin, Whelpton, & Parnum. (*Journ. Scient. Instr.*, Jan. 1937, Vol. 14, No. 1, pp. 14–24.)

1954. THE THEORY OF THE ELECTRON MIRROR and Its Errors: Practical Method of Calculating Electron Paths: Calculation of Paths in Special Case].—A. Recknagel. (*Zeitschr. f. Physik*, No. 5/6, Vol. 104, 1937, pp. 381–394.) For the electron mirror considered *see* 1568 of 1936 and 1111 of March.

1955. A 913 OSCILLOSCOPE WITH LINEAR SWEEP.—J. B. Carter. (*QST*, Jan. 1937, Vol. 21, No. 1, pp. 22–24 and 108, 110.) *Cf.* 1368 of April.

1956. APPLICATION OF THE METHODS OF ELECTRON OPTICS TO MASS SPECTROGRAPHY.—Cartan. (*Comptes Rendus*, 3rd Nov. 1936, Vol. 203, No. 18, pp. 867–869.)

1957. A HIGH-SENSITIVITY MASS SPECTROGRAPH WITH AN AUTOMATIC RECORDER.—Smith, Lozier, & others. (*Review Scient. Instr.*, Feb. 1937, Vol. 8, No. 2, pp. 51–55.)

1958. MECHANICAL TRACER FOR ELECTRON TRAJECTORIES [using Electrolytic Tank, Probes, Pantograph, Trolley, Pencil on Drawing-Board: Steering Angle determined by Special Bridge].—Gabor. (*Nature*, 27th Feb. 1937, Vol. 139, p. 373.)

1959. THE STRUCTURE OF A BETA-RAY LINE BY SEMICIRCULAR MAGNETIC FOCUSING [with Calculations of the Actual Distribution of a Homogeneous Group of Electrons from Different Types of Source: Dependence of Maximum Intensities on Radius of Curvature of Electron Paths: Tables of Effective Solid Angle subtended by Photographic Plate at Electron Source].—Li. (*Proc. Camb. Phil. Soc.*, March, 1937, Vol. 33, Part 1, pp. 164–178.)

1960. A SYMMETRICAL SLIT OF VARIABLE WIDTH.—Hughes & McKay. (*Journ. Scient. Instr.*, Jan. 1937, Vol. 14, No. 1, pp. 25–28.)

1961. CYCLOTRON OPERATION WITHOUT FILAMENTS [H.F. Power supplied by Transmission Line: Continuous Glow Discharge in Vacuum Chamber: Curve relating Pressure in Vacuum and Ion Current: Optimum Pressure].—Kruger, Green, & Stallmann. (*Phys. Review*, 15th Feb. 1937, Series 2, Vol. 51, No. 4, p. 291.)

1962. LUMINESCENCE AND ITS APPLICATIONS.—Randall. (*Journ. Roy. Soc. Arts*, 5th March, 1937, Vol. 85, pp. 354–381.) From the G.E.C. laboratories.

1963. THE FLUORESCENT MATERIALS FOR TELEVISION.—Ivanov. (*See* 1875.)

1964. PROBLEMS CONCERNING THE PRODUCTION OF CATHODE-RAY TUBE SCREENS.—Leverenz. (*See* 1874.)

1965. BRIGHTNESS OF CATHODE-LUMINESCENCE AT LOW CURRENT DENSITIES AND LOW VOLTAGES.—Brown. (*Journ. Opt. Soc. Am.*, Jan. 1937, Vol. 27, No. 1, p. 62: summary only.)

When the fluorescent surface is very carefully shielded electrostatically, secondary emission from it will maintain its potential to within one or two volts negative of the potential of the shield. With binder-less artificial willemite there is no measurable threshold voltage: fluorescence is measurable down to 140 volts, at which voltage the fluorescent surface abruptly charges up. "This peculiar phenomenon is discussed in some detail" [in the full paper].

1966. PUSH-PULL RESISTANCE-COUPLED AMPLIFIERS.—Offner. (*See* 1713.)

1967. AN APPARATUS FOR WAVE-FORM IMPROVEMENT AND PHASE COMPENSATION FOR USE WITH A CATHODE-RAY OSCILLOGRAPH [in determining Static or Dynamic Characteristics of Valves, Undistorted Output of Amplifiers, etc.].—F. Dohnal. (*Funktech. Monatshefte*, Jan. 1937, No. 1, pp. 17–18.)

