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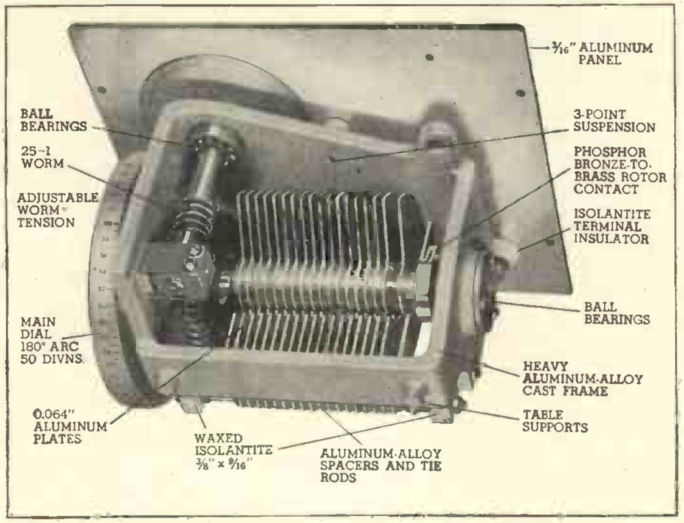

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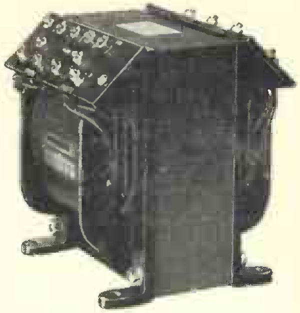

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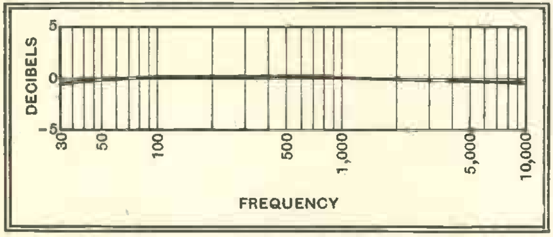

Response curve of B.S.R. heavy-duty output transformer. (Reproduced by permission of "WIRELESS WORLD")

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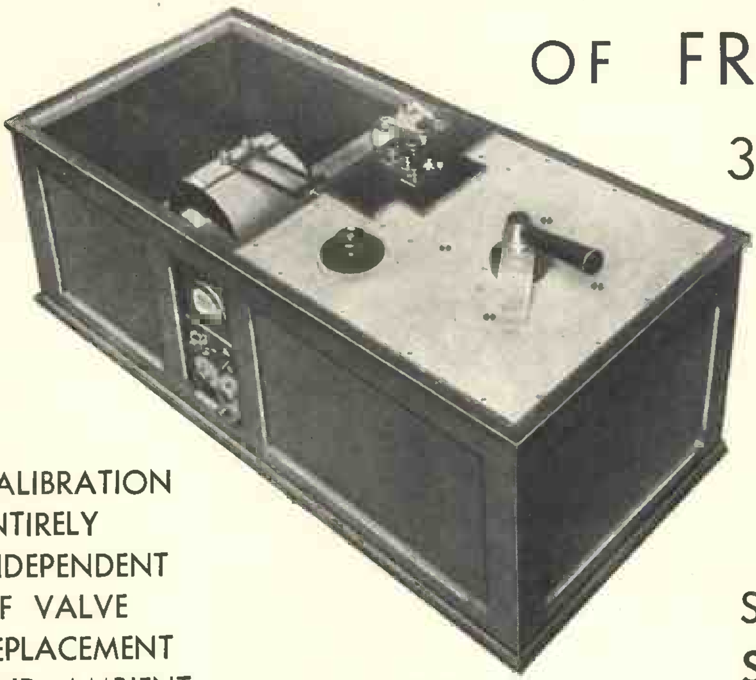

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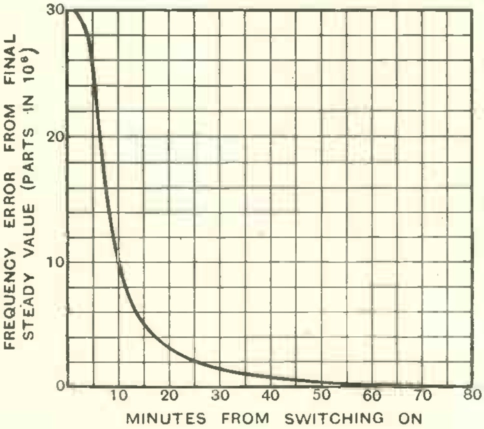

Curve showing the settling down of frequency of Sullivan-Griffiths Wavemeter.

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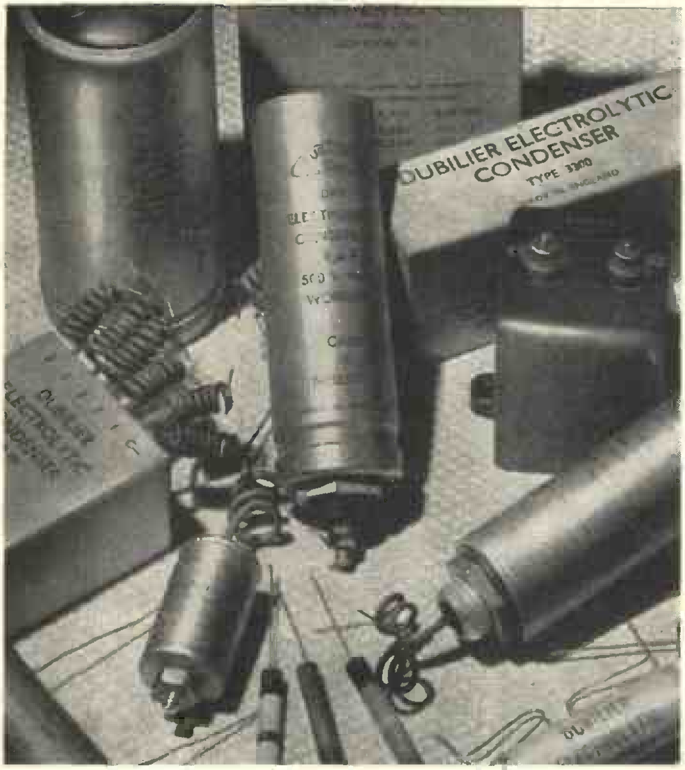
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THE
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VOL. XIII. APRIL, 1936. No. 151

The Magnetic Recording of Sound

THE magnetic recording of sound is by no means new, but it is only quite recently that it has been developed to the stage where it can compete with mechanical and photographic methods. Both the A.E.G. and the Lorenz Co. have recently put magnetic recorders on the market, but they differ very essentially in the nature of the record material. The former use a film coated with a deposit of iron, whereas the latter employ a steel band. The Lorenz Co.* have recently supplied their steel band recorders to the German Broadcast authorities for outdoor broadcasts, for which purpose it is claimed to be specially suitable on account of its immunity from the effects of vibration.

The steel band is 3 mm. wide and 0.08 mm. thick (about $\frac{1}{8}$ inch by 3 mils). This is wound off one drum on to another, and although it is possible to use a length suitable for about 50 minutes, the usual length runs for 30 minutes. The inner diameter of the drums is 20 cm. and the outer for a 30-minute run about 57 cm. The working speed is about 1.5 metres per second and the speed of the drums therefore varies from about 50 to 150 revolutions per minute. The maintenance of a constant band speed is ensured by an induction motor of ample power driving a pulley *f* over which the band passes under considerable pressure from an endless fabric band shown dotted in Fig. 2, the tension on which can be adjusted by means of the upper pulley *l*. It is very important to avoid any slack between the drums and the driving pulley; this necessitates very rapid stopping of the drums if the driving motor stops, and this is not a simple matter in view of the large moment of inertia of the rotating drums when loaded with the steel band. The leading drum must always tend to run faster than the band speed, whereas the trailing drum must be braked sufficiently to maintain some tension on the band. The two drums must also be able to reverse, because when a recording is complete it is necessary to wind the band back on to the other drum before it can be reproduced. This necessitates reversing the driving motor and exchanging the rôles of the two drums, the driven drum becoming the braked drum and vice versa. How this is done is shown in Fig. 3; the band *a* is running on to the leading drum *b* fixed to the shaft *k* which is coupled to the shaft *g* by the friction drive *f* the slip of which allows the drum to rotate at the band speed whatever the speed of *g*. The pulley *c* is driven by the belt *d* from the main induction motor, but this pulley is loose on the shaft which carries the coupling *e*. If this sliding coupling *e* is locked to the fixed part *h*, the pulley *c* runs idle and *f* acts as a friction brake on the drum, whereas if *e* is locked to the pulley *c*, *g* runs faster than

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* See "Die neue Stahlton-Bandmaschine." *Lorenz Berichte*, Jan., 1936, page 49.

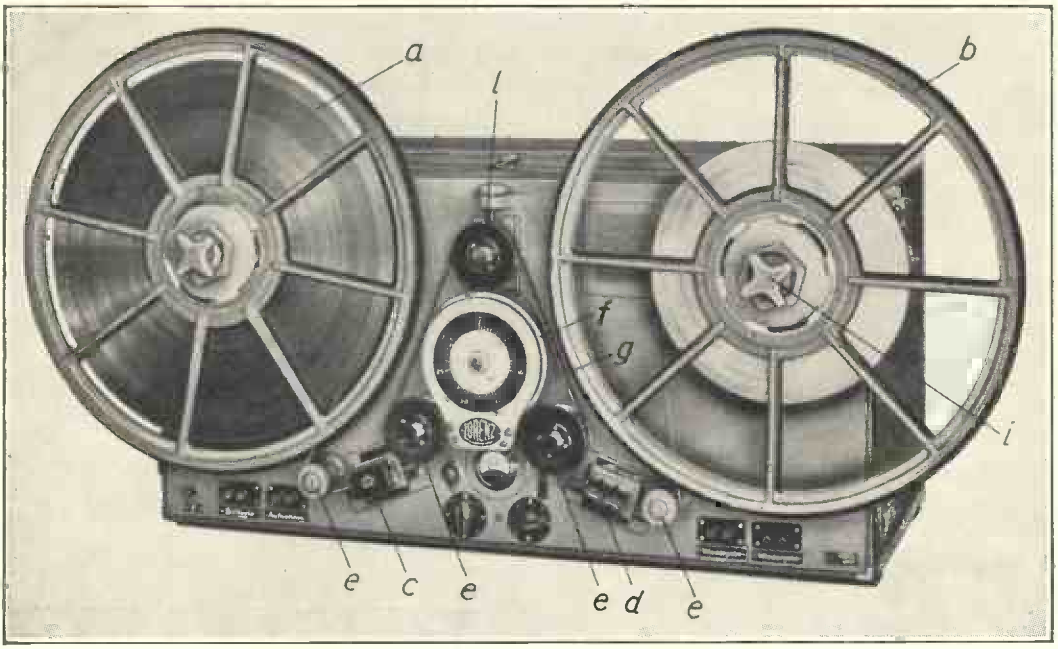


Fig. 1.

k ever runs, and thus maintains tension on the steel band. In case of a stoppage the rapidity with which the trailing drum can be brought to rest, and thus prevented from paying out steel band, depends on the moment of inertia—which depends on the length of band, *i.e.*, on the length of record required—and on the power which one is prepared to dissipate in braking. Both drums can be removed and new ones fitted in less than a minute.

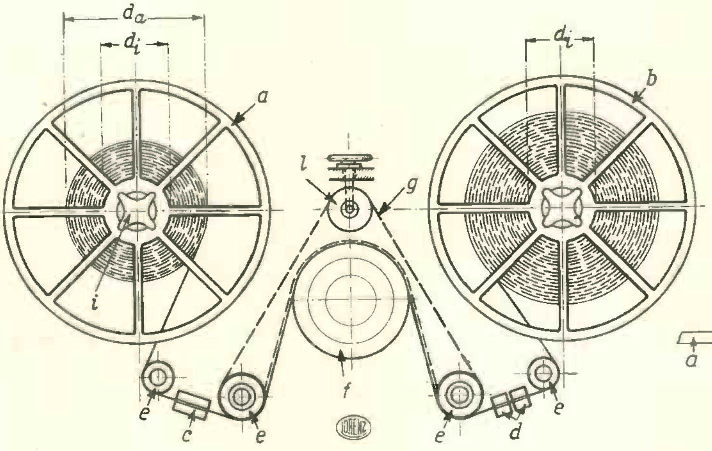


Fig. 2.

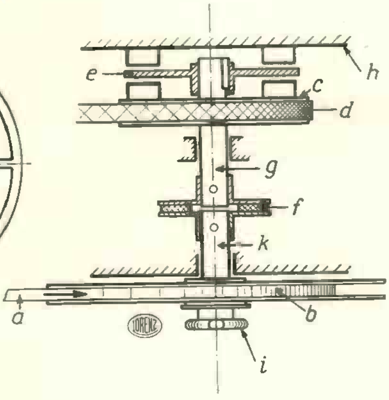


Fig. 3.

Between the left-hand drum and the driving pulley the steel band passes through the wipe-out and recording apparatus (Fig. 5a, and *c* in Figs. 1 and 2) and similarly between the pulley and the right-hand drum it passes through duplicate sets of reproducing apparatus (Fig. 5b, and *d* in Figs. 1 and 2). The principle of these can be seen from Figs. 4 and 6. Two chisel-ended pole pieces are pressed by springs against opposite sides of the band and the operating coils are wound round the pole cores. These pole pieces are not exactly opposite each other but are displaced by an amount *a* (Fig. 6) which can be adjusted by the micrometer screws and verniers seen in Fig. 5. The operating flux is that along the band between the pole pieces. The wipe-out magnets are energised by direct current and remove all trace of previous magnetisation by saturating the band up to S (Fig. 7). On passing on, the value of H not only falls to zero but is actually reversed, due to the stray field (Fig. 6), thus bringing the magnetisation back along the hysteresis loop to some point R_1. When the band passes beyond the influence of this stray field, the magnetisation will follow some such line as R_1R_1'. The band now passes between the recording pole pieces which are energised by two currents, one a steady direct current i_g which would bring the magnetisation to some such point as V in the middle of a long linear portion of the curve, the other the current i_w to be recorded.

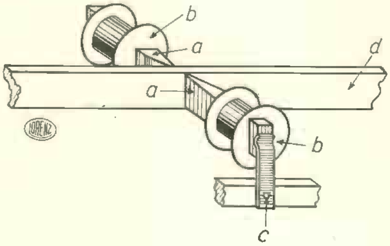


Fig. 4.

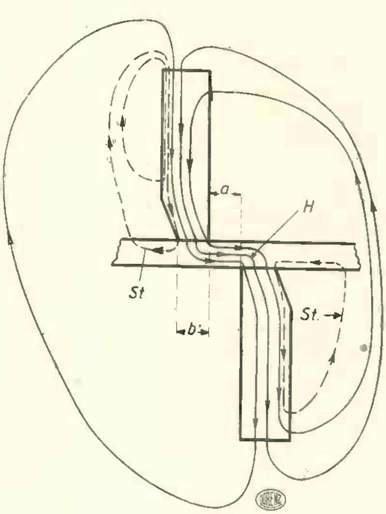
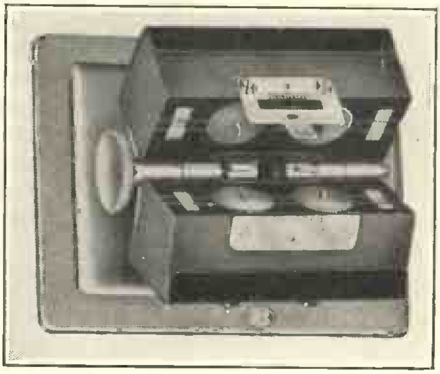


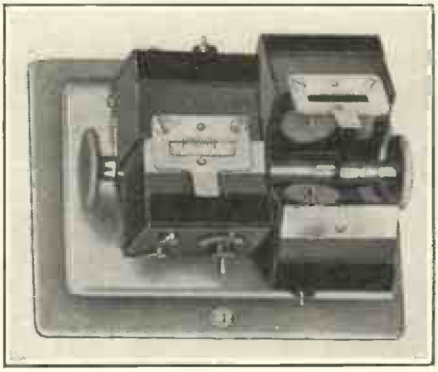
Fig. 6.

In Fig. 7 this current is represented as a sine curve causing the point on the curve to move sinusoidally between V_a and V_b. As the band passes out of the field it will be left with a magnetisation varying sinusoidally between V_a' and V_b'. The disturbing effects of the stray fields make it impossible to utilise more than a small portion of the left-hand side of the hysteresis loop; both the direct current and the alternating current must be kept small.

There are duplicate sets of reproducing apparatus side by side as shown in Fig. 5b. The principle of these is illustrated in Fig. 8 where the upper diagram shows the assumed magnetic state of the band and the lower

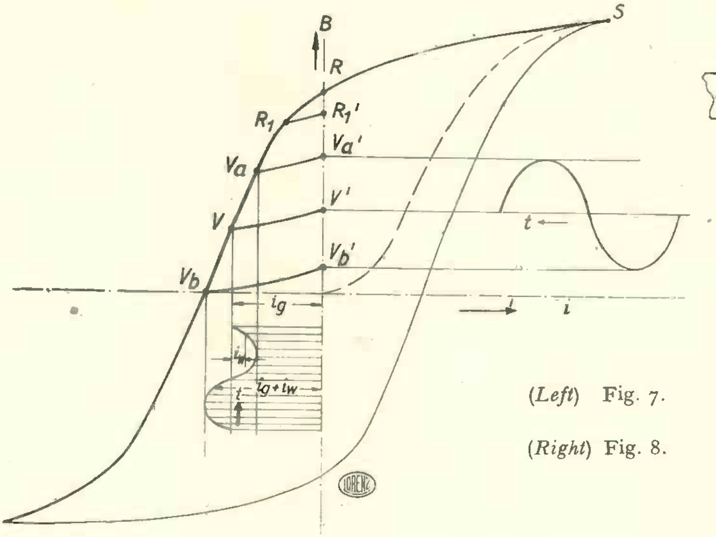


(*Left*) Fig. 5a.—*Wipe-out and recording.*

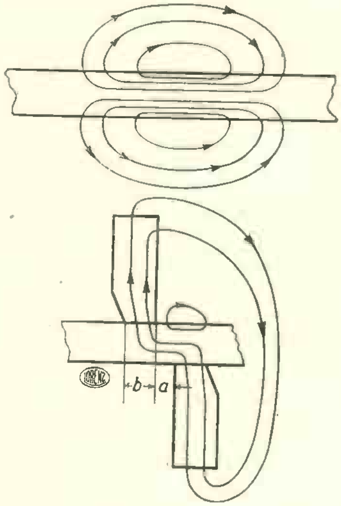


(*Right*) Fig. 5b. —*Reproducing apparatus.*

one the path of the resulting flux through the soft iron cores upon which are the coils in which an e.m.f. is induced by every variation of the flux, *i.e.*, by every variation of the magnetic condition of the passing band. At first sight one might expect the induced e.m.f. to increase with the frequency since the rate of change of the flux will be greater ; this is true up to a certain point, but for very high frequencies the length of band corresponding to a wavelength will become comparable with the distances *a* and *b* in Fig. 8 and the impressed magnetisation and the induced e.m.f. fall off. Fig. 9 shows the variation of voltage in the reproducing coils for a signal current of constant amplitude and variable frequency. Curves 1 and 2 refer to different adjustments of the distance *a* between the pole pieces of the reproducing apparatus. By suitable design of the amplifier it is possible to correct for this variation of output and so obtain a constant output from 70 to 5,500 cycles per second.



(*Left*) Fig. 7.



(*Right*) Fig. 8.

As in every method of sound recording, there is a background of noise ; in this case it is due to magnetic inequalities in the band and also to the mechanical vibrations set up in the magnet cores by the friction of the passing band against which they are being pressed. Special precautions have been taken in the design and construction of the reproducing apparatus to reduce this noise to a minimum. A Lorenz steel-band recorder mounted in a car is in regular use by the German Broadcasting Company.

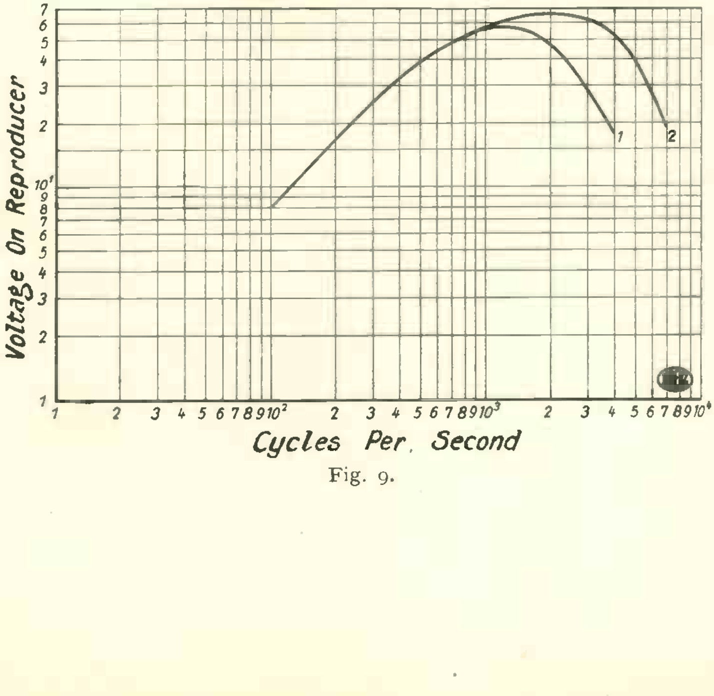


Fig. 9.

G. W. O. H.

Variable Selectivity and the I.F. Amplifier

Part II.*—Coupling the I.F. Amplifier to the Detector

By W. T. Cocking

THE conditions which govern the design of the coupling between the last I.F. valve and the detector differ in two ways from those which govern the choice of a coupling between two amplifying valves. In the first place the detector has a comparatively low input resistance, and, secondly, the voltages involved are much greater. These two factors greatly modify the design of the coupling, for the effective H.F. resistance of the circuits employed is increased by the input resistance of the detector, while the high voltages involved sometimes necessitate the design being carried out primarily for the avoidance of amplitude distortion; amplification and selectivity then become secondary considerations.

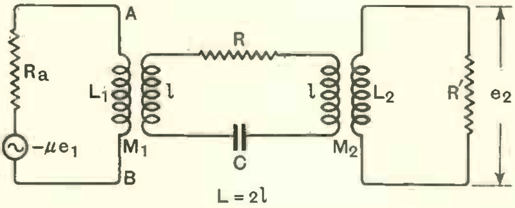


Fig. 13.—*A single tuned circuit coupling two valves can be generalised in the manner shown here where R′ is the input resistance of the second valve.*

There are many different arrangements which can be employed, and as a choice will be dictated by the requirements of the receiver in other respects, it is necessary to consider them all. The first system embodies a single tuned circuit, and the generalised circuit is shown in Fig. 13 in which R_a is the internal A.C. resistance of the last I.F. valve and R' the detector input resistance. By the straightforward application of Kirchhoff's laws the following equation can be developed

$$\frac{e_2}{e_1} = \frac{\mu R' \omega^2 M_1 M_2}{Z_1(Z_2 Z_3 + \omega^2 M_2^2) + Z_3 \omega^2 M_1^2} \quad \ldots \quad (41)$$

where $Z_1 = R_a + j\omega L_1 \approx R_a$ when $R_a >> \omega L_1$

$Z_2 = R + j\omega L - j/\omega C$

$Z_3 = R' + j\omega L_2 \approx R'$ when $R' >> \omega L_2$

Equation (41) reduces to

$$\frac{e_2}{e_1} = \frac{g a_1 a_2 \sqrt{R_a R'}}{\sqrt{[(1 + a_1^2 + a_2^2)^2 + y^2 Q^2]}} \quad \ldots \quad (42)$$

Where $a_1^2 = \omega^2 M_1^2 / R R_a$

$a_2^2 = \omega^2 M_2^2 / R R'$

$Q = \omega L / R$

$y = (\omega^2 LC - 1) \approx 2n/f$ when $n << f$

$g = \mu / R_a$

n = frequency different from resonance

f = resonance frequency.

It can readily be seen that the impedance into which the I.F. valve works, that is the impedance between AB of Fig. 13, is at resonance the transferred resistance of the following circuits, for the reactance of L_1 is usually small enough to be neglected. The resistance of the tuned circuit is increased by the detector loading to $R(1 + a_2^2)$ so that the load R_L on the valve is this value of resistance transferred to the primary, or

$$R_L = \frac{\omega^2 M_1^2}{R(1 + a_2^2)} \quad \ldots \quad \ldots \quad (43)$$

When $y = 0$, equation (42) reduces to

$$\frac{e_2}{e_1} = \frac{g a_1 a_2 \sqrt{R_a R'}}{1 + a_1^2 + a_2^2} \quad \ldots \quad \ldots \quad (44)$$

and it can be seen that this is a maximum when either

$$a_1^2 = 1 + a_2^2$$

or $$a_2^2 = 1 + a_1^2$$

The optima for a_1 and a_2 cannot be satisfied simultaneously, but if either be held constant an optimum can be found for the other. In practice, therefore, it is necessary to fix the value of one arbitrarily, and it is most convenient to do this by making either

$L_1 = L = M_1$ or $L_2 = L = M_2$,

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

for then one circuit disappears and the system can be redrawn as in Figs. 14 and 15 respectively. In the case of Fig. 15

$$a_1^2 = \omega^2L^2/RR_a = R_D/R_a$$

and for Fig. 14

$$a_2^2 = \omega^2L^2/RR' = R_D/R'$$

where $R_D = \omega^2L^2/R = \omega LQ =$ the dynamic resistance of the tuned circuit alone.

The choice between the two arrangements depends on which is the greater, the A.C. resistance of the I.F. valve or the input resistance of the detector. If $R_a > R'$ the circuit of Fig. 14 should be adopted, but if $R_a < R'$ then Fig. 15 is better, for this course leads to the minimum H.F. resistance for the tuned circuit assuming that the other coupling is optimum.

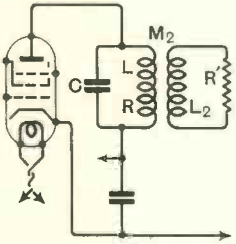

Fig. 14.—*When $R_a > R'$, a single circuit is best connected in this manner.*

When $R_a < R'$, as when a triode is used for the I.F. valve,

$$a_2^2 = R_D/R'$$

$$(a_1^2)_{\text{opt.}} = 1 + a_2^2 = 1 + R_D/R'$$

and equation (42) reduces to

$$\frac{e_2}{e_1} = \frac{g\sqrt{R_aR_D(1 + R_D/R')}}{\sqrt{[4(1 + R_D/R')^2 + y^2Q^2]}} \quad \ldots \quad (45)$$

$$= \frac{g\sqrt{R_aR_D}}{2\sqrt{1 + R_D/R'}} \text{ when } y = 0 \quad \ldots \quad (46)$$

The physical significance of this is more readily seen if the terms are arranged in the form

$$\frac{e_2}{e_1} = \frac{\mu}{2} \times \sqrt{\frac{R_DR'}{R_D + R'}}\bigg/\sqrt{R_a}$$

It can be seen that the gain is equal to half the amplification factor of the valve multiplied by the turns ratio of an ideal transformer of turns ratio equal to the square root of the ratio of secondary to primary resistance, the primary resistance being the valve resistance and the secondary the dynamic resistance of the tuned circuit in parallel with the detector input resistance. The dynamic resistance of the tuned circuit represents a loss and the gain reaches its maximum value when $R_D = \infty$ for then the loss is absent.

It is clear that the higher the value of R_D the better from the point of view of amplification, and this is also true if amplitude distortion be important. Whatever the value of R_D, the load R_L on the valve remains the same, for

$$R_L = \frac{\omega^2M_1^2}{R(1 + a_2^2)} = \frac{a_1^2R_a}{1 + a_2^2} = R_a$$

since $a_1^2 = 1 + a_2^2$

If the valve will give a certain undistorted output when operating with this load a greater detector input is secured by the use of a high value of R_D than a low one, for the increase in amplification does not occur in the valve but through the reduction of losses in the coupling system.

The selectivity S is given by the ratio of equations (46) and (45)

$$S = \frac{\sqrt{[4(1 + R_D/R')^2 + y^2Q^2]}}{2(1 + R_D/R')} \quad \ldots \quad (47)$$

This equation, however, is of little help in design for it is usually required to determine Q or R_D, the desired values of S and L being known. R_D is a function of Q so that for design purposes it is better to derive the relationship of Q and S in a different manner.

Let the total resistance of the tuned circuit be

$$\begin{aligned} R_T &= R + \omega^2L^2/R' + \omega^2M_1^2/R_a \\ &= R(1 + a_1^2 + a_2^2) \\ &= 2R(1 + a_2^2) \text{ since } a_1^2 = 1 + a_2^2 \\ &= 2R + 2\omega^2L^2/R' \end{aligned}$$

whence $R = R_T/2 - \omega^2L^2/R'$

$$\text{and } Q = \frac{\omega L}{R_T/2 - \omega^2L^2/R'} \quad \ldots \quad \ldots \quad (48)$$

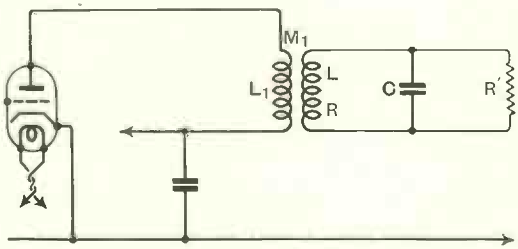

Fig. 15.—*When $R_a < R'$, the output circuit R' is connected to the tuned circuit directly.*

The ratio of response at resonance to response at any other frequency for a series resonant circuit is

$$S = \frac{\sqrt{[R_T^2 + (\omega L - 1/\omega C)^2]}}{R_T}$$
$$= \sqrt{1 + y^2 Q_T^2}$$

where $Q_T = \omega L/R_T$

$$\therefore \quad Q_T = \frac{\sqrt{S^2 - 1}}{y} = \frac{f\sqrt{S^2 - 1}}{2n}$$

and $R_T = \omega L/Q_T = \dfrac{2n\omega L}{f\sqrt{S^2 - 1}}$ .. (49)

combining (48) and (49).

$$Q = \frac{1}{\dfrac{n}{f\sqrt{S^2 - 1}} - \dfrac{\omega L}{R'}} \quad \ldots \quad \ldots \quad (50)$$

Practically, there is a limit to the selectivity obtainable without regeneration, for Q tends to infinity as $n/f\sqrt{S^2 - 1}$ approaches equality with $\omega L/R'$. When $n/f\sqrt{S^2 - 1} < \omega L/R'$, Q is negative and this means that R must be negative. This can be obtained by means of regeneration and it should be noted that Q or R negative does not necessarily mean Q_T or R_T negative, so that the system can remain stable. This condition corresponds to the one commonly known as removing the valve damping with reaction.

In design it is necessary to know f, n, S, L, R', and R_a. Equation (50) gives Q, and

$$R = \omega L/Q \quad \ldots \quad \ldots \quad \ldots \quad (51)$$

$$C = 1/\omega^2 L \quad \ldots \quad \ldots \quad \ldots \quad (52)$$

$$M_1 = \sqrt{\left[\frac{RR_a}{\omega^2}(1 + R_D/R')\right]} \quad \ldots \quad (53)$$

$$R_D = \omega L Q \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (54)$$

If too high a value be chosen for S, Q will be negative, or positive but impracticably high, and the conditions can then only be satisfied by the use of reaction.

Now in modern practice a triode valve is likely to be used only when the output of a tetrode or pentode is inadequate. The use of a suitable triode enables a much greater undistorted output to be obtained, and this is indeed probably the only justification for its employment. If it is used for this end, however, it is important to see that it is used to the best advantage, and the conditions just discussed, although they lead to the greatest amplification, are not the best from the viewpoint of distortion.

The detector is a power operated device and the I.F. valve must give out power rather than voltage. Although maximum power output is obtained from a valve under the same conditions as those for maximum voltage amplification, namely, that $R_L = R_a$, it is well known that the maximum *undistorted* output is obtained when $R_L > R_a$ for triodes. The optimum relationship varies with different valves, but for small triodes it is usually close to $R_L = 2R_a$. If this relationship is adopted, the maximum undistorted power will be secured in the load and hence the maximum value of e_2, but e_1 will be greater than when $R_L = R_a$ and the amplification correspondingly lower. The selectivity will also be lower. Where it is necessary to use a triode, however, amplification and selectivity are usually of secondary importance to freedom from distortion, so that the condition that $R_a = 2R_a$ is usually the best.

Suitable design equations for this case may be derived by writing

$$R_L = 2R_a = \omega^2 M_1^2/R(1 + a_2^2)$$

whence $a_1^2 = 2(1 + a_2^2) = 2(1 + R_D/R')$ for $a_2^2 = R_D/R'$ as before.

Inserting these values in equation (42) gives

$$\frac{e_2}{e_1} = \frac{g\sqrt{2R_a R_D(1 + R_D/R')}}{\sqrt{[9(1 + R_D/R')^2 + y^2Q^2]}} \quad \ldots \quad (55)$$

$$= \frac{g\sqrt{2R_a R_D}}{3\sqrt{[1 + R_D/R']}} \text{ when } y = 0 \quad \ldots \quad (56)$$

The design equations may be derived in the same way as before and are :

$$Q = \frac{1}{\dfrac{2n}{3f\sqrt{S^2 - 1}} - \dfrac{\omega L}{R'}} \quad \ldots \quad \ldots \quad (57)$$

$$R = \omega L/Q \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (58)$$

$$M_1 = \sqrt{\left[\frac{2RR_a}{\omega^2}(1 + R_D/R')\right]} \quad \ldots \quad (59)$$

$$S = \frac{\sqrt{[9(1 + R_D/R')^2 + y^2Q^2]}}{3(1 + R_D/R')} \quad \ldots \quad (60)$$

The choice of the valve which precedes the coupling is of considerable importance. The equations show that whatever the load imposed upon it, the greatest stage gain is secured from the valve having the highest value of $g\sqrt{R_a} = \mu/\sqrt{R_a}$. The accompanying Table gives values of $g\sqrt{R_a}$ for typical modern triodes, the values being for normal working voltages and not the makers rating at zero grid bias. It will be seen that the MH41 stands out above the others from the point of view of amplification. With a triode, however, output is more important than amplification and the greatest output will be secured from the valve having the greatest D.C. anode dissipation. A low resistance valve such as the ML4 would be chosen, therefore, when maximum output is required. In general, however, the output of this valve is unnecessarily large for ordinary purposes, and when this is so either a higher resistance valve can be used or the low resistance one retained and operated at a lower anode voltage to economise in anode current. The ML4, for instance, consumes about 20 mA. anode current at 200 volts, and this is higher than can often be allowed. The use of a lower anode voltage only leads to a saving through the reduction in anode current which it entails and is not in itself usually of any benefit. It is better, therefore, to employ a higher resistance valve operated at the full 200 volts, because the anode dissipation is higher for the same anode current consumption and the output is consequently larger. At the same time, higher amplification is likely to be secured. This effect is quite marked in practice.

These remarks about output always hold true, but those regarding amplification are true only if feed-back effects through the grid-anode interelectrode valve capacity are negligible, and they are negligible only if the valve capacity be carefully neutralised or the input circuit between grid and cathode be of very low impedance. The input impedance due to feed-back effects depends on the ratio of the voltage across AB (Fig. 13) to e_1 and not upon the total stage gain. For maximum input impedance, therefore, the gain in the valve should be as small as possible and the gain in the coupling as high as possible. If it be possible to obtain the same value of e_2/e_1 with two different valves, one of high resistance and the other of low, the latter should be selected, for if the grid-anode capacities be equal, its input impedance will be the higher. It is also the better valve from the point of view of power output, although it will consume a greater anode current.

Colebrook gives the following equations for the input impedance of a valve when the anode load is tuned to resonance.

$$R_g' = \frac{G_a + G_L}{\omega^2 C_{ga}^2} \quad \ldots \quad \ldots \quad \ldots \quad (61)$$

$$C_g' = C_{ga}\left(1 + \frac{g}{G_a + G_L}\right) \quad \ldots \quad (62)$$

where R_g' = input resistance } due to feed-back
C_g' = input capacity } due to feed-back
C_{ga} = grid-anode capacity
$G_a = 1/R_a$
$G_L = 1/R_L$

A tuned coupling between the last and the penultimate I.F. stages is hardly feasible for R_g' will usually be low and negative at certain frequencies and instability will occur. The best scheme, if neutralisation is not adopted, is that put forward by Colebrook and shown here in Fig. 16. A full description of its characteristics appeared in his original paper[1], and it is sufficient to say here that if a high gain is to be secured from V_1 the input capacity C_g' of V_2 must be as high as possible. When V_2 is working under optimum amplifying conditions $G_a =$

TABLE.

Type.	μ	Ra Ω	g mA/v.	$g\sqrt{R_a}$	C_{ga} $\mu\mu$F.	μC_{ga} $\times 10^{-12}$
ML 4	12	3,500	3.43	0.2025	7	84
MHL 4	20	10,000	2.0	0.2	7	140
MH 4	40	15,000	2.66	0.327	7	280
MH 41	80	18,000	4.44	0.595	7	560
MHD 4	40	20,000	2.0	0.283	3	120

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[1] A Study of the Possibilities of Radio-Frequency Voltage Amplification with Screen-grid and with Triode Valves, by F. M. Colebrook, B.Sc., *Journ. I.E.E.*, February, 1934.

G_L and equation (62) becomes

$$C_g' = C_{ga}(1 + \mu/2) \approx \mu C_{ga}/2 \quad .. \quad (63)$$

When V_2 is working under conditions of maximum undistorted power output $G_a = 2G_L$ and equation (62) becomes

$$C_g' = C_{ga}(1 + 2\mu/3) \approx 2\mu C_{ga}/3 \quad .. \quad (64)$$

In either case it is important that μC_{ga} be as small as possible and this is the criterion of a good valve from the point of view of input capacity.

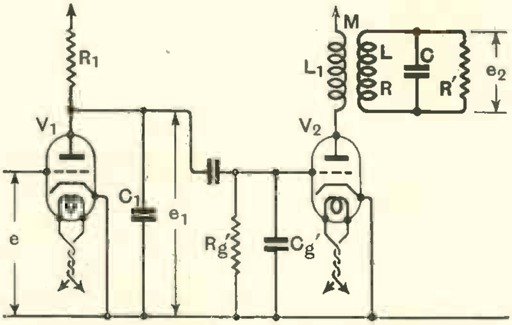

Fig. 16.—*The Colebrook double-triode amplifier. C_1 represents the stray and valve capacities and R_g' and C_g' are the input resistance and capacity of V_2 due to feed-back effects.*

Previous conditions give a maximum of $g\sqrt{R_a} = \mu/\sqrt{R_a}$ as desirable. The best valve, therefore, is the one which gives maximum values for both $\mu/\sqrt{R_a}$ and $1/\mu C_{ga}$.

Turning now to the use of tetrode and pentode type valves, R_a is usually very high and with diode and grid detectors R_a is nearly always greater than R'. The connections of Fig. 14 are used, therefore, in accordance with the rule laid down earlier, and the values to be inserted in equation (42) are

$$a_1^2 = R_D/R_a$$

$$(a_2^2)_{\text{opt.}} = (1 + a_1^2) = (1 + R_D/R_a)$$

Equation (42) then becomes

$$\frac{e_2}{e_1} = \frac{g\sqrt{R_D R'(1 + R_D/R_a)}}{\sqrt{[4(1 + R_D/R_a)^2 + y^2Q^2]}} \quad .. \quad (65)$$

which reduces to

$$\frac{e_2}{e_1} = \frac{g\sqrt{R_D R'}}{2\sqrt{1 + R_D/R_a}} \text{ when } y = 0 \quad .. \quad (66)$$

By a similar process to that adopted earlier the relevant design equations can be derived and are as follows:—

$$S = \frac{\sqrt{[4(1 + R_D/R_a)^2 + y^2Q^2]}}{2(1 + R_D/R_a)} \quad .. \quad (67)$$

$$Q = \frac{1}{\dfrac{n}{f\sqrt{S^2 - 1}} - \dfrac{\omega L}{R_a}} \quad .. \quad .. \quad (68)$$

$$R = \omega L/Q \quad .. \quad .. \quad .. \quad (69)$$

$$C = 1/\omega^2 L \quad .. \quad .. \quad .. \quad (70)$$

$$M_2 = \sqrt{\left[\frac{RR'}{\omega^2}(1 + R_D/R_a)\right]} \quad .. \quad (71)$$

$$R_D = \omega LQ \quad .. \quad .. \quad .. \quad .. \quad (72)$$

At resonance the load on the valve is given by

$$R_L = \frac{\omega^2 L^2}{R + \omega^2 M_2^2/R'} = \frac{R_D}{2 + R_D/R_a} \quad (73)$$

In very many cases $R_D << R_a$ and then $R_D/R_a \approx 0$ and the formulae can be simplified accordingly.