1968. THE CALCULATION OF THE RELAXATION-OSCILLATION ["Kipp"] FREQUENCY OF SIMPLE GLOW-DISCHARGE-TUBE CIRCUITS.—Bergtold. (*Funktech. Monatshefte*, Jan. 1937, No. 1, pp. 30–31.)

1969. A NEW TIMING MOTOR FOR OSCILLOGRAPHS [for driving the Time-Marking Interrupting Disc: Tuning-Fork Feed: Stability improved by Series Condenser just below Resonance Value].—Morton. (*Bell Lab. Record*, March, 1937, Vol. 15, No. 7, pp. 229–231.)

1970. A ROTATING-DRUM CAMERA FOR PHOTOGRAPHING TRANSIENT PHENOMENA [Film Speeds up to 750 Inches per Second: Synchronisation by Rotating Switches].—Lambert. (*Review Scient. Instr.*, Jan. 1937, Vol. 8, No. 1, pp. 13–15.)

1971. A FILM CAMERA FOR USE WITH THE CATHODE-RAY OSCILLOGRAPH [with Automatic Reverse and Jacking, giving Four Tracks, etc.].—Grimmett & Rann. (*Journ. Scient. Instr.*, March, 1937, Vol. 14, No. 3, pp. 96–100.)

1972. QUICKER STARTING AUTOMATIC OSCILLOGRAPH [Starting Time 0.004 Sec.].—Hathaway. (*Gen. Elec. Review*, Feb. 1937, Vol. 40, No. 2, pp. 98–100.)

1973. THREE-STAGE MERCURY CONDENSATION PUMP FOR USE WITH HIGH FORE PRESSURES [giving 9×10^{-6} mm Hg].—Thermal Syndicate. (*Journ. Scient. Instr.*, Jan. 1937, Vol. 14, No. 1, p. 32.)

1974. MANOMETER [of Radiometric Type] FOR HIGH VACUA.—Bonét-Maury. (*Comptes Rendus*, 3rd Nov. 1936, Vol. 203, No. 18 [misprinted 17 on cover], pp. 839–841.)

1975. THREE-PHASE RECTIFIER CIRCUITS [for Rectifiers having Separate Cathode to Each Anode, *e.g.* Ignitrons].—Maslin. (*Electronics*, Dec. 1936, Vol. 9, pp. 28–31.)

1976. HIGH-FREQUENCY POWER SOURCE WITH MERCURY-VAPOUR ARC RECTIFIER.—Ohtsuki & Horikoshi. (*Journ. I.E.E. Japan*, Aug. 1936, p. 939: Japanese only.)

1977. SPARKING POTENTIAL OF MERCURY VAPOUR [Variation with Vapour Density and Cathode Material: Electrons emitted from Cathode under Impact of Positive Ions predominate in Spark Production and Discharge Maintenance].—Jones & Galloway. (*Nature*, 5th Dec. 1936, Vol. 138, p. 973.)

1978. LOW PRESSURE ARC CHARACTERISTICS [Reignition Potential is Linear Function of Gas Pressure: Factors affecting Reignition: Mechanism of Phenomenon].—Cobine. (*Physics*, April, 1936, Vol. 7, No. 4, pp. 137–142.) *See* also 2888 of 1935.

1979. IMPROVEMENT TO ELECTRICAL DISCHARGE TUBE WITH GASES OR IONISED VAPOURS [Sudden Discontinuity of Low-Pressure Arc avoided by Additional Magnetic Field acting during Discharge Periods].—Als-Thom. (*Rev. Gén. de l'Élec.*, 26th Sept. 1936, Vol. 40, No. 13, p. 104D: French Pat. 800 490 of 10.1.1936.)

1980. EXPERIMENTAL INVESTIGATIONS OF THE CORONA DISCHARGE IN AIR, HYDROGEN, AND CARBON DIOXIDE.—Daubenspeck. (*Arch.f. Elektrot.*, 8th Sept. 1936, Vol. 30, No. 9, pp. 581–589.)

1981. ELECTRICAL BREAKDOWN IN THE CLOUD CHAMBER [Cloud Photographs of Preliminary Ionisation Processes: Curves of Breakdown Voltage, etc., as Functions of Impulse Time: Photoelectrons produced by Radiation from the Discharge Path support Discharge at High Pressures].—Raether. (*Physik. Zeitschr.*, 1st Aug. 1936, Vol. 37, No. 15, pp. 560–562.)