As $R_L < R_a$ the value of R_L has very little effect upon the dynamic characteristics of the valve and the dynamic curves are little different from the static. There is consequently no value of R_L which can normally be reached which is particularly desirable from the point of view of obtaining maximum undistorted output. Distortion in the valve is set rather by the static characteristics than by those characteristics in conjunction with the load resistance. This being so, it follows that there is a maximum input to the valve which is set by the appearance of distortion and that this input is almost independent of R_L. For a given value of R', both R_L and e_2/e_1 increase with an increase in the value of R_D; maximum output is secured, therefore, for those conditions which give maximum stage gain.

Even with screened tetrodes and pentodes the grid-anode valve capacity is not zero, so that the input resistance is still of importance. M. O'Connor Horgan[2] gives the following equation for the limiting condition for stability for a valve with tuned grid and anode circuits.

$$2 = g\omega C_{ga} R_L R_g$$

where R_g is the dynamic resistance of the tuned grid circuit. This condition is obviously the one where the input resistance

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[2] "The Grid-Anode Capacity of Valves," by M. O'Connor Horgan, M.Sc., *The Wireless Engineer*, September, 1934.

of the valve is negative and has its minimum value which is just equal to R_g. This equation, therefore, can be used to give the minimum value of R_g', the input resistance of the valve, by writing it in the form

$$R_g = -R_g' = 2/g\omega C_{ga}R_L$$

The characteristics of any system are most easily realised by means of typical examples and a common case will accordingly be considered. Suppose the valve has $g = 2.7$ mA/V., $R_a = 1 M\Omega$, and $C_{ga} = 0.0026$ $\mu\mu$F. A common value for R' is $1.25 \times 10^5 \Omega$, for a diode detector can hardly have a load resistance higher than 0.25MΩ in a high quality receiver and the input resistance of a diode rectifier operating with a large input tends to one-half the D.C. load resistance. For a frequency of 465 kc/s, L cannot normally be greater than 2,000 μH.

If $n = 10^4$c/s and only 1 db. loss can be tolerated at this frequency, $S = 1.12$ and equations (68) to (72) give $Q = 26.9$, $R = 217\Omega$, $C = 58.8$ $\mu\mu$F., $R_D = 1.57 \times 10^5$ Ω, $M_2 = 1,920$ μH, and $R_g' = 1.38$ MΩ.

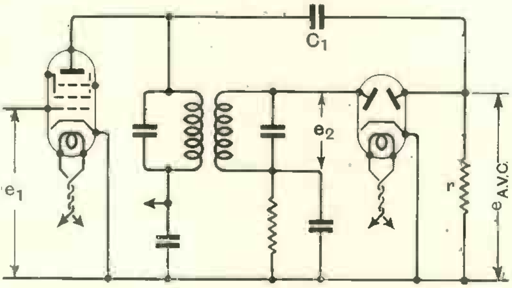

Fig. 17.—*A commonly used circuit for the last I.F. stage and the detector.*

Now L_2 cannot be larger than L if the circuit equations are to apply with any reasonable degree of accuracy, for with $L_2 > L$ the self-capacity of L_2 will become important. Even if $L_2 = L$, M_2 cannot be as great as 1,920 μH. when $L = 2,000$ μH., for this would demand $k = M_2/\sqrt{LL_2} = 0.96$,—a degree of coupling which it seems impossible to obtain. In this case M_2 is so near L that the difficulty can be got over by connecting the detector across the tuned circuit so that $M_2 = L$. Assuming optimum values, equation (66) gives $e_2/e_1 = 130$.

It is possible, however, to obtain a value of $Q = 100$ for reasonably inexpensive coils. If $Q = 93.5$ (the value used for the three-stage filter of Part I and employed here since the same coils would presumably be used throughout a receiver) and $L = 2,000$ μH., $R_D = 0.545$ $M\Omega$, $R = 62.5$ Ω, $C = 58.8$ $\mu\mu$F., $M_2 = 1,190$ μH., $R_g' = 0.47$ $M\Omega$ and $e_2/e_1 = 440$. For $n = 10^4$c/s, $S = 1.635$ (4.25 db.).

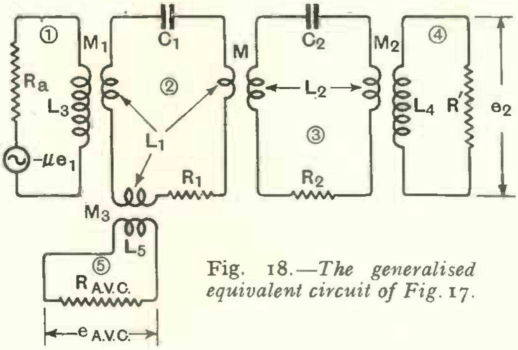

Fig. 18.—*The generalised equivalent circuit of Fig. 17.*

It may be remarked that although the effect of the input resistance of an A.V.C. rectifier has not been treated, it may readily be allowed for by lumping it with the detector input resistance; that is, R' can be taken as being not the detector resistance alone but this resistance in parallel with that of the A.V.C. rectifier.

Now a single tuned circuit is quite rarely employed in the detector coupling of modern superheterodynes, and a pair of coupled circuits is almost universally used, the A.V.C. system being fed from the primary as shown in Fig. 17. This circuit may be generalised as in Fig. 18, and it should be noted that if the A.V.C. system be paralleled with the detector, as is sometimes the case, the following equations may still be used by writing $R_{AVC} = \infty$, and R' = detector and A.V.C. input resistances in parallel, and $e_{AVC} = e_2$.

By the application of Kirchhoff's laws, the following equations can be derived:

$$\frac{e_2}{e_1} = \frac{\mu R'\omega^3 M M_1 M_2}{Z_1\{Z_2(Z_3Z_4+\omega^2M_2^2)+Z_4\omega^2M^2\} + \omega^2M_1^2(Z_3Z_4+\omega^2M_2^2)} \quad (74)$$

$$\frac{e_{AVC}}{e_1} = \frac{\mu\omega^2M_1M_3(Z_3Z_4+\omega^2M_2^2)}{Z_1\{Z_2(Z_3Z_4+\omega^2M_2^2)+Z_4\omega^2M^2\} + \omega^2M_1^2(Z_3Z_4+\omega^2M_2^2)} \quad (75)$$

where

$$Z_1 = R_a + j\omega L_3 \approx R_a \text{ when } R_a >> \omega L_3$$

$$Z_2 = R_1 + \omega^2M_3^2/R_{AVC} + j\omega L_1 - j/\omega C = R_1(1 + a_3^2 + jyQ_1)$$

$Z_3 = R_2 + j\omega L_2 - j/\omega C_2 = R_2(1 + jyQ_2)$

$Z_4 = R' + j\omega L_4 \approx R'$ when $R' >> \omega L_4$

$L_1 =$ total inductance of first tuned circuit.

$L_2 =$ total inductance of second tuned circuit.

Then

$$\frac{e_2}{e_1} = \frac{gaa_1a_2\sqrt{R_aR'}}{\sqrt{[\{(1 + a_2^2)(1 + a_1^2 + a_3^2) + a^2 - y^2Q_1Q_2\}^2 + y^2Q_1^2\{1 + a_2^2 + Q_2/Q_1(1 + a_1^2 + a_3^2)\}^2]}} \quad (76)$$

$$= \frac{gaa_1a_2\sqrt{R_aR'}}{B} \quad \ldots \quad (77)$$

$$\frac{e_{AVC}}{e_1} = \frac{ga_1a_3\sqrt{[R_aR_{AVC}\{(1+a_2^2)^2+y^2Q_2^2\}]}}{B} \quad (78)$$

$$\frac{e_{AVC}}{e_2} = \frac{a_3\sqrt{(1 + a_2^2)^2 + y^2Q_2^2}}{aa_2\sqrt{R'/R_{AVC}}} \quad \ldots \quad (79)$$

When $y = 0$, equation (76) reduces to

$$\frac{e_2}{e_1} = \frac{gaa_1a_2\sqrt{R_aR'}}{a^2 + (1 + a_2^2)(1 + a_1^2 + a_3^2)} \quad (80)$$

The optimum values for the damping factors may be found by differentiating with respect to them and equating to zero and are

$$(a^2)_{\text{opt.}} = (1 + a_2^2)(1 + a_1^2 + a_3^2) \quad (81)$$

$$(a_1^2)_{\text{opt.}} = (1 + a_3^2) + \frac{a^2}{1 + a_2^2} \quad \ldots \quad (82)$$

$$(a_2^2)_{\text{opt.}} = 1 + \frac{a^2}{1 + a_1^2 + a_3^2} \quad \ldots \quad (83)$$

From equation (78), $(a_3^2)_{\text{opt.}}$ can be found and is

$$(a_3^2)_{\text{opt.}} = (1 + a_1^2) + \frac{a^2}{1 + a_2^2} \quad \ldots \quad (84)$$

Equation (82) cannot usually be satisfied in practice when $R_a > R_D$, for this would involve $L_3 > L_1$ and the self-capacity of L_3 would become important, so that the valve is usually connected across the whole of the first circuit together with the A.V.C. system. The detector also is usually connected across the whole of the second tuned circuit as in Fig. 17. a_1, a_2, and a_3 are then fixed and have the values

$$a_1^2 = \omega^2M_1^2/R_1R_a = \omega^2L_1^2/R_1R_a = R_{D1}/R_a \quad \ldots \quad (85)$$

$$a_2^2 = \omega^2M_2^2/R_2R' = \omega^2L_2^2/R_2R' = R_{D2}/R_a \quad \ldots \quad (86)$$

$$a_3^2 = \omega^2M_3^2/R_1R_{AVC} = \omega^2L_1^2/R_1R_{AVC} = R_{D1}/R_{AVC} \quad \ldots \quad (87)$$

Before proceeding further it is necessary to consider the relative magnitudes of the damping corresponding to the various factors. R_D is usually of the order of 0.1 to 0.5 $M\Omega$; R' is about 0.125 $M\Omega$ with a good quality diode detector, R_a is some 1 $M\Omega$ and R_{AVC} is a variable quantity. With the usual delayed A.V.C. system, the A.V.C. diode is inoperative for signals below the delay voltage, so that the input resistance of the diode itself is infinity. As the signal increases, the input resistance falls, tending eventually to a value of one-half the D.C. load resistance. As regards the damping on the coupling, however, the system as a whole is more complicated than this. Referring to Fig. 19, it is easy to see that when the signal is smaller than the delay voltage E the input resistance $R_{AVC} = r_1r_2/(r_1+r_2)$ for the reactances of C_1 and C_2 are, or should be, negligibly small. With a very large input, the diode resistance tends to $r_1/2$, so that

$$R_{AVC} = 1/[3/r_1 + 1/r_2] = r_1r_2/(r_1 + 3r_2)$$

It might be thought that R_{AVC} could be made as high as desired merely by using large enough values of r_1 and r_2. This was the case in the past but valve makers are now placing a limit to the maximum resistance which must be used in the grid circuit of H.F. pentode type valves. In the case of the VMP4G, it is only 2.0 $M\Omega$. If one valve of this type be used, therefore, $r_1 + r_2$ must not exceed 2.0 $M\Omega$ for they are in series with the grid-cathode circuit of all controlled valves. If more than one valve be controlled, $r_1 + r_2 = 2/m$ (megohms) where $m =$ number of valves. It is quite common for three valves to be controlled and then $m = 3$ and $r_1 + r_2 = 0.6$ $M\Omega$ only.

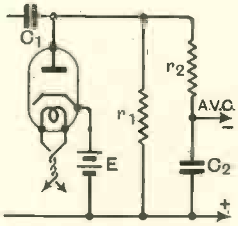

Fig. 19.—*The usual A.V.C. circuit in which the delay voltage is represented by a battery.*

With a small signal R_{AVC} is a maximum when $r_1 = r_2$, but with a very strong signal it is a maximum for $r_1 = 3r_2$. Thus with three valves, $r_1 + r_2 = 0.6$ $M\Omega$, $r_1 = r_2 = 0.3$ $M\Omega$ with a weak signal and $R_{AVC} = 0.16$ $M\Omega$. With a strong signal, however,

r_1 should equal $3r_2 = 0.49\ M\Omega$, and then $r_2 = 0.16\ M\Omega$ and $R_{AVC} = 0.08\ M\Omega$.

As distortion in the valve is most likely when it is giving its largest output, the coupling should be designed for this condition and the lower value of R_{AVC} used in the calculations. It has already been pointed out by the writer[3] that this variation in R_{AVC} can lead to distortion so that ideally the A.V.C. diode should be fed with the aid of an extra amplifying valve used only for this purpose. This is, however, too expensive a solution for most purposes even although it relieves the coupling of the damping of the A.V.C. system as well as removing one possibility of serious distortion.

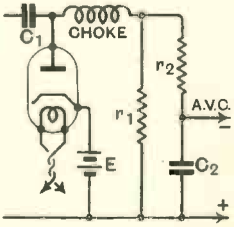

Fig. 20.—*A modified A.V.C. circuit having a higher input resistance.*

It should be pointed out that a considerable improvement in the A.V.C. arrangements is possible if an H.F. choke is interposed between the diode and r_1 and r_2 as in Fig. 20. If the choke is a good one, $R_{AVC} = \infty$ with a small signal and $R_{AVC} = r_1/2$ with a large signal. With $r_1 + r_2 = 0.6\ M\Omega$, r_1 can be $0.5\ M\Omega$ with $r_2 = 0.16\ M\Omega$ and then R_{AVC} has the minimum value of $0.25\ M\Omega$, about three times as great as before. An alternative arrangement giving the same result is shown in Fig. 21, but it necessitates an extra coupling coil to the tuned primary and this will introduce losses.

Returning to the coupling, typical values for damping are thus

$$R_a = 1\ M\Omega$$
$$R' = 0.125\ M\Omega$$
$$R_{AVC} = 0.25\ M\Omega.$$

The primary circuit damping is due to R_a and R_{AVC} in parallel and their combined value is some $0.2\ M\Omega$. Since it is of the same order as R' it would be easy to equalise them by modifying the value of r_1 and this would permit considerable simplification of the equations. Although there is mathematically a temptation to do this, there seems to be no electrical justification for it and the case is more general if unequal loading of the circuits be permitted.

Having fixed convenient arbitrary values for a_1, a_2 and a_3, the only remaining coupling factor is the term a. It can be shown that when a is small the resonance curve has a single peak, but when it is large two peaks occur. The frequencies corresponding to these peaks can be found by differentiating B (equation 77) with respect to y and equating to zero. This process gives

$$y = \frac{2n_P}{f}$$
$$= \pm\sqrt{\left[\frac{a^2Q_2/Q_1 - \frac{1}{2}\{(1 + a_2^2)^2 + (1 + a_1^2 + a_3^2)^2Q_2^2/Q_1^2\}}{Q_2^2}\right]} \quad \text{.. .. (88)}$$

for the particular case when the primary damping equals the secondary damping, i.e., $Q_1 = Q_2$ and $a_2^2 = a_1^2 + a_3^2$, this simplifies to

$$y = \pm\sqrt{[a^2 - (a_2^2 + 1)^2]}/Q \quad \text{.. (88a)}$$

The values of y removed from resonance for which the response is the same as that at resonance may be calculated from (76) and (80).

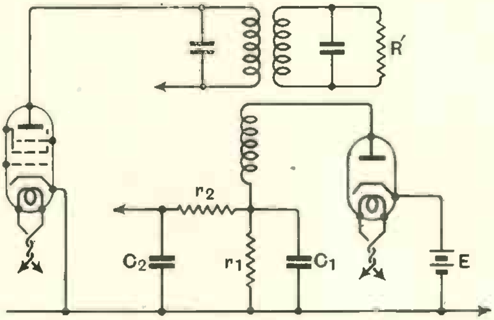

Fig. 21.—Another modification of the A.V.C. system giving a higher input resistance than usual.

$$y_{PB} = \pm\sqrt{\left[\frac{2a^2Q_2/Q_1 - \{(1 + a_2^2)^2 + (1 + a_1^2 + a_3^2)^2Q_2^2/Q_1^2\}}{Q_2^2}\right]} \quad \text{.. .. (89)}$$

so that

$$n_{PB} = n_P\sqrt{2} \quad \text{.. .. (90)}$$

The formulæ given enable the performance under any conditions to be calculated and it is only necessary to deal here with one or

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[3] "The Design of A.V.C. Systems," by W. T. Cocking, *The Wireless Engineer*, August, September and October, 1934.

two special cases. The first of these is of great importance when variable selectivity is required. It was pointed out in Part I that each pair of variably coupled circuits should have associated with it a single circuit having one-half the Q of those used for coupled pairs. It was proposed that this third circuit be coupled loosely to the variably coupled pair so forming a three-circuit intervalve coupling which in itself has the required characteristics. Where very high selectivity is needed this is an advantage since it permits a large number of tuned circuits to be used with a small number of valves. Where a lower standard of selectivity is required or where cost demands the use of fewer circuits, the possibility of using a total of only three coupled pairs was mentioned. With this arrangement two I.F. valves might be used and one two-circuit variably coupled transformer employed for the coupling between the frequency-changer and the first I.F. valve with a second between the two I.F. valves. It was pointed out that to obtain the correct characteristics two single circuits having one half the value of Q should be included in the amplifier. Now it is possible by careful design to use a pair of loosely coupled circuits between the second I.F. valve and the detector for this purpose.

The resonance curve obtained from a pair of coupled circuits differs from the square of that of a single circuit, but it closely approaches it if the coupling is made loose enough. It can be seen, therefore, that the coupling must be loose, but, of course, no looser than necessary for this would involve a loss of amplification. The effective Q of both circuits must be the same and equal to one-half the Q of the variably coupled circuits. Consequently, if the coils have the same Q the damping imposed on each must be the same.

Of the many possible methods of obtaining the correct value of Q, the simplest seems to be to make each circuit have the same value of Q which, without external damping, is equal to the Q of the variably coupled circuits. The damping on each circuit, therefore, must reduce Q to one-half. Now in general the factors responsible for the damping are unequal. On the primary circuit the valve and A.V.C. system damp the circuit, and on the secondary the detector. As already mentioned, in the primary circuit it is customary to dispense with the coupled arrangement of Fig. 18 and to connect both valve and A.V.C. system across the tuned circuit so that

$$a_1^2 = R_{D1}/R_a$$
$$a_3^2 = R_{D1}/R_{AVC}.$$

Now R' is usually smaller than R_a and R_{AVC} in parallel, so that if $L_1 = L_2$ and $Q_1 = Q_2$, so that $R_{D1} = R_{D2}$, R' cannot be connected directly across the second tuned circuit for then the second circuit would be more heavily damped than the first. There are two possibilities; the first is to step-down to R' by adopting either the coupled arrangement of Fig. 18 or a tapping on the second circuit; the second is to connect R' across the whole circuit but to reduce L_2 so that $R_{D2} = R'$. As regards normal operation there is no difference between the two possibilities, but when the load on the second circuit is a detector it is better to obtain matching by adjusting the coil inductance appropriately than by using a transformer type feed. The reason is that in this circuit there is not only the intermediate frequency to be considered but the harmonics of this which are inevitably generated by the detector. If a coupled circuit or tapped coil be used, the impedance presented by the output circuit to the detector at the harmonic frequencies is the reactance of L_4 or the reactance of the inductance between the end of the coil and the tapping point. This reactance is proportional to frequency so that it becomes increasingly large as the degree of harmonic goes up. If matching is secured by adjusting L_2, however, the impedance presented to the detector is the reactance of the condenser C_2, and as this is inversely proportional to frequency it falls with an increase in the degree of harmonic. Compared with the other arrangement, the impedance at any harmonic is much lower. It makes for better detector action, and there is less chance of feed-back of harmonics to earlier circuits, where they may cause serious trouble, if the output impedance of the coupling is low at the harmonic frequencies, so that it is obviously desirable to match by varying the coil inductance. Consequently

$$a_2^2 = R_{D2}/R'$$

Now the total damping of the first circuit s represented in the equation by $(1 + a_1^2 + a_3^2)$ and of the second circuit by $(1 + a_2^2)$. Equality of damping is thus obtained when

$$(1 + a_1^2 + a_3^2) = (1 + a_2^2) \qquad .. \quad (91)$$

It is readily seen from equation (76) that the a-terms represent the external damping and that the numeral is due to the circuit resistances themselves. The condition in which the external damping has the value necessary to reduce Q to $Q/2$ is thus obtained by writing

$$1 = a_2^2 = (a_1^2 + a_3^2) \quad .. \qquad .. \quad (92)$$

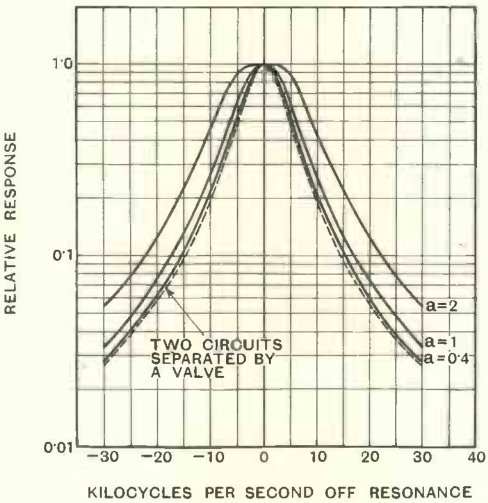

Fig. 22.—*The resonance curves of a pair of coupled circuits with various degrees of coupling compared with the curve (dotted line) of two circuits separated by a valve.*

The insertion of these values in equation (76) gives, when $Q_1 = Q_2 = Q$,

$$\frac{e_2}{e_1} = \frac{gaa_1\sqrt{R_aR'}}{\sqrt{[(4+a^2-y^2Q^2)^2+16\,y^2Q^2]}} \quad .. \quad (93)$$

which reduces to

$$\frac{e_2}{e_1} = \frac{gaa_1\sqrt{R_aR'}}{4+a^2} \quad \text{when } y = 0 \quad .. \quad (94)$$

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

For the particular case under consideration the value of a must be selected not for amplification but for the correct resonance curve. The curves of Fig. 22 have been calculated from equation (93) and show the results for three different values of a, compared with the response (dotted curve) of two single circuits which is the required result. As it was found in Part I that the correct results are secured with $Q = 93.5$ this value has been used for the coupled circuits and $Q_T = 46.75$ for the single circuits, since the damping factors for the coupled system reduce the effective Q to the required value of 46.75. It will be seen that when $a = 0.4$ the resonance curve is almost indistinguishable from the ideal. The efficiency, however, is rather low, for Fig. 23 shows that $a/(4 + a^2) = 0.095$ only as compared with the value of 0.25 obtained with optimum coupling. The resonance curve for $a = 2$, however, differs too widely from the ideal for it to be permissible, but it should be possible to employ $a = 1$ without the divergencies being too great. The factor $a/(4 + a^2)$ then has the value of 0.2. In other words, the efficiency is 80 per cent. of the maximum. This is quite good and amply justifies the choice of this value of a if the divergencies from the ideal in the matter of the resonance curve can be permitted.

The type of response obtained for this system is shown in Fig. 24 in which curve A represents the combination of two variably-coupled two-circuit transformers of the type described in Part I in conjunction with one loosely coupled transformer having $a = 1$. Curve B represents the ideal case of two separate circuits, instead of the loosely coupled pair, in conjunction with the same two variably-coupled transformers. The

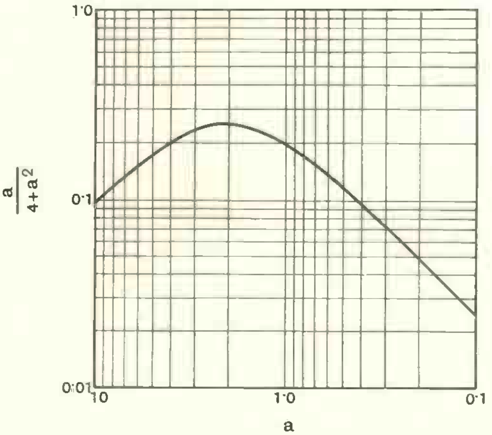

Fig. 23.—*The variation of efficiency with coupling for a pair of coupled circuits.*

difference between the curves illustrates the price which must be paid for the convenience of using a coupled pair instead of separate circuits. It can be seen that with either arrangement the divergencies from a flat response in the pass region are about the same (2 db.), but that with curve *A* the centre-peak is so small as to be virtually non-existent. The outer peaks are prominent instead of being equal to the centre-peak. It is clear, however, that if response up to 10,000 c/s only be required the coupling could be reduced somewhat in the variably-coupled circuits and this would tend to make the peaks in the pass region less prominent, and would give increased efficiency. Alternatively the coupling of the fixed pair could be reduced and the curve would then approximate more closely to (*B*) but at the expense of amplification. In the writer's opinion, however, the response given by curve *B* is quite good enough for high-quality broadcast reception.

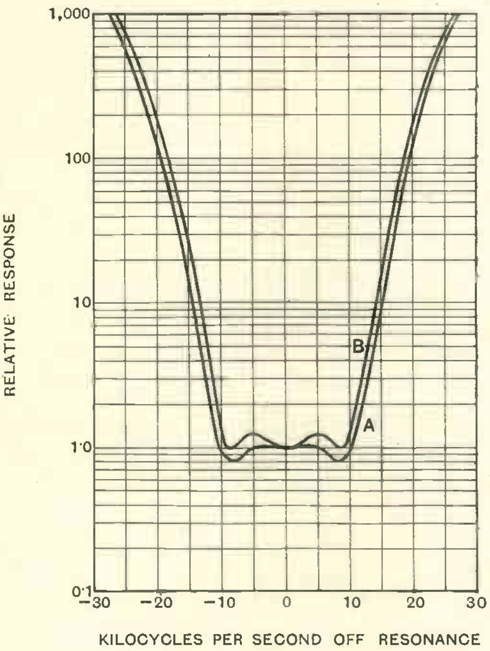

Fig. 24.—*The combination of two variably-coupled transformers with two circuits of Q/2 is shown here. Curve A represents the ideal case when the Q/2 circuits are separated by valves and curve B that when they are loosely coupled together.*

The next step, therefore, is to develop the design equations for the I.F.-detector coupling, for the formulæ governing the choice of components in the variably-coupled transformers were given in Part I. In the light of the results just discussed an arbitrary value can be fixed for a and a_1, a_2, and a_3 are also fixed. Thus

$$a = 1 = \omega^2 M^2 / R_1 R_2$$

$$a_2^2 = a_1^2 + a_3^2 = 1 = R_{D2}/R' = \omega L_2 Q/R'$$

$$= R_{D1}/R_a + R_{D1}/R_{AVC} = \omega L_1 Q(1/R_a + 1/R_{AVC})$$

$$\therefore \quad \frac{L_1}{L_2} = \frac{R_a R_{AVC}}{R'(R_a + R_{AVC})}$$

Q, R', R_a, R_{AVC}, are known, therefore,

$$L_2 = R'/\omega Q \quad \ldots \quad \ldots \quad \ldots \quad (95)$$

$$L_1 = \frac{L_2 R_a R_{AVC}}{R'(R_a + R_{AVC})} \quad \ldots \quad \ldots \quad (96)$$

$$C_2 = 1/\omega^2 L_2 \quad \ldots \quad \ldots \quad \ldots \quad (97)$$

$$C_1 = 1/\omega^2 L_1 \quad \ldots \quad \ldots \quad \ldots \quad (98)$$

$$R_2 = \omega L_2/Q \quad \ldots \quad \ldots \quad \ldots \quad (99)$$

$$R_1 = \omega L_1/Q \quad \ldots \quad \ldots \quad \ldots \quad (100)$$

$$M = \sqrt{R_1 R_2}/\omega \quad \ldots \quad \ldots \quad \ldots \quad (101)$$

From (94) $e_2/e_1 = 0.2g\sqrt{R_{D1}R'}$ .. (102)

For the case first discussed $Q = 93.5$, $R' = 1.25 \times 10^5 \Omega$, $R_a = 10^6 \Omega$, $R_{AVC} = 2.5 \times 10^5 \Omega$, $f = 4.65 \times 10^5$ c/s. Therefore, $L_2 = 457.5$ μH., $L_1 = 731$ μH., $C_2 = 258$ μμF., $C_1 = 161$ μμF., $R_2 = 14.3 \Omega$; $R_1 = 22.9 \Omega$, $M = 6.2$ μH.

In this section the properties of a single tuned circuit coupling between the last I.F. valve and the detector have been fully discussed for the cases of a triode and a tetrode or pentode I.F. valve and a pair of coupled tuned circuits as the coupling has been generally treated, special attention being given to the case where the circuits must have particular characteristics to work in conjunction with two-circuit variable-selectivity I.F. transformers. The equations given already enable the performance under any conditions to be calculated and it seems unnecessary at this stage to treat any other special cases, and this will be reserved for Part III which will deal with the design of the I.F. amplifier as a whole.

The Anode to Accelerating Electrode Space in Thermionic Valves*

By J. H. Owen Harries

PART I

1. Introduction.

IF the length from the anode to the cathode in thermionic valves could be greatly increased without increasing the voltage to current ratios above the values found in short streams (*e.g.* in triodes and diodes), many advantages would result. Some of these advantages appear to have been fairly well known for many years (Bib. Nos. 1 and 2), but no method of gaining this end appears to have been published. The advantages might be expected to include the prevention of the retrograde passage of secondary electrons from the anode, and a substantial reduction in interelectrode capacities. Of the multitudinous publications on electron jet frequency multipliers (*e.g.* Bib. Nos. 3, 4, 5, 6, 7, 8, 9, 10 and 11) there are few indeed which fail to call attention to the desirability of using long streams, so that the sensitivity to deflection may be reasonably great, but such long streams invariably possessed an impracticably high voltage to current ratio.

2. The Two Principal Parts of a Valve

Valves of the kind considered in this paper may be thought of as consisting of two parts, the cathode space, from the cathode to the first accelerating electrode, and the anode space, from the first accelerating electrode to the anode (Fig. 1). The physical relationships of the cathode space have been analysed to a satisfactory degree of accuracy (Bib. 12). The only information the author was able to find about the anode space (where the electrons have an initial energy which is as high or higher than that corresponding to the potential of the anode) is concerned with the production of jets of electrons, having very high voltage to current ratios, as in oscillographs; and, with respect to short stream tetrodes and pentodes, statements that the anode must be placed close to the accelerating electrode to produce a practicably large current, at a sufficiently low voltage. The familiar dynatron characteristic will then appear due to the retrograde passage of secondary electrons. "The maximum current which can flow to the plate gets less as the distance between the grid and plate is increased," is a typical quotation from conclusions, based upon the classical solutions of the basic differential equations only, and arrived at from an analytical consideration of the anode space.

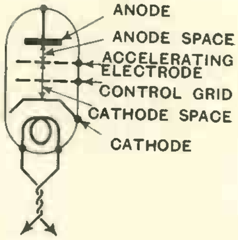

Fig. 1.—*The anode and cathode space of a valve.*

3. Method of Attack on the Problem

An examination of the problem indicated that there was little hope of arriving at the necessary information about the anode space by endeavouring to obtain a complete solution of the basic differential equations. (Bib. No. 12).

Mathematical analysis is a process of producing on paper, by a special notation, a working model of a particular part of the universe which it is desired to study. When a correctly carried out mathematical analysis fails, it is because insufficient data has been provided from which to build the model. It is then necessary to make a physical model, in the form of experimental apparatus, and to obtain the missing information from that. The difficulty with experimental apparatus lies in the fact that it is necessary that the physical model be so designed that other effects than those which it is actually required to study are negligible, and that those it is required to study are readily observable.

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

4. Sliding Anode Tubes

Fig. 2 illustrates the type of valve finally employed as an experimental model to investigate the problem and to obtain the data for mathematical analysis. The anode is arranged to slide in guides, and its position is adjusted by tilting and tapping the tube. This rather crude method was the only one found to be successful in practice.

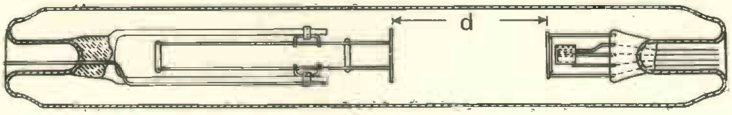

Fig. 2.—*A type of movable anode discharge tube used experimentally to determine the characteristics of the anode space.*

The essential features of the sliding anode tubes are as follows :—

(*a*) A focused cathode of ample emission.

(*b*) An accelerating electrode close enough to the cathode to obtain a space current of at least 5 to 10 mA. at not less than 200 volts or so. (To complete the investigations sliding anode valves having more than one accelerating electrode are necessary.)

(*c*) A mesh formation of the accelerating electrode so that it does not intercept more than a very small part of the total space current. (An important part of the work was the realisation of the fact that such mesh electrodes may be made to give entirely satisfactory results in the production of an electron jet. Prior "electron gun" accelerating electrodes are no good for solving the problem. Their focusing action is unnecessary. They intercept almost all the space current, or only produce a very low space current, and therefore make the anode current too small to be of use.)

(*d*) An anode which is readily and accurately adjustable in position from about 0.25 cm. to 7 cm. from the nearest accelerating electrode. The anode must be of reasonable area, and have a positive electrical contact to the external circuits.

5. Electrical Characteristics of Sliding Anode Tube

Fig. 3 shows the anode current/anode voltage characteristics for various distances, in centimetres, between the anode and accelerating electrode of a typical sliding anode tube.

At short distances the familiar dynatron characteristic appears. As the distance is increased, the anode voltage E_b at which substantial saturation of the anode current occurs shifts to the left until it reaches a minimum, and the dynatron characteristic disappears. As the distance is still further increased, E_b becomes greater once more. That the retrograde passage of secondary radiation disappears at extreme distances is not surprising, but the fact that the primary saturated anode current is independent of the distance, and that the saturation voltage is very low at not very long distances immediately outside the dynatron distance, is remarkable. At extremely long distances a peculiar phenomenon appears. Almost no anode current (except that due to stray unfocused electrons) flows until the anode voltage has risen considerably above zero. At a certain anode voltage E_b, however, the anode current suddenly rises to a saturated value, and remains at substantially this value independently of how much further the anode voltage is raised. The accelerating grid current has a characteristic which is the reverse of this, *i.e.* virtually all the space current goes to the accelerating grid until E_b is reached, when it drops to a steady value, which is about one-sixth of the anode current in the case of the tube illustrated in Fig. 2.

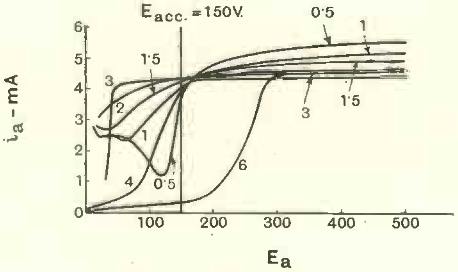

Fig. 3.—*Anode voltage/anode current characteristics of the valve illustrated in Fig. 2.*

An important characteristic of the tube is the "distance curve," connecting the distance *d*, between the anode and the accelerating electrode, and the anode saturation voltage E_b. It is illustrated in Fig. 4.

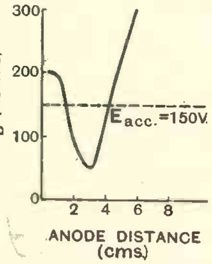

Fig. 4.—*The distance curve. The critical distance is that at which the curve is at its minimum.*

Further measurements show the effect upon the position of the minimum in the distance curve of changing the accelerating voltage. The distance curve remains about the same, as regards the position of the minimum, because lowering the voltage of a single accelerating electrode decreases the current and the potential gradient simultaneously.

The anode distance at which the distance curve is at a minimum has been christened the " critical anode distance " (Bib. No. 13). The trough of the distance curve is quite flat and if an anode is placed at the precise minimum, accidental or manufacturing variations in its position will make little difference to the characteristics. A tetrode valve made with its anode at this critical distance has a characteristic curve free of the effects of the retrograde passage of secondary radiation. Provided that the accelerating electrode substantially shields the anode from the cathode space, then at low screen voltages the critical-distance valve has an extremely high anode differential resistance R_a, *i.e.* the slopes of the E_a/i_a curves are very small. The fact that there is always a certain amount of slope is because it is impossible completely to separate the cathode and anode spaces, and principally because secondary radiation from the surface of the accelerating electrode adds to the anode current. This latter addition is a constant fraction of the anode current. Therefore, the slope increases with anode current.

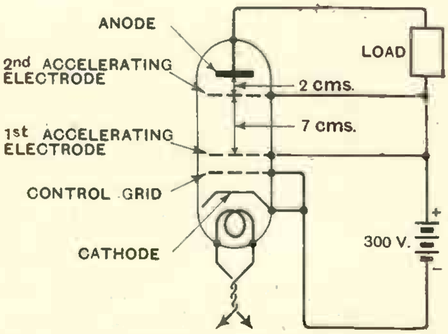

Fig. 5.—*A long-stream critical-distance valve.*

A wide choice of forms of characteristic, particularly as regards the anode differential resistance, is found according to whether the anode is at one side or the other of the minimum of the distance curve. To the left a low anode differential resistance is produced, and to the right a higher value.

6. A "Long-Stream" Valve

The original problem was solved by the results of the above experiments. For instance, Fig. 5 shows a long-stream valve diagrammatically. The control grid and cathode are close together. The first accelerating electrode is near to these two. The second accelerating electrode is spaced from the first by a distance of about 7 cm., which is just not too long to cause the stream across the gap to lose saturation at the working accelerating electrode potential. This space will be operating under the conditions of the curve 6 in Fig. 3. The distance between the second accelerating electrode and the anode will be the critical distance, of, say, 2 cm. The anode voltage/anode current characteristics of a critical distance type of valve are shown in Fig. 6, and they will be recognised as satisfactory from the power efficiency and amplification standpoint. The breakdown voltage at the critical anode distance is less, for instance, than the corresponding saturation voltage of an ordinary short-stream pentode.

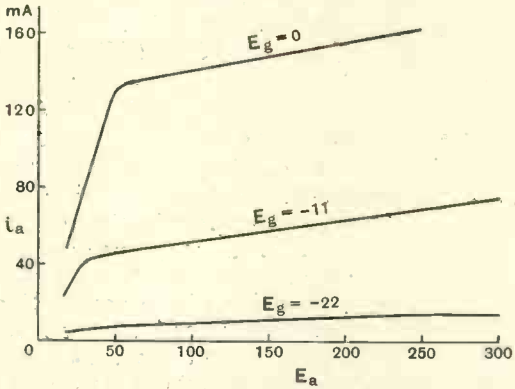

Fig. 6.—*Electrical characteristics of the type of valve illustrated in Fig. 5.*

Of course, additional accelerating electrodes may be used in this manner to lengthen the stream still further. These, being well spaced from the preceding electrode, will be found to intercept very little of the total space current.

Thus it is possible to design a type of long-stream valve which has characteristics the excellence of which, from a power handling or amplification standpoint, is unaffected by extreme length between cathode and anode.

7. Analysis

Having obtained these results from experimental models, it was possible to produce an analytical interpretation of the phenomena.

It may be shown that both the cathode and anode spaces may respectively be represented by a diagram such as Fig. 7, where electrons are emitted from a cathode K and tend therefore to travel to a positive anode A across a distance x. The plane of the accelerating electrode is considered as a cathode with respect to the anode, the potential difference between them being the difference between the accelerating voltage E_{acc} and the anode voltage E_a. The only difference between the anode and cathode spaces, from the analytical standpoint, is the difference in the values and distributions of initial velocities of the emitted electrons.

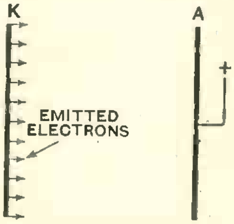

Fig. 7.—*The cathode and anode of a high vacuum discharge tube.*

Fig. 8 illustrates the general form of the potential gradients between any cathode and any anode in a vacuum. OE represents the plane of the cathode and DC represents the plane of the anode. V is the potential of a point x distance from the cathode. The magnitude of the initial velocities may be represented on the same scale from O downwards.

Applying this diagram to the cathode space we may indicate the maximum emission velocity by v_0 and assume that a continuous spectrum of initial velocities extended from v_0 to zero, *i.e.* over the interval v_0 to O in Fig. 8. Only those electrons, the initial energy of which is greater than the negative potential dip AB or $A'B'$ or $A''B''$ (which decreases as the anode voltage is raised from E_{a1} through E_{a2} to E_{a3}) can pass to the anode.