1982. CLOUD TRACKS OF NEGATIVE BRUSH DISCHARGES [Gleitentladung].—Trey. (*Physik. Zeitschr.*, 1st Oct. 1936, Vol. 37, No. 19, pp. 688–690.)

1983. GENERATION AND ABSORPTION OF GAS IN INSULATING OILS UNDER THE INFLUENCE OF AN ELECTRIC DISCHARGE.—Nederbragt. (*Journ. I.E.E.*, Sept. 1936, Vol. 79, No. 477, pp. 282–290.)

1984. DIELECTRIC LOSSES IN AN ALTERNATING H.F. FIELD AND MOLECULAR DIMENSIONS [Measurements for Some Organic Liquids].—Henrion. (*Comptes Rendus*, 6th July, 1936, Vol. 203, No. 1, pp. 52–54.)

1985. On the Dielectric Behaviour of Colloidal Systems: III—Electrical Effects on the Fibrous Dispersed Systems [Influence of Water Content, etc.].—Nishi & Uyeda. (*Jap. Journ. of Phys., Transactions & Abstracts*, Dec. 1936, Vol. 11, No. 2, Abstracts pp. 60–61.) For II *see* 707 of February.

1986. Artificial Resins.—Potter. (*Journ. Roy. Soc. Arts*, 29th Jan. 1937, Vol. 85, pp. 243–264.) Lecture by the managing director of Bakelite, Ltd.

1987. "Standardisation of Synthetic-Resin Plastic Materials, Laminated and Non-Laminated" [Notice of Leaflet].—(*Zeitschr. V.D.I.*, 6th Feb. 1937, Vol. 81, p. 157.)

1988. "Kunst- und Presstoffe" [Synthetic and Plastic Materials for Various Purposes: Book Review].—(*Zeitschr. V.D.I.*, 6th Feb. 1937, Vol. 81, p. 142.) Collection of papers, issued by the V.D.I.

1989. The Production, Application, and Characteristics of Various Moulded Plastics suitable for General Engineering Purposes.—Dunton. (*Metropolitan-Vickers Gazette*, March, 1937, Vol. 16, pp. 381–388: to be continued.)

1990. Artificial Organic Materials: Chemical Composition and Methods of Preparation.—Sauter. (*Zeitschr. V.D.I.*, 2nd Jan. 1937, Vol. 81, pp. 17–22.)

1991. The New Incombustible Conductor "Pyrotenax" with Mineral Insulating Material.—(*Génie Civil*, 2nd Jan. 1937, Vol. 110, pp. 19–20.)

1992. On the Plastification of Polystyrols.—Dalesky & Korzhavin. (*Izvestiya Elektroprom. Slab. Toka*, No. 12, 1936, pp. 52–54.) Concluded from 705 of February.

1993. Insulating Materials: a Year of Active Development.—Dunton. (*Electrician*, 29th Jan. 1937, Vol. 118, pp. 129–130.)

1994. Rotosil, a Quartz Insulating Material, centrifuged into Tube Form during Its Formation by the Fusing of Quartz Sand.—Hecht. (*Zeitschr. V.D.I.*, 6th Feb. 1937, Vol. 81, pp. 156–157.) For 30 m waves tan δ is about 4×10^{-4}. The various advantages of the patented Rotosil process are set out.

1995. Polarisation Impedance [of $Pt/H_2SO_4/Pt$ Electrolytic Cell] at Low Frequencies [Empirical Law for Capacity/Frequency Relation: Results for Aperiodic Currents].—Murdock & Zimmerman. (*Physics*, June, 1936, Vol. 7, No. 6, pp. 211–219.)

1996. About R.F. Voltage and Current Ratings of Mica Transmitting Condensers.—Aerovox Company. (*QST*, Jan. 1937, Vol. 21, No. 1, pp. 43 and 116.)

1997. The Testing, and the Reliability in Service, of Condensers.—Linder. (*Veröff. a. d. Geb. d. Nachr:tech., Siemens*, No. 2, Vol. 6, 1936, Sec. VI, 6 pp.)

1998. Use of the "C-tan δ" Recorder in Combination with the Schering Bridge [for testing Condensers, Insulating Materials, etc.].—Geyger. (*Arch. f. Elektrot.*, 18th Feb. 1937, Vol. 31, No. 2, pp. 115–123.)