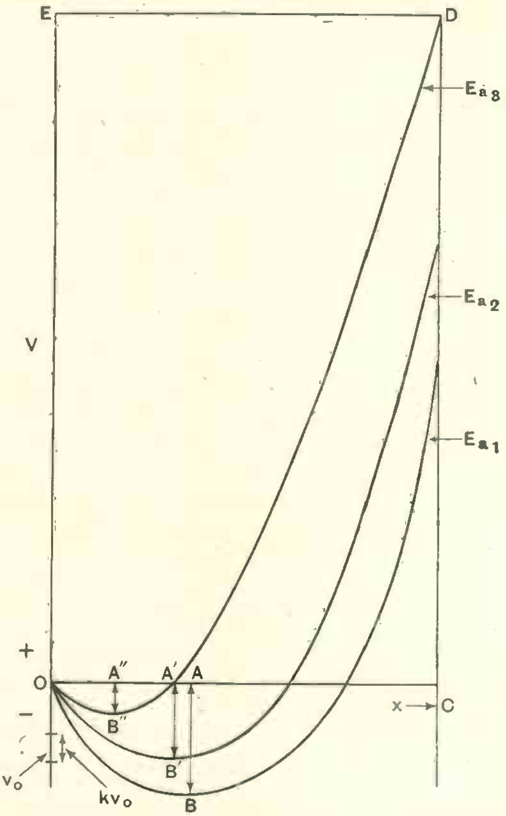

Fig. 8.—*The potential gradients and conditions between the cathode and anode illustrated in Fig. 7.*

The basic differential equation to Figs. 7 and 8 is:

$$\left(v_0^2 + \frac{2eV}{m}\right)\left(\frac{d^2V}{dx^2}\right)^2 = 16\pi^2 i^2 \quad \ldots \quad (1)$$

There is no complete general solution to this as far as the author is aware. A specific solution to the case just explained, where the initial energies extend over a continuous spectrum the maximum value of which is very small compared with the potential of the anode, is the familiar Langmuir 3/2 law. The conditions corresponding to the anode space cannot, however, have initial velocities which fulfil these conditions. If the accelerating electrode were a perfect uni-potential plane, then all the electrons issuing into the anode space would have one single velocity. A consideration of Fig. 8 will show that the E_a/i_a characteristic corresponding to the single velocity case is illustrated in Fig. 9, curve *GADE*.

Because the accelerating electrode consists of spaced wires which are in the neighbourhood of a fairly dense space charge, and quite possibly also in the neighbourhood of earthed or negatively charged metal, the potential of the equivalent cathode falls between the wires, and the initial energies will therefore vary from a value tending to equal the potential of the accelerating electrode, down to a minimum. The resulting emission spectrum extending from v_0 a short distance towards zero is indicated by kv_0' in Fig. 8. The rise in anode current at saturation point will no longer be infinitely steep. The result is shown by curve *GABE* in Fig. 9.

(Later in this paper it will be shown that the production of as sharp a knee as possible to the characteristics in the anode space is desirable in the design of valves. To attain this sharp knee, it is necessary to have as nearly as possible a single value of initial energy, and therefore to have as little reduction in potential as possible in the neighbourhood of the positive grid immediately preceding the anode.

The above reasoning has neglected the effect of diffusion due to uneven emission from the accelerating electrode. It will be equivalent to having a number of ideal single velocity valves in parallel having slightly different initial energies of emission. The result will be to round the curves at *A* and *B* in Fig. 9. Such diffusion may be neglected without much error when the anode distance is considerable, because the small change of potential gradient due to diffusion will be negligible compared with the large negative dip produced due to the space charge and the long distance.

In Fig. 9 the dotted curve *FHDE* represents the result to be expected at a short anode distance in the absence of diffusion (and secondary radiation), and with an initial velocity v_0 of one value only. In the presence of varying initial velocities and of diffusions, the curve will be changed to dotted curve *GIDE*.

These results take no account of the emission of secondary electrons. The similarity of the general form of curve *GABE* with curve 6, Fig. 3, can, however, be noted. The curve marked for 3 cm. distance in Fig. 3 will be seen to approximate very closely to that in Fig. 9 at *GIDE*.

To obtain a complete solution of (1) is not of great practical importance. Partial solutions showing the positions of the potential minimum and so relating i_a and V, etc., may be found. The saturation current i_0 is equal to the current to the accelerating electrode flowing in the cathode space, less that portion intercepted by the accelerating electrode. Thus i_0 is entirely independent of anode distance d or anode potential above saturation. This is an important confirmation of the practical results of Fig. 3. (If the screening effect of the accelerating electrode is small the current will be added to by the anode field extending to the cathode space, but this effect is subsidiary and usually negligible.)

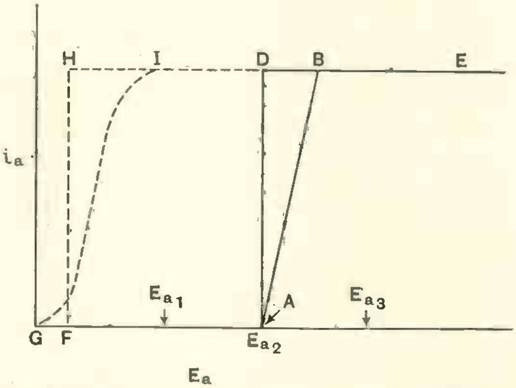

Fig. 9.—*Theoretically deduced anode voltage/anode current characteristics for the anode space.*

8. The Effect of Secondary Electron Emission

Consider the effect of the emission of secondary electrons from any metal. (Bib. 14, 15, 16 and 17). Fig. 10 is reproduced from Farnsworth (Bib. Nos. 14, 15, 16) and shows that the bulk of secondary electron emission consists of a spectrum which is almost entirely of much lower velocity electrons than the velocity of impact giving rise to the emission. (Emission and reflection are considered as the same thing for the purpose of this analysis.) The primary velocity of impact is indicated at v_p. I_s/I_p is the ratio between secondary and primary electrons. v_s is the velocity of secondary emission.

Consider first the effect of secondary emission from the accelerating electrode on the characteristics of the anode space. The result will be that secondary electrons will enter the anode space, and will have a spectrum of initial energy extending from a value tending to be equal to that of the potential of the accelerating electrode, and continuing down to zero. The result may be referred to Fig. 8 by imagining that the initial spectrum of width kv_0' extends from v_0 down to zero. Fig. 11 *OGE* and *BCD* shows *GIDE* and *GABE* Fig. 8 redrawn to suit these circumstances. The slope of the characteristics above the saturation point has been increased and the secondary electrons of low velocity have rounded the knees of both the characteristics for short and for long distances. This makes these characteristics a closer approximation to those experimentally determined and shown in Fig. 3. Stray electrons and diffusion will tend to produce the departure from zero current shown by the line *OE*.

The presence of secondary radiation from the accelerating electrode constitutes a limitation in the design of screened valves. If a very effective positive electrostatic screen grid, having a close mesh, is used, the anode differential A.C. resistance R_a will fall and the knees of the E_a/i_a curves become rounded to an undesirable extent. This is the reason why many short-spaced screened tetrodes have a very low value of R_a under working conditions. As secondary radiation is drawn from the positive grid, the total positive grid current is reduced. This result will be at the expense of the anode differential resistance, which will fall. This agrees with common experience in the design of screened tetrodes of the dynatron type in which the anode field is extremely strong. The reduction in R_a under these circumstances is sometimes accepted as a penalty inseparable from adequate screening between the anode and cathode spaces in such tetrodes. A very good positive electrostatic screen will have a large number of positive wires. Unless a great deal of secondary radiation is drawn from this positive grid, the screen current will be impracticably high; whereas by drawing sufficient secondary electrons away it may actually be made negative.

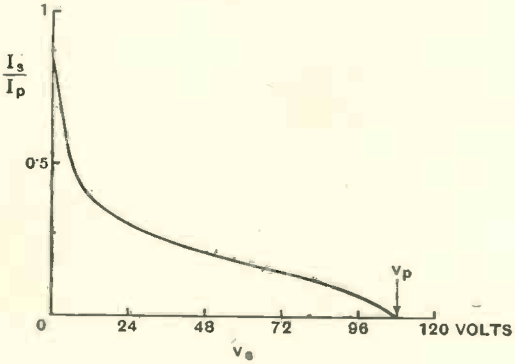

Fig. 10.—*Velocity spectrum of emission of secondary electrons from nickel. The primary velocity of impact is indicated at v_p. I_s/I_p is the ratio between secondary and primary electrons. v_s is the velocity of secondary emission.*

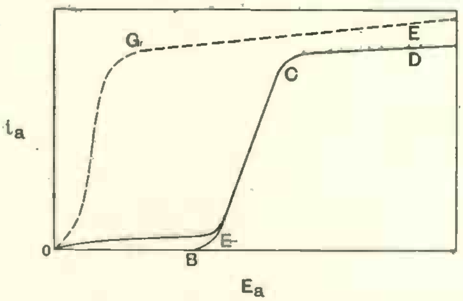

Fig. 11.—*Theoretically deduced anode voltage/anode current curves showing the effects of secondary radiation from an accelerating electrode to an anode.*

The emission of secondary electrons from the anode, as well as from the accelerating electrode, tends to reduce the value of V in the neighbourhood of the anode and alters the potential gradient from the theoretical shape in the absence of secondary radiation. At values of E_a greater than the accelerating voltage E_{acc}, the only result of this is to reduce the effective anode potential acting in the plane of the accelerating electrode or equivalent cathode. Provided E_{acc} is sufficiently great for the secondary emission to be produced from the anode when the anode potential is less than that of the accelerating electrode, then, when it is less, the emission will tend to travel back to the accelerating electrode, and will do so unless the negative space charge potential dip between the two electrodes is sufficient to prevent this.

(9) The Theory of the Critical Distance

The minimum found in the distance curve (Fig. 4) may be explained as follows. Since the velocities of almost all secondary electrons are less than the velocity corresponding to the anode potential, and therefore less under these conditions than the velocity of the primary electrons issuing from the plane of the accelerating electrode, it is possible to find a value of potential gradient sufficient to prevent the retrograde passage of secondary electrons when E_a is less than E_{acc}, but which is not sufficiently great at anode voltages in excess of a small value, to prevent the passage of primary electrons. From the preceding analysis, the negative potential gradient in a given tube is proportional to the spacing between the anode and accelerating electrode. Therefore, this explains the fact that the experiments with a sliding anode tube resulted in finding a "critical anode distance" at which the retrograde passage of secondary radiation is prevented and yet, at this distance, anode current saturation occurs at an anode voltage E_b considerably less than that of the accelerating voltage.

It may be expected that the distribution of space charge will be affected by the relative configurations of the accelerating electrode (or equivalent cathode) and anode, and by the degree or otherwise of focusing of the electron stream, due to the effect of this upon current density and upon diffusion. This is actually found to be the case. For instance, in the sliding anode valve illustrated in Fig. 2 the critical anode distance is about 3 cm. If an ordinary fixed anode valve is constructed having a tubular section anode, a circular cross-section positive grid and a filament cathode within the latter, a very diffuse radially directed stream will be produced in which the current density is low. The critical anode diameter, will then be of the order of, say, 5 to 6 cm. or more. For commercial valves, it is usually necessary so to focus the stream into a jet that the critical anode diameter is very much smaller than this, so as to go into a reasonably compact bulb. Details of the methods of design in this respect are beyond the scope of this paper. Wide bulbs with very large openings to admit a short electrode assembly of considerable diameter are extremely difficult to seal in by machinery.

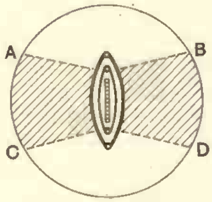

Fig. 12.—*A sectional view of a typical commercial Harries critical-distance valve. The shaded area indicates the approximate path of the discharge.*

Fig. 12 shows a section of a typical tetrode having a focused stream and its anode at the critical anode distance. The stream is confined to the shaded path. Practically the same result is obtained in the absence of those portions of the circular anode from *A* to *B* and from *C* to *D*.

PART II

1. Ideal Valve Characteristics

Fig. 13 shows the anode voltage/anode current characteristics of an ideal valve. It may be shown that E_b should be as small as possible, and that the slope of the lines from E_b upwards should be constant. The more linear the curves are to the right of the knee and the lower the value of E_b, the lower the distortion.

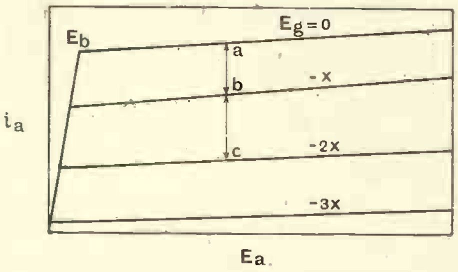

Fig. 13.—*Theoretically perfect anode voltage/anode current characteristics of a multi-grid valve.*

2. Design of the Anode Space and Examples of Valves

Referring back to Figs. 9 and 11 in the previous part of this paper, it will be seen that the characteristics illustrated in Fig. 13 correspond to those referring to valves in which secondary radiation in both directions has been rendered as low as possible, and the screening of the anode from the cathode space is as complete as possible. The effects of diffusion should also be avoided as far as possible by widely spacing the anode, and yet not spacing it so far as to cause E_b to become greater than is desirable in any given circumstances.

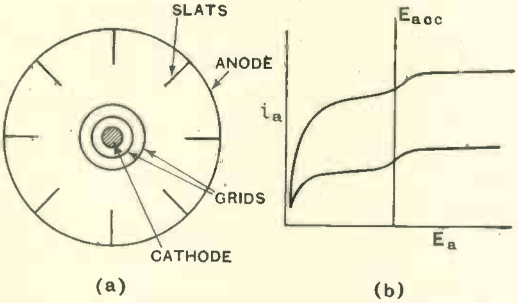

Fig. 14.—(*a*) *A type of anode design intended to prevent the emission of secondary electrons from the anode into the anode space.* (*b*) *The anode voltage/anode current characteristics of this type of valve.*

There are three possible methods of anode space design, as regards that part of the problem having to do with preventing the retrograde passage of secondary radiation :—

1. The prevention of emission of secondary electrons from the anode surface.

2. The prevention of passage of secondary radiation across the anode space.

3. A combination of the above.

So far as the author is aware 1. has never been successful. 2. is very effective, and is exemplified both in the critical-distance valve and in the pentode valve. 3. is also effective, particularly with the critical-distance valve, though usually it is not worth the trouble, because excellent characteristics are obtained by 2. without it.

The prevention of the emission of secondary electrons (method 1) was tried by Hull by chemical treatment of the anode surface (Bib. No. 17). It was only partially successful. Another suggestion which has been carried out in practice is to arrange the anode to have radially directed slats or holes therein. It is intended that primary electrons will travel into the space between the slats, and that secondary electrons will then not readily leave the space between the slats and travel back to the accelerating electrode. Figs. 14*a* and 14*b* show, respectively, the section of a slatted anode, and the type of characteristic usually found with this kind of valve. It is not very satisfactory, because it appears to be quite impossible completely to trap the electrons in the spaces between the slats.

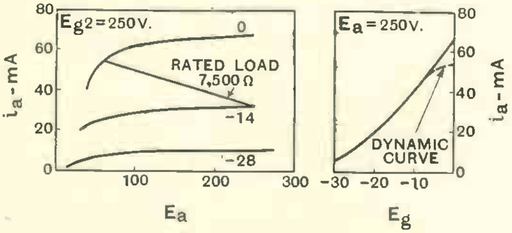

Fig. 15.—*Typical characteristics of a power output receiving valve of the pentode type. Note curved top of the dynamic characteristic producing distortion of a complex input wave.*

Fig. 15 shows the characteristics of a pentode. These have a rounded knee compared with Fig. 13. The reason for this is that the anode of the pentode is immediately preceded by an earthed grid. Electrons in the neighbourhood of the wires of this grid are reduced in velocity, whilst in between the wires the velocity of the stream tends to rise. Thus there is a wide spectrum of initial velocity from zero upwards. The anode is close to the equivalent cathode, causing diffusion effects to become important.

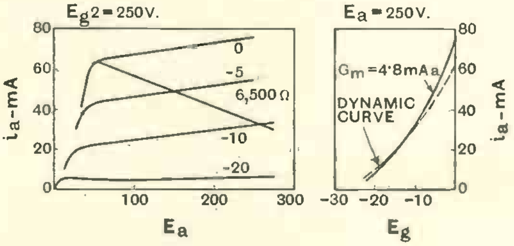

Fig. 16.—*Characteristics of commercial Harries mains type critical-distance valve. Note dynamic characteristic.*

Fig. 16 shows the characteristics of a spaced anode power output valve. This valve has been described elsewhere (Bib. 18). It is found to give a substantially lower distortion level, and greater power output, than the equivalent pentode of Fig. 15. The focusing in this valve has been arranged so that the anode will go inside a reasonable size of bulb. Everything possible is done to remove negative or earthed metal from the neighbourhood of the anode space, and thus, together with the longer anode space, because of the comparatively small width of initial energy spectrum, results in the sharp knee and linear characteristics, shown.

The rounded knees and S shaped dynamic characteristic of the pentode (Fig. 15) is the cause of a very serious type of distortion. This distortion is not indicated by, or proportional to, the amplitudes of second and third harmonic, neglecting phase angle, obtained by conventional distortion measurements with a sine wave input. It may be evaluated by measurements on harmonic distortion using an input consisting of two simultaneously applied waves, simulating the actual conditions of telephony reception. This distortion is absent in the case of the characteristic of Fig. 16. Oscillographic records of complex wave distortion have been published (Bib. No. 19).

During the past few years the author has investigated the effect of the anode critical distance on a large number of control-grid type valves. It is not possible within the space of this paper to give more than two examples, which are of interest as illustrating method 3 of designing the anode space. In Fig. 17 two separate anodes are employed, one on each side of the positive grid, and are spaced from it at the critical distance. The resemblance to Fig. 12 if the portions of the anode from A to B and from C to D are removed will be noted. The earthed plates E_1, E_2 are too far outside the anode field substantially to affect the passage of secondary radiation. The field of these plates is very slight and similar in its action to a suppressor grid. The result is that the knee of the characteristics are in general not quite so sharp as those of a pure spaced anode valve; but the critical distance effect still appears, and the anode is at the critical distance. It is of interest to observe that whenever there is sufficient metal in the accelerating electrode to give a substantially positive field and a "single velocity" emission "sharp knee" effect, then secondary radiation will travel back to the accelerating electrode at small anode spacings and the typical distance curve minimum, or "anode critical-distance effect," will appear.

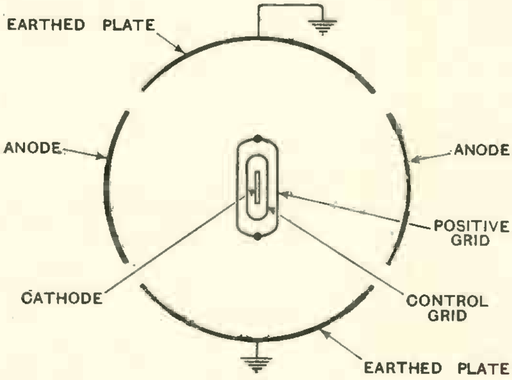

Fig. 17.—*An alternative anode design for a critical distance valve using earthed side plates.*

If a slatted anode is employed at the anode critical distance, the unsatisfactory nature of the characteristic (Fig. 14*b*) at the shorter distance disappears. Provided the slats are fairly deep it is largely immaterial whether the back portion of the anode is present or not.

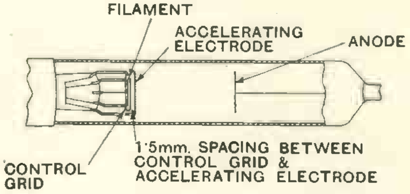

Fig. 18.—*Illustration of a type of low capacity critical distance receiving valve. The capacity can be reduced further by taking the grid lead out at the side of the bulb.*

Extremely low capacity valves may be produced by taking advantage of the long spacings possible. It is not difficult, by means of conventional screened grid constructions, only to screen one electrode, such as the anode, from the control grid; but electrostatic screens, when this is done, increase the capacities to earth. By means of such a construction as that illustrated in Fig. 18 a short wave valve is produced having extremely low capacities, not only from anode to control grid, but also from these electrodes to earth.

3. Screened Voltage Amplifier Valves

As previously pointed out, ordinary dynatron tetrodes, when well screened to give an anode to control grid capacity as low as 0.002 to 0.001$\mu\mu$F, have undesirably low A.C. anode resistances and curved characteristics. A way of overcoming this is by the introduction of a suppressor grid, but the reduction in anode field then causes the screen current to become impracticably great unless the screening is also reduced. Thus, screened pentodes have anode to control grid capacities never less than 0.004$\mu\mu$F and usually of about twice or more this value. On the other hand, their anode A.C. resistances are satisfactorily high, namely, about 1,000,000 ohms at 7 mA anode current. A screened critical-distance type valve has been produced with a close mesh screen, having a screen current of the normal value, an anode A.C. resistance of 1,000,000 ohms, and an anode to control grid capacity of as low as 0.001 $\mu\mu$F.

4. Conclusions

From the theoretical considerations outlined in Part I, and from comparative experiments made with some thousands of valves over a period of several years (a few typical results of which are set out in Part II), it is considered that the correct design of the anode space of a multi-grid valve should utilise the anode critical distance and that the design of very long stream valves should be in accordance with the methods of spacing accelerating electrodes described herein.

BIBLIOGRAPHY

1. Gill, *Philosophical Magazine*, May, 1925, pp. 993–1005.
2. Tellegen, *British Patent*, No. 287,985**, 1926.
3. Robert Von Lieben, *German Patent*, No. 179,807.
4. Dieckmann & Glage, *German Patent*, No. 184,710, 1906.
5. Rene Zei, *British Patent*, No. 18,438, 1913.
6. Nasarischwily, *Ann. de Phys.*, 1921, Vol. 64, p. 759.
7. Gebbert, *Jahrboch derdrahtlosen Telegraphie*, 1923, Vol. 22, p. 107.
8. Dieckmann & Glage, *Jahrboch derdrahtlosen Telegraphie*, 1922, Vol. 19, p. 194.
9. Harries, *British Patent*, No. 328,680, 1929.
10. Alfven, *Zeitschr. f. nochf. Tech.*, July, 1934, Vol. 38, pp. 27–29.
11. Dieckmann & Gebbert, *German Patent*, No. 375,808, 10th July, 1921.
12. J. J. Thomson, *Conduction of Electricity Through Gases*, Third Edition, 1928, p. 373.
13. Harries, *British Patents*, 380,429, 385,968, 1931.
14. Farnsworth, *Physical Review*, 1922, Vol. 20, p. 358.
15. Farnsworth, *Physical Review*, 1925, Vol. 25, p. 41.
16. Farnsworth, *Physical Review*, 1926, Vol. 27, p. 413.
17. Hull & Williams, *Physical Review*, 1926, Vol. 27, p. 432.
18. Harries, *Wireless World*, 2nd August, 1935.
19. Bartlett, *Wireless Engineer*, Feruary, 1935, Vol. 12, pp. 70-74.

Osram Valve for Microphone Amplifiers

THE new Osram MH40 valve is similar to the well-known MH4 type, but has several features which particularly adapt it to the early stages of a microphone amplifier. It is an indirectly heated valve with a heater consuming 1.0 ampere at 4.0 volts, and it is fitted with a standard 5-pin base. An automatic bias resistance of 1,000 ohms is recommended, and with its maximum anode potential of 200 volts, the anode current is 2.7 mA. The optimum load resistance is 50,000 ohms and the valve has a mutual conductance of 2.4 mA/V., with an A.C. resistance of 16,700 ohms. These figures are, of course, for 100 volts anode potential and zero grid bias. The inter-electrode capacities are given as: grid-anode 7.3 $\mu\mu$F., grid-other electrodes 6.0 $\mu\mu$F., and anode-other electrodes 4.0 $\mu\mu$F.

The particular features claimed for the valve, and the ones which make it so suitable for the early stages of a high-gain amplifier, are the very low degree of microphony and the high insulation of the electrodes. This is accomplished by the use of steatite insulators for the electrode spacers instead of the usual mica separators.

The valve is priced at 50s. and the makers are The General Electric Co., Ltd., of Magnet House, Kingsway, London, W.C.2.

Book Reviews

The Radio Amateur's Handbook, 1936 edition

By the A.R.R.L. Headquarters Staff. 480 pages (including a 96-page catalogue section) approximately 500 diagrams, illustrations and charts. Published by The American Radio Relay League, West Hartford, Conn. U.S.A. Price $1.15 with paper cover, or $2.50 with linen cover, post free.

Probably no reference book contains such a wealth of practical data for the short-waves amateur experimenter as the 1936 edition of The Radio Amateur's Handbook. It has been revised and brought up-to-date and forms a worthy successor to the twelve previous editions. Of the several new chapters added, the 30 pages of tabulated matter giving characteristics, operating data, and base connections of practically every type of American valve likely to be used in amateur short-wave receivers and transmitters, is a most valuable feature, and of considerable interest also are the new sections on the ultra-short waves which deal with transmission and reception on frequencies of 224 Mc/s, 112 Mc/s, and 56 Mc/s.

The 1936 edition contains no fewer than 21 chapters, and more than half are devoted to essentially practical matter, such as the design and construction of receivers, transmitters, monitoring apparatus, aerial arrangements, and the layout of a complete station. There is, also, an extensive appendix of miscellaneous information.—H. B. D.

Elementi di Radiotecnica Generale

By Cesare Rimini. Pp. 566+xx, 383 Figures. Published by Nicola Zarichelli, Bologna.

This is a book eminently suitable for students in Universities and Technical Colleges. It has a satisfactory air of carefulness and thoroughness, the diagrams are very good, the formulae are set out in a way that will appeal to the teacher and student alike. The author is in the Radio Communication Department of the University of Bologna, and is evidently experienced in the careful presentation of radio problems to students. The thirteen chapters and an appendix cover the whole field of radio communication. The first six chapters deal with electric circuits, their characteristics, etc., including filters and allied problems; the remaining chapters deal with valves, their theory and applications, high frequency generators, the radiation and reception of electromagnetic waves, etc. The last forty pages are devoted to a mathematical appendix dealing with differential equations, Fourier's theorem, etc.

The book can be heartily recommended to anyone who can read Italian.—G.W.O.H.

Correspondence

Johnson Noise

To the Editor, The Wireless Engineer

SIR,—Briefly—I feel that Mr. Robin's experience is bound up with a thermal variation in the wire of the line (or elsewhere in the circuit). If so it should easily be demonstrated.

Reference to Planch's radiation function (page 44–45, Tables of Functions, Johnson and Emden) would indicate that " Whereas a body of absolute temperature emits electromagnetic waves of all possible wavelengths, the radiated energy is very unequally distributed " from which I assume that a variation in temperature would alter the distribution. In the particular case reported this variation might account for a peak 5 times per second at all the frequencies examined.

Ware, Herts. GERALD SAYERS.

New Ediswan Output Valve

A NEW valve designed to give a large output is being produced by the Edison Swan Electric Co., Ltd.; it is the ES 100. It has a filament rated for 6 volts at 3 amperes, and in normal operation it should be A.C. heated; if a D.C. filament supply be used, however, the anode return leads should be joined to the positive filament terminal. The internal A.C. resistance is 1,750 ohms, and the optimum load impedance is some 7,000 ohms. With its rated anode potential of 1,000 volts, the anode dissipation is 100 watts and the valve can deliver an output of 30 watts. It has a special 4-pin base and is priced at 10 guineas.

The Industry

"MEASURING and Testing Instruments for the Electrical and Allied Industries " is the title of a well-prepared loose-leaf catalogue issued by the Instrument Department of E. K. Cole, Ltd., Southend-on-Sea. The apparatus introduced so far is all of direct application to radio research and production; a standard signal generator, beat frequency oscillator, variable attenuator, inductance bridge, and an A.F. oscillator are included in the series. As befits a catalogue of this kind, ample data for the benefit of engineers is given.

Doolittle & Falknor, Inc., 1306, West 74th Street, Chicago, Illinois, U.S.A., have sent us leaflets describing concentric transmission cable designed for carrying radio frequency power over considerable distances. The screened cable is weatherproof, and in the smaller sizes is quite flexible. A filling of dry nitrogen at slightly above atmospheric pressure is recommended for outdoor installations as a precaution against condensation. The loss in the 1-inch cable is given as 0.3 db per 1,000 feet at 1,000 kc/s.

The M.S.S. Recording Co., Ltd., 99a, Charing Cross Road, London, W.C.2, conducts a service whereby B.B.C. transmissions may be recorded on discs for the exclusive use of speakers, artistes, etc., responsible for the item recorded.

Voltage Measurements at Very High Frequencies—II. *(Concluded)*

By E. C. S. Megaw, B.Sc., D.I.C.

(From the Research Staff of the M.O. Valve Company, Limited, Wembley)

III. Comparison of Peak Voltmeter with a Thermal Measurement of Measurement.

(*a*) *Method.*

Advantage was taken of the special form of resistance, used as transmission line termination in the experiments of Section II, to check the "true voltage" derived from the peak voltmeter readings against an independent determination. The arrangement of the apparatus is shown diagrammatically in Fig. 17, which should be compared with the photograph in Fig. 10. The resistance consisted of a film of colloidal graphite* of the order of 0.1 mm. thick (resistance about 58 ohms) on the outside of a thin-walled silica tube, the inside of which was water cooled.† This resistance, which is capable of dissipating over 1 kW., was mounted in a brass screening tube forming a short length of concentric line of very high damping closed at the end remote from the oscillator. Calculation shows that the skin effect is negligible at frequencies of the order of 100 Mc. The input impedance at the point A could therefore be determined from the measured resistance (at 50 cycles) and the calculated inductance and capacitance per unit length, since

$$Z_i = Z_0 \tanh \gamma l$$

where l = length of resistance (= 18.1 cm.),

$$\gamma = \sqrt{ZY},\ Z_0 = \sqrt{Z/Y}$$

and $Z = R + j\omega L$, $Y = j\omega C$, R, L, and C being the resistance, inductance, and capacitance per cm.

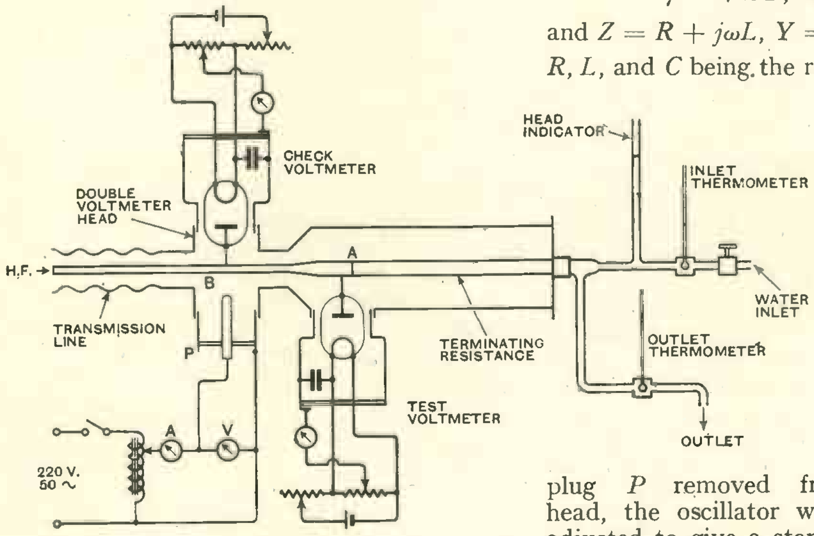

Fig. 17.—*Arrangement of apparatus for comparison between peak voltmeter and thermal method of voltage measurement.*

The H.F. voltage at the point A was determined in the following way. With the 50-cycle plug P removed from the voltmeter head, the oscillator was switched on and adjusted to give a standard reading on the check voltmeter (about 185 v. peak). The cooling water flow was maintained constant by means of the head indicator and inlet tap, and the temperature rise of the water was measured after thermal equilibrium had been reached. The test voltmeter reading was also noted. The oscillator was then switched off and the 50-cycle plug connected to the line. Blocking condensers at the

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* *See* H. Higinbotham, *Wireless Engineer*, 12, 373 (July, 1935).

† I am indebted to Mr. B. S. Gossling for suggesting this form of resistance.

oscillator end of the line enabled this to be done without any alteration to the circuit. The value of the resistance and the temperature rise were then determined for several 50-cycle voltages in the neighbourhood of 130 v. R.M.S. Interpolation gave the voltage and resistance corresponding to the temperature rise obtained on H.F., the water flow being constant throughout. The input impedance was then calculated for the appropriate values of resistance and frequency, giving a result of the form $Z_i = A + jB$ ohms. Now if $k_1 = |Zi|/R_0$ and $k_2 = A/R_0$, where R_0 is the total resistance at 50 cycles, it can easily be shown that the ratio of H.F. voltage at A to 50-cycle voltage for the same temperature rise is $k_1/\sqrt{k_2}$.

Owing to imperfect matching the voltage at B, the measuring point in the double voltmeter head, was slightly different from that at A, the beginning of the graphite resistance. The ratio of the two was obtained by transferring the test voltmeter from A to its normal position B. Since this ratio was not greatly different from unity (about 10 per cent. at 100 Mc.) it could be determined with negligible error by using a diode having small inter-electrode clearance in the test meter. The H.F. voltage at B is thus determined in terms of the 50-cycle voltage.

Thorough precautions were taken to ensure accuracy. The A.C. instruments were of the dynamometer type accurate to about 0.25 per cent., and the electrostatic voltmeters were calibrated to an accuracy of the same order. The largest experimental inaccuracy (possibly 1 per cent.) occurred in reading the temperature rise, which was not allowed to exceed about 20 deg. C. to ensure constancy of the graphite resistance, which had previously been "aged," during the measurements. The resistance was carefully adjusted and checked, by means of an electrostatic voltmeter, for uniformity. Its temperature coefficient, and the effect of the small dissipation of heat otherwise than in the cooling water, were eliminated by the method of measurement. The rate of flow of the cooling water was held constant to less than 0.5 per cent.

(*b*) *Results.*

Several trial runs were carried out to find the time necessary to reach thermal equilibrium (about 5 minutes) and to check the experimental accuracy. The results were consistent to about 1 per cent. Comparisons between the thermal and peak voltmeter methods of determining the voltage at B (Fig. 17) were carried out at 103 Mc. and 35.3 Mc. (*see* Figs. 13 and 14) giving the following results:

Frequency	103	35.3 Mc.
Voltage by peak voltmeter	189.5	186.8 V. peak
Voltage by thermal method	172	182 V. peak
Difference	9.3	2.6%

While the discrepancy between the two methods is not very large, it is considerably greater than had been expected and can hardly be explained by experimental inaccuracies.

There are two other possible causes: (1) there may have been a small difference of H.F. potential between the outer conductor of the line at the measuring point and at the further end of the resistance, and (2) the thermal method is essentially an R.M.S. measurement and the form factor of the H.F. wave may have differed from $\sqrt{2}$, which value is assumed in the table above. While both these effects may have been appreciable, it seems likely that the second was the more important. The oscillator used in these tests had been adjusted and accurately calibrated for other purposes at a considerably higher anode voltage than that used in the tests. As it was not permissible to alter the adjustment, the frequency being varied by a single remote control, the load coupling was tighter than the optimum at the anode voltage used, particularly at 103 Mc. The "flywheel" effect of the anode oscillatory circuit would thereby be reduced with an increase in the flattening of the voltage wave due to grid damping. Owing to the effect of electron inertia the latter would be greater at 103 Mc. than at 35.3 Mc. In addition the C/L ratio in the anode circuit was smaller at the higher frequency. Direct measurement of the form factor (*e.g.* by cathode ray oscillograph) seems hardly possible to the required accuracy without a major investigation into the measuring apparatus.

The effect of displacement currents in the silica tube or the cooling water was also considered as a possible source of error.

A rough estimate of the magnitude of this effect indicates that it is unimportant.

While it is believed that the peak voltmeter measurements are considerably more accurate than the discrepancies in this comparison might suggest, the results illustrate the great difficulty of carrying out an absolute standardisation of voltage at very high frequencies.

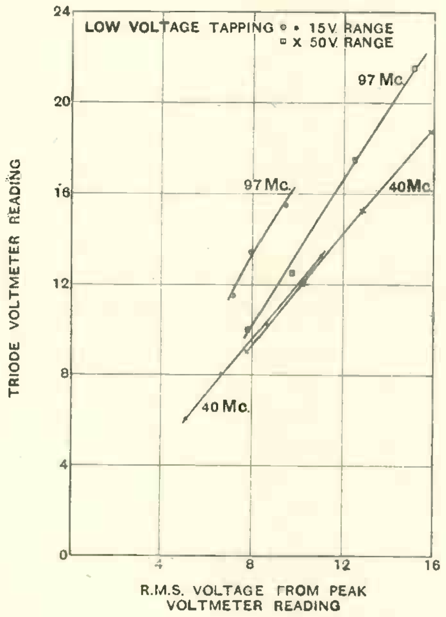

Fig 18.—*Calibration curves for triode voltmeter* 1 (*standard valve*).

IV. Calibration of Other Valve Voltmeters against Peak Voltmeter.

A few calibration curves of two triode "anode-bend" voltmeters were taken at frequencies of 40 Mc. (7.5 m.) and 97 Mc. (3.1 m.). It was not possible to arrange for making these measurements to a high degree of accuracy but the results serve as a guide to the performance of triode voltmeters at frequencies above 30 Mc.

Voltmeter 1 used a valve similar to the standard ML4 with the grid lead brought out at the top of the bulb; voltmeter 2 a valve of very small dimensions ("acorn" type), actually a pentode with the screen used as anode. The former was a standard instrument intended primarily for broadcast wavelengths, the latter an experimental one for short and ultra-short wavelengths.

The apparatus was that previously described (*see* Figs. 9, 10 and 17). As interest lay chiefly in the performance of the triodes at low voltages, use was made of a tapping (removed during the previous tests) on the terminating resistance, since voltages lower than about 35 peak could not conveniently be produced at the voltmeter head. The ratio of this tap at 50 cycles, with an allowance for the difference in H.F. voltage between points *A* and *B* (Fig. 17), was taken as an approximation. A different resistance unit was used which was known to be less uniform than the one referred to previously. The peak voltmeter diode had a clearance of 0.12 mm. and the necessary corrections (all small) were applied to its readings. The triode voltmeters were connected either to the tapping or to the voltmeter head by concentric leads about 14 cm. long for voltmeter 1 and 8 cm. for voltmeter 2. These were the shortest the form of the apparatus would allow. An approximate calculated correction for the error due to the impedance of these leads was applied.

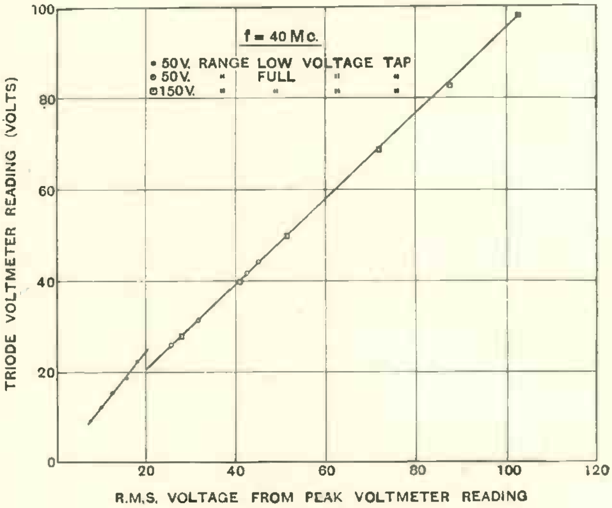

Fig. 19.—*Calibration curves for triode voltmeter* 1 *showing error introduced by using low voltage tap.*

The results are shown in Figs. 18, 19 and 20. A form factor of $\sqrt{2}$ has been assumed in converting the peak voltmeter readings to R.M.S. values, the triode voltmeters being originally calibrated in R.M.S. voltage at 50 cycles.

Owing to the uncertainty in determining

the tap ratio and triode impedance error, the calibration curves do not give an exact account of the performance of the triode itself. However, the presence of electron inertia error may be detected by (1) curvature of the calibration line, and (2) discrepancy between different voltmeter ranges involving different electrode potentials. The following conclusions can thus be drawn about the *inertia error* :

Voltmeter 1 :

40 Mc. The error becomes appreciable at about the following voltages :

150 v. range, 25 v.
50 v. range, 10 v.
15 v. range, 6 v. (?)

97 Mc.

50 v. range, error large at about 15 v.
15 v. range, error much smaller at about 10 v., but probably still quite large.

Voltmeter 2 : (15 v. range, higher ranges not (available).

40 Mc. No appreciable error down to 6 v.
97 Mc. Error appreciable below about 10 v.

An appreciable error may be taken to mean one of a few per cent. or more. The slight increase in apparent error at the higher voltages in Fig. 19 may possibly have been due to a change of triode input impedance or oscillator wave-form with voltage. The fact that the upper line is straight, but does not quite pass through the origin when produced, makes the latter explanation more probable.

Fig. 19 indicates that the readings at the low voltage tap are about 18 per cent. high at 40 Mc. with voltmeter 1, while Fig. 20 shows that they are about 7 per cent. high with voltmeter 2 at this frequency. The error in the estimated tap ratio therefore cannot be more than about 7 per cent. and may well be less at this frequency. The remainder of the 18 per cent. is due to the error in estimating the effect of the connecting lead impedance which is likely to have been greater at the low voltage tap than at the voltmeter head. It is clear that in all the 97 Mc. readings this effect outweighs the reduction in reading due to electron inertia.