A method is described by which the Schering bridge can be made to produce an automatic ink record of the capacity change and loss factor of the object under test as a function of the working voltage or time of switching in circuit. The fundamental circuit adopted is shown in Fig. 1. The principle of the method is that "a complex a.c. compensator [*see* 1192 of March] is introduced into the circuit of the standard condenser; the compensator is automatically balanced by two 'C-tan δ' recorders working with phase-dependent null motors with a valve amplifier in common." Selection of the fundamental vibration is achieved by means of two null motors externally excited by sinusoidal currents (Fig. 5). The sensitivity and tests of the apparatus are discussed. For the "C-tan δ" recorder *see* 2000/1 of 1936 and 1090 of March. *See* also 1943, above.

1999. Theory of the Self-Compensating D.C. Amplifier with Direct Mechanical Control [with Equivalent Circuit: Optimum Circuit: Attainable Ranges of Measurement: Amplifier Oscillations and Their Suppression by Condenser Retroaction].—Merz. (*Arch. f. Elektrot.*, 23rd Jan. 1937, Vol. 31, No. 1, pp. 1–23.)

2000. On the Question of the Use of Bi-metallic Strips in Radiation Measurement and Photometry.—Klumb. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 17, 1936, pp. 279–280.)

2001. Radiation-Counting Circuits [and a Successful Alpha-Particle Counter Equipment using Triodes and Thyratrons].—Porter. (*Electronics*, July, 1936, Vol. 9, No. 7, pp. 28–29 and 66.)

2002. A Relay for a Radiation Integrator [Voltage Variation across a Condenser produced by Ionisation Currents, works Counter through Electrometer Valve and Thyratron Relay: Protection of Thyratron against H.F. Disturbances].—Lane. (*Journ. Scient. Instr.*, Nov. 1936, Vol. 13, No. 11, pp. 364–366.)

STATIONS, DESIGN AND OPERATION

2003. Broadcast Station Statistics [Capital Investment, Maintenance Costs, etc.].—(*Electronics*, Jan. 1937, Vol. 10, pp. 24–26.)

2004. Broadcasting on 546 kc/s [Experience with Budapest I (Lakihegy) as Argument in Support].—Babits: Aiken. (*Electronics*, Jan. 1937, Vol. 10, p. 32.) *See* 1592 of April.

2005. Practical Organisation and Equipment for Emergency Operation: S.A.R.O. Experience in Preparation for Amateur Service in Times of Disaster.—Tynes. (*QST*, Feb. 1937, Vol. 21, No. 2, pp. 13–16 and 72, 74.) For articles on the work in the recent U.S.A. floods see *ibid.*, March and April.

2006. Indicating Monitoring Apparatus for Broadcast Transmissions. — Liersch. (*Veröff. a. d. Geb. d. Nachr:tech., Siemens*, No. 2, Vol. 6, 1936, Sec. VI, 6 pp.)

GENERAL PHYSICAL ARTICLES

2007. A New Group of Action Functions in the Unitary Field Theory: II, *and* Born's Electrodynamics in Complex Form.—Infeld: Weiss. (*Proc. Camb. Phil. Soc.*, March, 1937, Vol. 33, Part 1, pp. 70–78: 79–93.) For Infeld I *see* 2022 of 1936.

2008. On a System of Functional Dynamics and Optics [Mathematical Scheme dealing with Dynamics of Lines and Corresponding Extension of Optics embraces Transformation Theory of Electromagnetism: Electronic Charge as Modulus of Discontinuity: Optics of Functional Waves: Association with Born's Field Theory].—Watson. (*Phil. Trans. Roy. Soc. Lond.*, Series A, 21st Jan. 1937, Vol. 236, No. 763, pp. 155–190.)

2009. The Effect of the Fitzgerald-Lorentz Contraction on the Frequency of Longitudinal Vibration of a Rod [Rod in Longitudinal Vibration rotated horizontally: Vibration Frequency accurately measured: Frequency Unchanged: Relativity Theory Prediction confirmed: Contraction in Length compensated by Modification of Velocity of Sound].—Wood, Tomlinson, & Essen. (*Proc. Roy. Soc.*, Series A, 3rd Feb. 1937, Vol. 158, No. 895, pp. 606–633.)

2010. The Cosmological Constants [Hypothesis that Numbers constructed from Them are Functions of Age of Universe: Consequent Increase of Amount of Matter in Universe and Decrease of Gravitational Constant: New Time Variable]: *also* The Constant of Gravitation.—Dirac: Milne. (*Nature*, 20th Feb. 1937, Vol. 139, p. 323: 6th March, 1937, p. 409.)

2011. On Equations for the Dirac Electron in General Relativity.—Yamamoto. (*Jap. Journ. of Phys., Transactions & Abstracts*, Dec. 1936, Vol. 11, No. 2, pp. 35–65.)

2012. Present-Day Values of the Atomic Constants *e* and *h* [Critical Summary of Recent Results].—Ladenburg. (*Ann. der Physik*, Series 5, No. 5, Vol. 28, 1937, pp. 458–464.)

2013. Ionisation of Gamma Rays in Air at High Pressure [to 152 Atm.] at Various Temperatures [20°–50°C: No Influence of Temperature on Saturation Value].—Clay, Stammer, & van Tijn. (*Physica*, March, 1937, Vol. 4, No. 3, pp. 216–220: in English.)

2014. Researches on the Interaction with Matter of Particles with Very Great Energy: Electrons of Various Origins and Particles of Cosmic Radiation.—Leprince-Ringuet. (*Ann. de Physique*, Jan. 1937, Vol. 7, pp. 5–70.)

2015. Physics in 1936.—Osgood. (*Review Scient. Instr.*, Jan. 1937, Vol. 8, No. 1, pp. 1–12.)

MISCELLANEOUS

2016. The Evolution of the Methods of Calculating Transitory Phenomena [Résumé of Theories due to Heaviside, Poincaré, Giorgi, Pomey, Wagner, Bromwich, Carson, van der Pol].—Blondel. (*Rev. Gén. de l'Élec.*, 20th, 27th Feb. & 6th March, 1937, Vol. 41, Nos. 8–10, pp. 227–240: 259–271: 298–311: to be contd.)

2017. The Reduction of Linear Homogeneous Differential Equations to Equations with Constant Coefficients [Theorems giving Conditions of Possible Reduction].—Favet. (*Comptes Rendus*, 1st March, 1937, Vol. 204, No. 9, pp. 650–652.)

2018. Significant Figures in Statistical Constants.—Moulton. (*Science*, 25th Dec. 1936, Vol. 84, pp. 574–575.) *See* also 754 of February.

2019. Method of Selection of Errors of Observation [Principles of Rejection of Observations differing widely from the Mean].—Calichiopulo. (*Comptes Rendus*, 1st March, 1937, Vol. 204, No. 9, pp. 642–644.)

2020. The Comparison of Series of Measures [Theory: Comparison of Standard Errors].—Jeffreys. (*Proc. Camb. Phil. Soc.*, March, 1937, Vol. 33, Part 1, pp. 35–40.)

2021. Probabilities of Locking [All Lines Engaged] in Selector Circuits [Mathematical Investigation].—Kosten. (*E.N.T.*, Jan. 1937, Vol. 14, No. 1, pp. 5–12.)

2022. "Höhere Mathematik für Mathematiker, Physiker und Ingenieure" [Book Review].—Rothe. (*Zeitschr. V.D.I.*, 2nd Jan. 1937, Vol. 81, pp. 30–31.)

2023. Influence of Industrial Electrical Networks on Telecommunication Circuits.—Holmgren & Swedenborg. (*Ericsson Technics*, No. 5, 1936, pp. 85–109: in French.)

2024. The Inductive Co-ordination of Common-Neutral Power Distribution Systems and Telephone Circuits.—Coleman & Davis. (*Bell S. Tech. Journ.*, Jan. 1937, Vol. 16, No. 1, pp. 76–100.)

2025. CURRENTS AND POTENTIALS ALONG LEAKY GROUND-RETURN CONDUCTORS.—Sunde. (*Bell S. Tech. Journ.*, Jan. 1937, Vol. 16, No. 1, pp. 110–112.)

2026. PHOTO-RADIO ANALOGS [Similarity between Emulsion Exposure Curve and Plate-Current/Grid-Voltage Curve: etc.].—Armer. (*Proc. Inst. Rad. Eng.*, Feb. 1937, Vol. 25, No. 2, p. 157: summary only.)

2027. A NEW SOURCE OF LONG-WAVE INFRA-RED RAYS.—Lewitskaja. (*See* 1729.)

2028. SHORT-WAVE THERAPEUTICS [Specific Action of Ultra-Short Waves: Evidence cited].—Hallberg. (*Electronics*, Jan. 1937, Vol. 10, p. 32.) Letter prompted by a remark in the article dealt with in 1627 of April. *Cf.* also 1620.