The results bring out another interesting point. In voltmeter 1 the change from the 50 v. to the 15 v. range involves a reduction anode voltage from 270 v. to 100 v. accompanied by a reduction of the (automatic) negative grid bias roughly in the ratio of the range voltages. It is clear from Fig. 18 that the grid bias change has a much greater effect on the inertia error than the oppositely acting anode-voltage change as, indeed, qualitative theoretical considerations might lead one to expect.

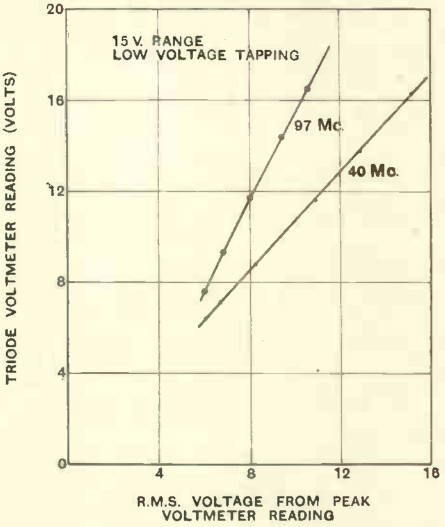

Fig. 20.—*Calibration curves for triode voltmeter 2 (" acorn " valve).*

In conclusion it may be stated that both types of triode voltmeter are serviceable, if not accurate, at frequencies of the order of 40 Mc. for voltages down to 5 or 10. The calibrations were not accurate enough to bring out the difference in inertia error at this frequency, but it is not this, but the low input impedance, both *per se* and through its exaggeration of the effect of the connecting leads, that is the chief disadvantage of these instruments as compared with the diode voltmeter evolved in this investigation, and of the standard as compared with the small triode. For very low voltages (of the order of 1 v. and less) the only hope for accurate measurements seems to be calibration from a diode peak voltmeter by means of an attenuating network capable of withstanding high voltages during its calibration. Schemes for such measurements have been devised and it is hoped shortly to carry them into effect.

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

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is generally no indication of the importance of the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

PROPAGATION OF WAVES

1341. Micro-Ray Communication. Effect of Weather on Transmission: Possible Future Uses of Wavelengths below 50 cm.—McPherson and Ullrich. (*Electrician*, 7th Feb. 1936, Vol. 116, pp. 181–182 and 184.) Summary of I.E.E. paper and subsequent Discussion.

1342. Some Examples of the Reflection and Diffraction [by Buildings] of Ultra-Short Waves of 3 Metres Wavelength.—J. Obata and Y. Munetomo. (*Journ. I.E.E. Japan*, November, 1935, Vol. 55 [No. 11], No. 568, p. 1002: Japanese only.)

1343. Transmission of 10-Metre Waves during the Summer of 1934, *and* Transmission of 20-Metre Waves during the Summer of 1934.—O. Burkard and G. Kunze: G. Kunze. (*Sci. Abstracts*, Sec. B, 25th Jan. 1936, Vol. 39, No. 457, p. 52.)

For the 10-m waves, sunspot maxima usually gave minimum intensity, but atmospheric conditions had a greater influence, the best conditions being when the transmitter was in a region of dry air under falling pressure. Fading occurred in 5½ day periods. For the 20-m waves the effect of sunspots was smaller and the 5½ day fading only sporadic. "Results are taken from experiments in all parts of the world."

1344. The Interaction of Radioelectric Waves [Results of U.R.S.I. Tests in Feb. and March, 1935: Observations by 30 Physicists in Various Countries].—B. van der Pol. (*L'Onde Élec.*, December, 1935, Vol. 14, No. 168, pp. 804–808.) *See* 3749 of 1935.

1345. The Luxembourg Effect [Survey and Discussion].—D. Graffi. (*Alta Frequenza*, January, 1936, Vol. 5, No. 1, pp. 42–48.)

A footnote remarks that "recent observations made by the R.I.E.C. at Leghorn indicate that this last rule [that the interfering station should be 250–300 km away along the great circle joining the receiver to the wanted station] is not always obeyed, since Luxembourg produced its effect on the Kattowice (Poland) station."

1346. Confirmation of Cosmic Phenomenon [54-Day Fade-Out], *and* The Hydrogen Outburst on the Sun and Radio Fading.—J. H. Dellinger: R. S. Richardson. (*Science*, 6th Dec. 1935, Vol. 82, pp. 548–549: 10th Jan. 1936, Vol. 83, Supp. pp. 6–7.) *See* also 1347.

1347. High-Frequency Radio Fade-Out on October 24, 1935.—Dellinger. (*Journ. Franklin Inst.*, January, 1936, Vol. 221, No. 1, pp. 157–158.)

See also 1346, above; 1348, below; and 862 of March. A fade-out of modified form occured on 24th Oct. 1935. The obliteration of signals did not extend to such low frequency values and was not so sudden. There was simultaneous sunspot activity and magnetic disturbance. The high-frequency transmission improved as sunspot activity increased but was suddenly impaired on 24th October, subsequently recovering. The cause of the fade-out may be a very sudden eruption on the sun.

1348. A New Solar Radio Disturbance [54-Day Fade-Out].—J. H. Dellinger. (*Electronics*, January, 1936, Vol. 9, pp. 25 and 34.) *Cf.* above.

1349. Electric Influence of the Active Region of the Sun [Five Terrestrial Electric Phenomena give Indications of 27·25-day Period in Phase with Variation of Sunspot Activity].—F. Sanford. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, pp. 206–207: abstract only.)

1350. Recent Large Sunspots [Data for December, 1935, and January, 1936].—(*Nature*, 1st Feb. 1936, Vol. 137, pp. 183–184 : short note only.)

1351. Data on Daily Number of Meteors.—C. C. Wylie. (*Sci. News Letter*, 25th Jan. 1936, Vol. 29, p. 56.)

1352. Searchlights to Explore the Upper Air.—Tuve, Johnson and Wulf. (*Science*, 13th Dec. 1935, Vol. 82, Supp. p. 13.) *See* also 861 of March.

1353. The Ionosphere and Its Influence upon the Propagation of Radio Waves [Survey].—J. P. V. Madsen. (*John Murtagh Macrossan Lecture*, 1935, University of Queensland, 43 pp.) Published by Simmons, Limited, Sydney.

1354. On the Method of Expressing and Utilising Data on Radiation and Propagation [and the Use of the Magnitudes "Forza Cimomotrice" (Cymomotive or "Wave-Producing" Force) and "Virtual Distance"].—L. Sacco and U. Tiberio. (*Alta Frequenza*, December, 1935, Vol. 4, No. 6, pp. 668–687.)

The need for these two quantities, long employed in the Italian army, is suggested by certain defects in the ordinary way of representing the characteristics of radio stations, and propagation data, revealed at the Lisbon reunion of the C.C.I.R. "Cymomotive force" (alternative terms suggested are "radiation potential" and "radiomotive force") denotes the capability of a transmitter to produce a field at a distance in a certain direction ; so that if E is the cymomotive force in volts, F the field strength produced, in mv/m, at a distance of D in km, then within certain limits $E = FD$: for a vertical earthed semi-dipole, of height much smaller than the wavelength, $E = FD = 300\sqrt{P}$, where P is the power in kw. Thus such an aerial, radiating 1 kw with circular emission, would possess a cymomotive force of 300 v in the horizontal plane. "Virtual distance" denotes the attenuating property of a given path, and is given by E/F', where F' is the field strength actually produced ; so that for 1 kw radiated circularly (as above) $D = 300/F'$.

1355. An Improved Pulse Transmitter [giving a Truly Square-Topped Pulse which can be made Very Narrow].—G. Millington and S. W. H. W. Falloon. (*Marconi Review*, Nov./Dec. 1935, No. 57, pp. 12–17.)

With the ordinary Ratcliffe-White circuit (1933 Abstracts, p. 495) the h.f. output remains at maximum for a short time and then falls rapidly *but not instantaneously* to zero, so that if a very narrow pulse is attempted its top will be so narrow that the transmitter will not have time to build up to the true peak value. The writers therefore employ a second thyratron, controlled by a delay circuit from the first thyratron, to give a very sharp cut-off.

1356. Measurement of the Atmospheric Ozone during the Polar Winter at Abisko [and the Relations between Quantity of Ozone and Horizontal Displacements of Large Masses of Air].—Barbier, Chalonge and Vassy. (*Journ. de Phys. et le Radium*, December, 1935, Vol. 6, pp. 132–133 s.) For a *Comptes Rendus* Note *see* 31 of January.

1357. The Oxygen Afterglow [Reply to Criticism].—E. M. Stoddart. (*Proc. Roy. Soc.*, Series A, 2nd Dec. 1935, Vol. 153, No. 878, pp. 152–157.) *See* Stoddart, *Phil. Mag.*, 1934, Vol. 18, p. 409 ; Rayleigh, *Proc. Roy. Soc.*, Series A, 1935, Vol. 150, p. 34.

1358. Zeeman Effect in the Atmospheric Oxygen Bands : Production of a Strong Magnetic Field over a Length of 80 cm.—R. Schmid. (*Phys. Review*, 1st Feb. 1936, Series 2, Vol. 49, No. 3, p. 271.)

1359. The Possible Identification of Certain Night-Sky Radiation with the Schumann-Runge Bands of the Oxygen Molecule.—J. Cabannes and J. Dufay. (*Comptes Rendus*, 5th Feb. 1936, Vol. 202, No. 5, pp. 365–367.)

1360. The Excitation of the Auroral Green Line by Metastable Nitrogen Molecules [Experimental Conditions compared with Those of Night Sky and Aurora Borealis].—J. Kaplan. (*Phys. Review*, 1st Jan. 1936, Series 2, Vol. 49, No. 1, pp. 67–69.)

1361. Ionic Dispersion [in Electrolytes] in the Extreme Infra Red [Introduction of Inertia Term into Equations for Infra-Red Reflection and Absorption by Thin Metallic Films].—C. H. Cartwright. (*Phys. Review*, 1st Jan. 1936, Series 2, Vol. 49, No. 1, pp. 101–102.)

1362. Aberration of Light and the Doppler Effect [Aberration Phenomena with Double Stars and Terrestrial Objects indicate that Velocity of Light depends on Time].—K. Papello. (*Zeitschr. f. Physik*, No. 7/8, Vol. 98, 1936, pp. 490–495.)

1363. Dispersion and Resonance Phenomena in the Upper Layers of the Ground [Natural Vibrations of Ground : Observed and Calculated Dispersion Curves for Rayleigh Waves].—R. Köhler. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 597–600.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

1364. Radio Noises from the Galaxy [due to Ionisation of Cold Matter by Diluted Stellar Radiation in Interstellar Space].—R. M. Langer. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, pp. 209–210 : abstract only.) *See* 892 of March : for previous papers by Jansky *see* 41 of January.

1365. CHANGE OF PATH OF LIGHTNING FLASH [occasioned by Induced Charges in Neighbourhood].—B. Walter. (*Ann. der Physik*, Series 5, Vol. 25, No. 2, 1936, pp. 124–142.)

A further discussion of some photographs of lightning flashes (Figs. 1–6) taken with a moving camera and already published and discussed by the writer (*Ann. der Physik*, Series 4, Vol. 10, 1903, p. 393). The main conclusion is that "the change with time of the path of a discharge from a thundercloud depends to a considerable extent on the number and nature of the induced charges produced in the neighbourhood of the cloud by its high potential." The path first taken is directed towards one of the induced charges, but the second stroke may be directed towards another, *e.g.* in another cloud, although the first path was already ionised and would seem to offer less resistance than a new path. Figs. 2 and 3 show cases when both paths end on the earth; this is explained by the assumption that the first path met a region of high conductivity surrounded by one of low conductivity; the second path strikes a more distant highly-conducting region. Subsequent return of the discharge to its original path may occur: there appears to be a high degree of electrical similarity between clouds holding induced charges and the upper layers of the earth's surface. *See* also 452 of February.

1366. THE USE OF ALUMINIUM FOR LIGHTNING-CONDUCTOR LEADS [and the Calculation of the Necessary Cross-Section to avoid Fusing].—B. Walter. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 17, 1936, pp. 17–19.)

1367. LIGHTNING INVESTIGATIONS ON A DISTRIBUTION SYSTEM [with Interconnection Method of Protection: Surge Recorder Results].—Halperin and Grosser. (*Elec. Engineering*, January, 1936, Vol. 55, No. 1, pp. 63–70.)

1368. OSCILLOGRAPHIC STUDY OF OVERVOLTED DISCHARGES [in Air: Field Emission initiates Discharge].—J. W. Flowers. (*Phys. Review*, 15th May, 1935, Series 2, Vol. 47, No. 10, pp. 801–802: abstract only.) *See* also 45 of 1935.

1369. A STUDY OF SHORT TIME LAGS IN SPARKS AS A FUNCTION OF OVERVOLTAGE [in Air at Atmospheric Pressure].—R. R. Wilson. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, p. 210: abstract only.)

1370. EFFECT OF RAINFALL ON IONISATION REGISTERED BY RECORDING COSMIC METER WITH TOP SHIELD REMOVED [Radioactive Materials brought down from Upper Atmosphere].—R. L. Doan. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, p. 198: abstract only.)

1371. FURTHER INVESTIGATIONS OF THE ATMOSPHERIC IONISATION ASSOCIATED WITH RAINFALL [Radioactive Matter accumulated in Thundercloud brought down by Rain].—G. R. Wait and A. G. McNish. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, p. 201: abstract only.) *See* 1934 Abstracts, p. 434.

1372. STUDY OF THE EARTH'S MAGNETIC FIELD, ATMOSPHERIC IONISATION AND VERTICAL CURRENT AT SCORESBY SOUND DURING THE POLAR YEAR.—Dauvillier. (*Journ. de Phys. et le Radium*, January, 1936, Vol. 7, No. 1, pp. 40–48.) For the beginning of this paper *see* 899 of March.

1373. STUDY OF SOME PROBLEMS OF TERRESTRIAL MAGNETISM: EXPLANATION OF THE DIURNAL VARIATION OF THE FIELD [based on Scoresby Sound Observations].—J. P. Rothé. (*Journ. de Phys. et le Radium*, January, 1936, Vol. 7, No. 1, pp. 148–149 D.) For a previous paper *see* 1934 Abstracts, p. 32.

1374. A PRACTICAL SYSTEM OF AUTOMATIC RADIO SIGNALS FROM A FREE BALLOON [Radiometeorograph using 5 m Waves].—Nat. Bureau of Standards. (*Journ. Franklin Inst.*, November, 1935, Vol. 220, No. 5, p. 659: short note only.)

PROPERTIES OF CIRCUITS

1375. SURVEY OF RECENT RESEARCHES ON NON-LINEAR OSCILLATIONS [Theoretical and Experimental Russian Work: Report to U.R.S.I., London Meeting].—Mandelstam, Papalexi, Andronow, Chaikin and Witt. (*Tech. Phys. of USSR*, No. 2/3, Vol. 2, 1935, pp. 81–134: in French.)

1376. RESONANCE PHENOMENA IN LINEAR SYSTEMS WITH PERIODIC PARAMETERS.—G. Gorélik. (*Tech. Phys. of USSR*, No. 2/3, Vol. 2, 1935, pp 135–180.) French version of the papers dealt with in 2592 of 1935 and 64 of January.

1377. ON A METHOD FOR PARAMETRIC EXCITATION.—J. B. Kobzarev. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 5, 1935, pp. 958–963.)

In the systems so far investigated, in which the frequency of oscillations is different from that of the applied e.m.f., it is observed that in addition to the variation of the parameters a "direct" action such as a forced variation of the oscillating current also takes place. In the present paper a case of a "pure" parametric excitation is examined. The circuit under consideration makes use of a dynatron oscillator adjusted for operation at the point of intersection of the anode-current/anode-voltage curves, *i.e.* the point for which the anode current is zero, and with the grid bias sufficient to prevent self-oscillations. If an e.m.f. is applied to the grid of the valve there will be no "direct" action, since no current is flowing through the circuit; the slope of the valve characteristic will, however, be varied periodically and it is shown that if the frequency of the applied e.m.f. is twice the natural frequency of the circuit, oscillations at the natural frequency will under certain conditions arise in the circuit.

A mathematical investigation of the system is given including the determination of the amplitude of the oscillations and of the time required for their growth and decay. Resonance curves obtained experimentally are also shown.

1378. On the Theory of Non-Linear Resonance.—J. B. Kobsarev. (*Tech. Phys. of USSR*, No. 1, Vol. 2, 1935, pp. 27–42: in German.)

Author's summary:—By the use of a special, clear method, consisting in the consideration of the action of an "ideal impulse" on a non-linear system and in the representation of the function in the form of a sum of a continuous succession of impulses, general formulae of the first approximation are obtained which are valid not only for the case of "dividing" resonance [$m \neq 1$, $n = 1$, where m/n is the ratio of the imposed frequency to the natural frequency of the non-linear system] but also for "multiplication" resonance [$m = 1$, $n \neq 1$; there is a printer's error here], "fractional" resonance [$m \neq 1$, $n \neq 1$], and for resonance with a periodic external force of arbitrary form. These formulae contain as dependent variables the slowly varying amplitude and phase of the natural oscillations of the system. By transformation of the equations to rectangular co-ordinates it is shown that in the special case of "dividing" resonance these equations become the same as those found by Mandelstam and Papalexi [1932 Abstracts, pp. 279–280]. In the same co-ordinates the general stability criteria of the periodic movements are obtained: these are generalisations of the known criteria obtained by Mandelstam and Papalexi by the use of Poincaré-Liapounov methods. The advantage of the method developed in the present paper consists, in the author's opinion, in the possibility it presents of a searching investigation of the mechanism of the phenomenon. For previous papers *see* 929 of March, and 1377, above.

1379. On a Case of "Pulling-In."—J. B. Kobzarev. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 5, 1935, pp. 964–974.)

It is known that if two e.m.fs of equal amplitude but different frequencies are applied to an oscillator oscillating at a frequency approximately equal to the arithmetic mean of the applied frequencies, "pulling-in" may take place. This is shown by the fact that out of the three frequencies originally present only the frequencies of the applied e.m.fs remain in the circuit.

A detailed mathematical investigation of this phenomenon, from the point of view of quasi-linear theory, is presented in this paper for a typical case of an inductively coupled oscillator. Equations of the first approximation are derived and conditions determined for the stability of the resultant oscillations. The relationship between the amplitude of the oscillations and the amount of detuning is also investigated and the results are shown in a number of graphs.

1380. Building-Up and Beat Processes in "Mitnahme" [Pull-In].—P. Riazin. (*Tech. Phys. of USSR*, No. 2/3, Vol. 2, 1935, pp. 195–214: in German.) Practically identical with the Russian paper dealt with in 3822 of 1935.

1381. A Negative-Resistance Oscillator [Use of Amplifier with Input and Output Terminals connected].—N. L. Yates-Fish. (*Proc. Phys. Soc.*, 1st Jan. 1936, Vol. 48, Part 1, No. 264, pp. 125–134.)

Author's abstract:—It is shown that an amplifier with its input and output terminals connected together can behave as a negative resistance. This principle leads to the design of an oscillator employing two triodes, and having certain advantages over both the ordinary reaction circuit and the screen-grid dynatron. Some special wave-forms which were observed are illustrated. A method of using the instrument to measure the dynamic resistance of an oscillatory circuit is suggested.

1382. [Theory of] Detection of High-Frequency Current by the Shunted Condenser in the Grid Circuit of a Valve.—D. Milossavliévitch. (*Comptes Rendus*, 10th Feb. 1936, Vol. 202, No. 6, pp. 472–474.)

An algebraical expression is found for the grid voltage when a sinusoidally varying voltage is impressed on the far side of a shunted condenser in series with the grid. The expression for the drop in voltage differs from the usual one by a factor of the order of 0.7.

1383. The Filter-Coupled Inductive Glow-Discharge Oscillator [Control Circuit comprising Multisection Filter: Characteristics: Frequency Stability of Resonance Band].—W. E. Kock. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, p. 196: abstract only.) For previous papers *see* 1906 of 1935.

1384. R.F. Transition Losses [due to Impedance Mis-Matching: Graphical Method of Evaluating], *and* R.F. Impedance-Matching Networks [with Chart of Pi-Section Networks].—H. A. Wheeler: R. P. Glover. (*Electronics*, January, 1936, Vol. 9, pp. 26–27 and 46: pp. 28–29.)