2029. VALVE AND SPARK-GAP GENERATORS FOR SHORT-WAVE THERAPY [Their Comparative Merits].—Eckert. (*Zeitschr. V.D.I.*, 27th Feb. 1937, Vol. 81, p. 280: short note.)

2030. SHORT-WAVE MEASUREMENTS OF THE CONDUCTIVITY AND DIELECTRIC CONSTANT OF BIOLOGICAL TISSUES AND LIQUIDS.—Osswald. (*Hochf:tech. u. Elek:akus.*, Feb. 1937, Vol. 49, No. 2, pp. 40–49.)

The barretter method (circuit scheme Fig. 4) is applied to measure the dielectric constant and conductivity of biological tissues and liquids at the wavelengths (3, 6 & 12 m) used in short-wave therapy; the l.f. conductivity is also measured. All tissues show a large increase in h.f. conductivity as compared with that at low frequencies and an increase of dielectric constant with wavelength and temperature. The results are discussed in relation to short-wave therapy.

2031. "PHENOMENA IN HIGH-FREQUENCY SYSTEMS" [Book Review].—Hund. (*World Power*, Feb. 1937, Vol. 27, p. 66.)

2032. "ELECTRIC COMMUNICATION AND ELECTRONICS" [Book Review].—Pender & McIlwain. (*Electronics*, Dec. 1936, Vol. 9, p. 37.)

2033. "ELECTRICAL ENGINEERS' HANDBOOK: VOL. 5—ELECTRIC COMMUNICATION AND ELECTRONICS" [Book Review].—Pender (Edited by). (*Proc. Inst. Rad. Eng.*, Jan. 1937, Vol. 25, No. 1, Part 1, p. 150.)

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2040. A METHOD FOR DETERMINING THE SPEED OF AIR-DRIVEN CENTRIFUGES [2000 r.p.s. upwards: from C-R-Oscillograph Lissajou Figure produced by Known Sinusoidal Frequency and Unknown Frequency obtained through Photocell].—Shapiro & Butt. (*Review Scient. Instr.*, Jan. 1937, Vol. 8, No. 1, p. 35.)

2041. MEASUREMENT OF THE BRIGHTNESS OF LUMINOUS PAINT WITH THE BLOCKING-LAYER PHOTOCELL USED AS PHOTOCONDUCTOR.—Byler. (*Review Scient. Instr.*, Jan. 1937, Vol. 8, No. 1, pp. 16–20.)

2042. THE APPLICATION TO ARTILLERY OF THE PHOTOELECTRIC CELL METHOD OF MEASUREMENT OF PROJECTILE VELOCITIES.—Rose. (*Canadian Journ. of Res.*, Jan. 1937, Vol. 15, No. 1, Sec. A, pp. 1–14.)

2043. TIMING DEVICES FOR RACE-TRACKS.—(*Ericsson Review*, No. 4, 1936, pp. 160–161.)

2044. PHOTOELECTRIC TUBE CONTROLS GAME IN LARGE GERMAN PRESERVE [traversed by High Road: Exit barred to Animals by Floodlights and Horn].—(*Electronics*, Jan. 1937, Vol. 10, p. 38.)

2045. PHOTOCELL AND TOTALLY-REFLECTING-PRISM MEASURE SMOOTHNESS OF PAPER [pressed against Back Face of Prism].—Davis & Malmstrom. (*Sci. News Letter*, 6th Feb. 1937, p. 88.)

2046. TUBES MEASURE PROTECTING FINISHES IN AUTOMOBILE MANUFACTURE.—Cadillac Laboratory. (*Electronics*, Dec. 1936, Vol 9, p. 44.)

2047. USE OF INFRA-RED RAYS AND PHOTOELECTRIC CELL IN SIGHT TESTING: THE COLLINS REFRACTIONOMETER.—Collins. (*Electrician*, 26th Feb. 1937, Vol. 118, p. 295.)

2048. PHOTOTUBES EXAMINE EDGES OF RAZOR BLADES.—Gillette Company. (*Electronics*, Jan. 1937, Vol. 10, p. 34.)

2049. NEW QUARTZ PRESSURE-MEASURING CHAMBERS FOR THE PIEZOELECTRIC METHOD OF MEASUREMENT [of Rapidly-Varying Pressure-Phenomena: Construction of Simple, Efficient Chamber: Typical Pressure Records].—Fahrentholz, Kluge, & Linckh. (*Physik. Zeitschr.*, 1st Feb. 1937, Vol. 38, No. 3, pp. 73–78.)

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

456 136.—Close-set aerial system for transmitting television signals in a selected direction.

E. L. C. White and W. S. Percival. Application date 3rd April, 1935.

TRANSMISSION CIRCUITS AND APPARATUS

460 222.—Method of modulating a carrier wave with picture signals and synchronising impulses.

A. J. Brown and Baird Television. Application date 23rd July, 1935.

456 270.—Multiplex signalling system in which both the carrier-wave and one of the side-bands are suppressed.

J. M. D. Dekker (assignee of the Kingdom of the Netherlands as represented by the Minister of the Interior). Convention date (Holland), 30th April, 1935.

RECEPTION CIRCUITS AND APPARATUS

455 619.—High-frequency couplings with adjustable band-width symmetrically disposed with relation to the carrier frequency.

Hazeltine Corporation (assignees of D. E. Harnett) Convention date (U.S.A.) 31st May, 1934.

455 665.—Circuit designed to give "delayed" A.V.C., the control bias being derived from a screen-grid valve.

Standard Telephones and Cables (assignees of Standard Villamossagi Reszvenytarsag). Convention date (Hungary) 3rd September, 1934.

456 100.—Automatic volume control system in which an amplifier valve is biased according to a non-linear function of the signal voltage.

Hazeltine Corporation (assignees of C. K. Huxtable). Convention date (U.S.A.) 22nd March, 1935.

456 450.—Intervalve coupling designed to transmit a wide band of signal frequencies, such as are used in television, with substantially uniform attenuation.

E. L. C. White. Application date 3rd April, 1935.

456 928.—Wireless receiver with automatic tuning control and means for indicating the extent of the automatic adjustment.

Murphy Radio; G. B. Baker; and F. Hawkins. Application date 23rd August, 1935.

457 018.—Cascade-coupled amplifier in which the "gain" is substantially independent of frequency over a wide band of wavelengths.

A. C. Price (communicated by Siemens and Halske Akt.). Application date 19th June, 1936.

457 091.—Tuning-dial with multiple indicators for a wireless set.

W. A. Burns. Application date 20th May, 1935.

457 207.—Knob-controlled motor for tuning a wireless receiver, combined with auxiliary means for fine-tuning.

W. J. Brown and E. C. Wadlow. Application date 26th June, 1935.

457 217.—Remote-control tuning for wireless sets combined with scale indicator.

E. K. Cole and R. I. Cowley. Application date 14th August 1935.

457 398. Band switching arrangement for a short-wave wireless receiver.

E. K. Cole and H. C. Rowe. Application date 29th June, 1935.

457 485.—Tuning device for a superhet, designed to compensate automatically for any frequency "drift" which may occur, either in the incoming carrier-wave, or in the local oscillator.

Kolster-Brandes and C. W. Earp. Application date 30th May, 1935.

457 614.—System of automatic volume control in which a time-lag is introduced by a resistance of the asymmetric type.

Kolster-Brandes and L. W. Reinken. Application date 1st June 1935.

458 031.—Method of automatic volume control in which signal strength is regulated by reaction.

N. V. Philips Lamp Co. and L. M. Meyer. Application date 6th June, 1935.

458 133.—Method of back-coupling a pentode valve used as a detector or amplifier, the anode being effectively earthed for radio-frequency currents.

Baird Television and L. R. Merdler. Application date 18th June, 1935.

458 449.—Preventing distortion due to valve-curvature, by utilising a feed-back component derived from a point of constant potential in the output circuit of an amplifier.

Marconi's W.T. Co. and G. M. Wright. Application date 21st June, 1935.

459 209.—Receiver in which automatic selectivity control is secured by varying the effective coupling across an intervalve transformer.

E. K. Cole; G. Bradfield; and F. A. Inskip. Application date 1st July, 1935.

459 300.—Controlling the quenching oscillations in order to increase the efficiency of an amplifier of the super-regenerative type.

L. M. Merdler; M. Scott; and Baird Television. Application date 5th July, 1935.

459 581.—Intervalve coupling designed to give uniform attenuation over a wide band of signal frequencies.

J. Hardwick and E. L. C. White. Application date 9th July, 1935.

VALVES AND THERMIONICS

456 301.—Ultra high-frequency amplifier, in which all the electrodes of the valve are longer than the working wavelength.

Standard Telephones and Cables (assignees of R. K. Potter). Convention date (U.S.A.) 22nd January 1935.

456 629.—Method of coating the inside walls of a cathode-ray tube with semi-conducting compounds laid on a conductive coating.

N. V. Philips Co. Convention date (Germany) 29th May, 1935.

DIRECTIONAL WIRELESS.

457 176.—Navigational path defined by two overlapping wireless beams, each radiated at different frequency.

Telefunken Co. Convention date (Germany) 3rd August, 1935.

460 076.—Method of combining the signal pick-up in spaced directional aerials of the Adcock type.

E. K. Cole. Convention date (Sweden) 16th September, 1935.

TELEVISION AND PHOTOTELEGRAPHY

455 858.—Transmitting and controlling the passage of impulses of different kinds, particularly those used for synchronising in television.

A. D. Blumlein. Application date 24th April, 1935.

456 288.—Tune-base circuit for a cathode-ray television receiver, in which the electron stream is extinguished during the fly-back periods

E. Reader and L. Glass. Application date 25th June, 1935.

456 515.—High-frequency transformer designed for the push-pull amplification of television signals.

The Loewe Radio Co. Application date 8th February, 1935.

456 564.—Method of synchronising in interlaced scanning for television.

Marconi's W.T. Co. Convention date (U.S.A.) 6th March, 1935.

456 650.—Television system of the kind in which synchronising impulses are transmitted in the intervals between successive trains of picture signals.

E. L. C. White. Application date, 18th March, 1935.

457 274.—Protective transparent window for viewing the fluorescent screen of a cathode-ray television receiver.

Marconi's W. T. Co. and A. A. Linsell. Application date 24th May, 1935.

457 510.—Arrangement of the viewing screen in a television-receiver cabinet.

General Electric Co., N. R. Campbell and L. C. Jesty. Application dates 5th July and 31st December, 1935.

457 532.—Separating synchronising impulses of different amplitudes in a television receiver.

Application date 7th June, 1935.

457812.—Separating the synchronising and picture signals in a television receiver.

E. D. McConnell and Baird Television. Application date 6th June, 1935.

457 879.—Preventing the picture signals in a television system from producing "false" synchronisation.

Radio-Akt. D. S. Loewe. Convention date (Germany) 6th April, 1934.

457 929.—Means for short-circuiting the magnetic deflecting coils used in a cathode-ray tube during the "fly-back" period.

Marconi's W.T. Co. and G. B. Banks. Application date 8th June, 1935.

458 618.—Anchoring the optical elements in a mirror-drum as used for television scanning.

Ferranti and M. K. Taylor. Application date 26th September, 1935.

458 750.—Means for taking "long shots" or "close-ups" on a cathode-ray television camera of the mosaic-cell type.

Marconi's W.T. Co. (assignees of H. Iams). Convention date (U.S.A.) 26th May, 1934.

458 791.—Televising pictures in natural colour, and with a sterioscopic effect.

Baird Television; T. M. C. Lance; and E. H. Foden-Pattinson. Application date 27th June, 1935.

459 723.—Amplifying television signals in two stages one of which handles the low-frequency components, and the other the high.

T. M. C. Lance; P. W. Willans; and Baird Television. Application date 13th July, 1935.

SUBSIDIARY APPARATUS AND MATERIALS

456 755.—Method of preparing the fluorescent screen of a cathode-ray tube.

Marconi's W. T. Co. (assignees of H. W. Leverenz.) Convention date (U.S.A.) 23rd May, 1934.

457 342.—Method of cutting a piezo-electric crystal so that, when oscillating in the "thickness" mode, it has a zero temperature coefficient.

Marconi's W. T. Co. (communicated by S. A. Bokovoy and C. F. Baldwin). Application date 31st May, 1935.

458 135.—Mains-supply unit for supplying all the necessary operating voltages to a cathode-ray television receiver.

E. Reader and L. Glass. Application date 21st June, 1935.

460 012.—Light-sensitive cell comprising an alloy of caesium or rubidium, with antimony or bismuth.

Zeiss Ikon Akt. Convention date (Germany) 8th August 1935.

MISCELLANEOUS

455 765.—"Prospecting" for hidden conductors or obstacles by short-wave radio beams.

Cie Generale de T. S. F. Convention date (France) 20th April, 1935.

456 840.—Multivibrator circuit arranged to have two conditions of virtual stability, one of greater duration than the other.

E. L. C. White. Application date 12th March, 1935.

457 886.—Utilising a four-electrode "dynatron" valve to increase the output from a photo-electric cell.

Baird Television and J. C. Wilson. Application date 8th April, 1936.