1385. "Introduction to Electric Transients."—E. B. Kurtz and G. F. Corcoran. (At Patent Office Library, London: Catalogue No. 75762.)

TRANSMISSION

1386. Fundamental Characteristics of Electronic Oscillations.—E. C. S. Megaw. (*Nature*, 1st Feb. 1936, Vol. 137, pp. 189–190.)

Experiments are described which show that "electronic oscillations can be produced without any external resonant circuit and that they can have a single frequency." The mode of oscillation may be the same as that reported by Slutzkin and Leljakow (1934 Abstracts, p. 33); oscillations due to "axial" and "radial" motion of the electrons could be simultaneously maintained.

1387. On the Theory of Generation of Oscillations in Lecher Systems [Analysis of Witt's Circuit for Short and Ultra-Short Waves].—S. Strelkov. (*Tech. Phys. of USSR*, No. 2/3, Vol. 2, 1935, pp. 232–247: in German.)

For Witt's paper *see* 1934 Abstracts, p. 612. It is here assumed that the characteristic impedance is large compared with the ohmic resistance, and that the electronic currents in the valve are small compared with the capacitive currents (the system consists of Lecher wires connected between anode and grid, the back coupling being provided by the capacities of the electrodes and of the conductors connected to them). Conditions for self-excitation are found, and formulae are obtained for the amplitudes of the oscillations ; the stability of these oscillations is investigated. The possibility of various oscillation régimes, for fixed parameters, is shown, and for certain special cases the dependence of these régimes on the length of the Lecher system is given. The far end of the Lecher system is taken as open, short-circuited, or closed by an inductance or a capacity.

Of the various oscillations which are found to be possible, only some are stable : those with the frequency of the fundamental are always stable, while those with frequencies of the higher overtones are only stable when their increment is at least twice as large as that of the fundamental ($A^2 > 2 \,.\, \theta_1/\Delta\delta$, where θ_1 is the increment of the fundamental and A the amplitude of the overtone : A^2 is proportional to the increment of the overtone —*see* eqns. 23 and 24).

1388. Deviation-Control in Micro-Wave Generator Valves [Theoretical and Preliminary Experimental Investigation of Recent "Cathode-Ray-Tube" Idea of Oscillation Mechanism in Barkhausen-Kurz and Magnetron Oscillators].—U. Tiberio. (*Alta Frequenza*, December, 1935, Vol. 4, No. 6, pp. 714–732.)

Recent work (*e.g.* Carrara's on detection—1034 of 1935 : *see* also 1879 of 1935) indicates that the negative resistance of micro-wave oscillators is due to partial deflection of the emission current alternately to each of the two electrodes (grid and plate in the B-K oscillator, and the two plates in the magnetron) under the control of the alternating p.d. between these. To analyse this hypothesis, the writer imagines a model valve in which the deflection principle is applied by a control mechanism of an oscillographic type. The mode of operation thus appears simple and clear, and allows various deductions to be made regarding impedance, maximum efficiency, etc. The possibility of constructing actual valves after this model is discussed, and the design of a recent experimental type illustrated : this has an anode current of 30 mA and a ray diameter about 1 mm. Alfvén's early valve on the "transverse field" principle (1931 Abstracts, p. 557) is referred to.

1389. On the Motion of Electrons in Crossed Electric and Magnetic Fields with Space Charge [Physical Meaning of Theory : Magnetic Cut-Off].—L. Tonks. (*Physik. Zeitschr. der Sowietunion*, No. 5, Vol. 8, 1935, pp. 572–578 : in English.)

An examination of Braude's theoretical solution (3437 of 1935) with an exposition of its physical meaning. "Braude's conclusion that his solution . . . shows the absence of cut-off by a critical magnetic field is shown to be incorrect. The nature of the potential distribution and its relation to cut-off is [here] analysed in detail. A series of virtual cathodes of a peculiar type are found, whose spacing is proportional to current. A similar type of solution must exist in the cylindrical case. Only that solution which has no virtual cathode is stable and hence of physical significance, except perhaps when a cut-off magnetron is generating oscillations. The theory accounts for the decrease in current in a magnetron as cut-off is approached." *See* 1390, below.

1390. On the "Cut-Off" in the Plane Magnetron with Space Charge.—S. J. Braude. (*Physik. Zeitschr. der Sowjetunion*, No. 5, Vol. 8, 1935, pp. 584–586 : in English.) Note on above paper, discussing physical and mathematical truth of equations obtained.

1391. The Motion of Electrons in Electric and Magnetic Fields, taking into consideration the Action of the Space Charge.—Braude. (*See* 1444.)

1392. Correction to the Paper "The Paths of the Electrons in the Magnetron including the Effect of Space Charge. I" [Paths of Electrons in Absence of Magnetic Field need not be Straight Lines : Dependence on Potential Field].—Awender, Thoma, and Tombs. (*Zeitschr. f. Physik*, No. 7/8, Vol. 98, 1936, pp. 534–535.) *See* 70 of January.

1393. The Possible Use of a Temperature-Limited Diode to generate Negative-Resistance Oscillations at Ultra-High Frequencies.—North. (*See* 1450.)

1394. A Negative-Resistance Oscillator [Amplifier with Input and Output Terminals connected].—Yates-Fish. (*See* 1381.)

1395. Modulation of Frequency and the Necessity of Treatment as a Non-Linear Phenomenon : Experiments with a Wien [Toothed-Wheel] A. F. Generator.—S. Rytov. (*Tech. Phys. of USSR*, No. 2/3, Vol. 2, 1935, pp. 214–231 : in French.)

Previous workers have dealt with frequency modulation by linear theory. This, the present writer urges, must be considered unsatisfactory for several reasons (p. 218), all the more so since frequency modulation can only be obtained in practice in a non-linear system such as a triode oscillator. His treatment by non-linear theory of such an oscillator, frequency-modulated, leads to the following results :—The oscillation spectrum is identical with that which linear theory gives, neglecting the regions of instability : regions of instability are non-existent (there are no phenomena analogous to linear instability) : frequency modulation is accompanied by a modulation of amplitude (this is different from the result given by linear theory). These results apply to practical conditions only, *e.g.* when the oscillator régime is sufficiently far from the threshold of oscillation, and the modulating frequency is low compared with the carrier frequency.

The second part of the paper deals with a frequency modulation phenomenon observed in a toothed-wheel generator of sinusoidal e.m.fs. The writer finds that besides the principal frequency of 540 c/s there are often present symmetrically placed satellite frequencies of 540 ±18, 540±36, and 540±54, of amplitudes respectively 86%, 40% and 10% of the principal amplitude. Investigation of these shows them to be the result of frequency modulation produced, not by inequalities in the spacing of the rotor teeth, but by slight variations in speed of rotation. The analysis was carried out with the help of a special stretched-string resonator: the method may have useful applications in the study of periodic inequalities in rotation in internal combustion motors, turbines, etc.

1396. Frequency Modulation Equipment [Note Modulation for Short-Wave Telegraphy, to reduce Selective Fading: Privacy Modulators or "Wobblers" for Secrecy in S.W. Telephony].—E. Green and J. L. Hewitt. (*Marconi Review*, Nov./Dec. 1935, No. 57, pp. 1–11.) For Roder's paper, on which the first section on theory is mainly based, *see* 1932 Abstracts, p. 162.

1397. Methods for the Compensation of Non-Linear Distortion [of Grid-Modulated Transmitters].—A. I. Eilenkrig and E. I. Gorodnichev. (*Izvestia Elektroprom. Slab. Toka*, No. 12, 1935, pp. 43–54.)

The non-linearity of the modulation characteristic of a radio transmitter using the grid modulation system is mainly due to the lower bend of the anode-current/grid-bias characteristic of the modulated amplifier valve. In the present paper the following three methods are proposed for correcting this distortion:

(1) The modulating frequency is applied simultaneously to the grids of two consecutive stages of h.f. amplification (Fig. 1). The first stage is arranged to operate near the upper bend of the characteristic so that it becomes effective only during the negative swings of the modulating frequency, with the result that the grid of the second stage receives an additional negative potential during these swings.

(2) The anode-filament circuit of a compensating valve is connected across a resistance R_1 in series with the grid of the modulated amplifier (Fig. 4). The modulating frequency is applied to the grids of both the modulated amplifier and compensating valve (180° out of phase in the latter case). The anode current flows through the compensating valve only during the negative swings of the modulating frequency and causes an additional voltage drop in R_1 and therefore a decrease in the grid potential of the modulated amplifier.

(3) A screen grid valve is used for the modulated amplifier (Fig. 11) and the screen voltage is regulated by means of a compensating valve as in (2). Some indications are given for determining the constants of the circuits and it is stated that circuit (2) has proved so successful that it was incorporated in radio broadcasters manufactured in the U.S.S.R. during 1935.

1398. "Quality": Modifying Broadcast Transmission to Aid the Listener [Present Demand for 90% Maximum Modulation Depth a False Step: Improvement in Received Quality if Modulation never exceeded 60%].—P. P. Eckersley. (*Wireless World*, 7th Feb. 1936, Vol. 38, pp. 133–134.)

1399. Grid-Leak Modulation [Good Results with Proper Arrangement: Advantages].—O. H. Huston. (*QST*, February, 1936, Vol. 20, p. 58.)

1400. A Method of Telegraphic Keying, and of Telephonic Modulation, for High-Power Radioelectric Transmitting Stations [by Variation of Impedance of Coupling between Oscillator and Amplifier Stages, or between Transmitter and Aerial].—M. Michel. (*Ann. des Postes T. et T.*, January, 1936, Vol. 25, pp. 47–71.) Giving excellent signals even on waves down to 20 m. The system is in permanent service at a 35 kw commercial telegraph station.

1401. Broadcast Transmitter Features [Cabinet-Style Construction: Accessibility: R.F. Insulators: Fewer Rotating Machines: etc.].—J. P. Taylor. (*Electronics*, January, 1936, Vol. 9, pp. 20–24.)

1402. High-Power Audio Transformers [for Class B Amplification: 7.5 and 180 kw Transformers used at WLW].—J. F. Peters. (*Elec. Engineering*, January, 1936, Vol. 55, No. 1, pp. 34–36.)

RECEPTION

1403. Unicontrol Radio Receiver for Ultra-High Frequencies using Concentric Lines as Interstage Couplers [λ/4 Lines grounded at One End, with Plungers ganged for Unicontrol: Four-Stage Amplifier with Amplification over 16 per Stage at 100 Mc/s, and 2 per Stage at 300 Mc/s].—F. W. Dunmore. (*Journ. of Res. of Nat. Bur. of Stds.*, December, 1935, Vol. 15, No. 6, pp. 609–618.) By running the d.c. plate supply lead down through the centre of the inner concentric tube, only one concentric line is used between each stage, in place of the obvious two. *See* also 1404.

1404. An Unconventional Receiver for the Ultra-High Frequencies; Details of a New Development from the National Bureau of Standards.—Dunmore. (*QST*, February, 1936, Vol. 20, pp. 21–23.) *See* also 1403.

1405. Ultra-Short-Wave Superhet for A.C. Mains: on *Wireless World* "Single-Span" Principle: extensible to an All-Wave Superhet.—G. Faust. (*Funktech. Monatshefte*, January, 1936, pp. 18–20.)

1406. A Ten-Metre Converter for Band-Switching Superhets without 28 Mc/s Coverage.—G. Grammer. (*QST*, February, 1936, Vol. 20, pp. 39–41.)

1407. A Noise-Silencing I.F. Circuit for Superhet Receivers: an Effective Method of Coping with Auto-Ignition and other Electrical Interference in C.W. and Telephone Reception.—J. J. Lamb. (*QST*, February, 1936, Vol. 20, pp. 11–14 and 38, 90, 92, 106, 108, 110 and 112.)

Making use of the short-time nature of the interference (until prolonged in effect by some element of the receiving circuit such as the loudspeaker) and acting *before* it reaches the stages most susceptible to overloading and cross-modulation, thus differing from other limiting devices. The noise peaks extending above the desired signal amplitude are amplified and rectified, and the rectified voltage is used to reduce the gain of the final i.f. stage, so that the noise kills itself by partly or wholly blocking this amplifier during the noise pulse. The time is so short that no audible gap in the desired signal is discernible. For the necessary small time constant and freedom from instability of the silencing action, not only proper circuit constants are required but also valves with suitable characteristics; no other valve has been found so suitable as the metal 6L7 (*cf.* 1455) for the i.f. silencer-amplifier. There is an enthusiastic editorial note on the performance of the scheme.

1408. AUDIO OUTPUT LIMITERS FOR IMPROVING THE SIGNAL-TO-NOISE RATIO IN RECEPTION.—H. A. Robinson. (*QST*, February, 1936, Vol. 20, pp. 27–30.)

1409. A DETECTOR CIRCUIT FOR REDUCING NOISE INTERFERENCE IN TELEPHONE RECEPTION [by Balancing-Out All Voltages beyond a Certain Amplitude].—L. E. Thompson. (*QST*, February, 1936, Vol. 20, pp. 44–45.) For a previous article, on c.w. reception, *see* 2243 of 1935.

1410. THE 11-WEEKS' MYSTERY INTERFERENCE [traced to Diathermy ("Inductotherm") Machines at Athletic Clubs].—(*QST*, February, 1936, Vol. 20, pp. 9–10: Editorial.) A "gargly" signal frequently changing its wavelength by a few hundred kilocycles and causing trouble to innumerable services. *Cf.* 964 of March.

1411. RADIO-INTERFERENCE: SUPPRESSION METHODS FOR [Oil-Burning] WATER-HEATING PLANTS.—Belling & Lee, Ltd. (*Electrician*, 24th Jan. 1936, Vol. 116, p. 96: summary only.)

1412. LUXEMBOURG EFFECT [Various Readers' Results].—(*World-Radio*, 7th Feb. 1936, Vol. 22, p. 9.) Interference examples in N.W. London, from Luxembourg, Droitwich, Kalundborg and Radio-Paris, show among other things that the affected stations were all above 350 m.

1413. PAPERS ON LUXEMBOURG EFFECT.—Graffi: van der Pol. (*See* 1344 and 1345.)

1414. SELECTIVITY OF TUNED CIRCUITS [increases with Wavelength, Decreased H.F. Resistance preponderating over Effect of Decreased L/C Ratio.]—S. O. Pearson. (*Wireless World*, 31st Jan. 1936, Vol. 38, pp. 100–102.)

1415. FEEDING [High-Fidelity Resistance-Coupled] PUSH-PULL AMPLIFIERS: METHODS OF PHASE REVERSAL.—W. T. Cocking. (*Wireless World*, 7th Feb. 1936, Vol. 38, pp. 126–128.) Including the "paraphase" system and a new system giving high-note accentuation without reducing gain at other frequencies (*see* also 983 of March).

1416. DETECTION OF H.F. CURRENT BY THE SHUNTED CONDENSER IN THE GRID CIRCUIT OF A VALVE.—Milossavliévitch. (*See* 1382.)

1417. THE PROBLEM OF "DYNAMIC INCREASE" [Contrast Expansion (and Compression) for Broadcasting, Sound Films, and Gramophones]: AMPLIFIERS WITH AUTOMATIC VARIATION OF AMPLIFICATION [Survey of Several Methods].—H. Lamparter. (*Funktech. Monatshefte*, January, 1936, pp. 13–17.)

With an enthusiastic introduction by Leithäuser. The author concludes that while satisfactory properties have already been obtained, all difficulties have not yet been eliminated: when this is accomplished, there is no doubt that volume compression at the microphone end, and expansion at the reproducing end, will come into use. *See* also 1935 Abstracts Index, under "Reception"—Volume.

1418. STUDY OF LEVEL REGULATORS AND "ANTI-FADING" DEVICES.—G. Espinasse. (*Ann. des Postes T. et T.*, December, 1935, Vol. 24, pp. 1098–1117.)

1419. THE EFFECTIVENESS OF AUTOMATIC VOLUME CONTROL DEVICES.—P. Mandel. (*Electronics*, January, 1936, Vol. 9, pp. 44–45.) Long summary of the French paper dealt with in 3854 of 1935.

1420. AUTOMATIC AUDIO-FREQUENCY VOLUME CONTROL DEPENDING ON THE EXTERNAL NOISE LEVEL [for Cinemas, Public Address, Restaurants, etc.].—H. Boucke. (*Funktech. Monatshefte*, January, 1936, pp. 31–32.)

1421. REMARKS ON AUTOMATIC SENSITIVITY CONTROL BY VARIABLE-MU VALVES: ADVANTAGE OF THE USE OF A SPACE-CHARGE-GRID VALVE.—M. Chauvierre. (*L'Onde Élec.*, December, 1935, Vol. 14, No. 168, pp. 809–820.)

In adopting the variable-mu valve for the automatic volume control of broadcast receivers, designers soon realised that valves with truly parabolic characteristics required considerable grid potentials—of the order of 40 or even 80 volts; in these conditions it was impossible to use, unchanged, the component of the current from the detector; it was necessary first to amplify it. The valve manufacturers, therefore, especially in Europe, brought out types of valve which gave great control of volume with only small variations in grid potential—thus producing valves which were indeed of variable amplification but which had by no means the fundamental properties indicated by Ballantine, who had stressed the importance of a curve of the 2nd degree. These AVC valves, on the contrary, had curves of at least the 3rd degree. In the last year or so the designs have been somewhat improved, but the writer's point is that even valves with a 2nd degree characteristic are bound to cause pre-detection, which favours all the phenomena of modulation of the incident wave by an undesired frequency and renders the receiver so susceptible to interference of various kinds that it cannot, as a rule, be worked at its maximum sensitivity.

The writer urges a return to the old ideal of rigorously straight characteristics over the working range, and envisages, as the ideal method of AVC, a hexode made by introducing, between the cathode and the control grid of an existing pentode, a slope-regulating grid. The slope would be steeper the less negative the grid, and could be completely annulled by a certain (fairly high) negative potential on the grid. He has not been able to make such a valve, but preliminary tests on existing hexodes (designed for an entirely different mode of use), in the space-charge-grid connection, illustrate the possibilities of his method. Thus, starting from the condition of maximum amplification, the variation is at first feeble and then grows rapid—exactly the contrary to what happens with an ordinary variable-mu valve arrangement. This property of the space-charge-grid control method avoids the need for delayed action. Moreover, the fact that the variable slope is obtained without departing from a first-degree characteristic enables the AVC to be applied also, if desired, to l.f. stages (a very useful possibility for certain purposes, including automatic contrast control) whereas "the use of a parabolic characteristic in l.f. is absolutely out of order"; even the carefully designed Cossor D.D. Pen. "introduces, mathematically, a certain amount of distortion, not a great deal in actual fact, but troublesome nevertheless."

Finally, the writer refers to criticisms by Bruck (Mazda), one being that it is difficult to leave a positive space-charge grid in the immediate neighbourhood of an oxide-coated cathode, owing to the rapid deterioration of the latter. The writer approves of the proposal to remedy this by having two grids between the control grid and the cathode, one negative, to which the slope control is applied, and the other positive, to give the electrons the desired velocity and to reduce the internal resistance. He disagrees with Bruck's objection that such a valve as he proposes would possess an insufficient grid swing.

1422. [Glow] Discharge Tubes in Radio Sets.—Heinze and Pohle: Miram. (*Electronics*, January, 1936, Vol. 9, pp. 42–43.) Based on the papers dealt with in 3855 of 1935 and 613 of February.

1423. Automatic Sharp Tuning ["Automatic Tuning Correction"].—R. Wigand: Murphy Radio Ltd. (*Funktech. Monatshefte*, January, 1936, pp. 21–23.) Based on the *Wireless World* description of the Murphy A 28 C receiver (4th Oct. 1935, pp. 380–382) and Power's description of the device (inset, 25th Oct. 1935).

1424. Broadcast Reception in Flats [and the Report of the Royal Institute of British Architects].—(*World-Radio*, 7th Feb. 1936, Vol. 22, p. 11.)

1425. Broadcast and Gramophone Distribution in Hotels, Inns and Institutions [Waldorf-Astoria and German Systems].—F. Linke. (*Funktech. Monatshefte*, January, 1936, pp. 33–35.)

1426. French Laws relating to Licences for Broadcast Receivers.—(*Rev. Gén. de l'Élec.*, 1st Feb. 1936, Vol. 39, No. 5, pp. 199–200.)

1427. Considerations in the Design of a High-Fidelity Radio-Gramophone.—W. J. Brown. (*Journ. I.E.E.*, February, 1936, Vol. 78, No. 470, pp. 194–212: Discussions pp. 212–228.) *See* 3425 of 1935.

1428. The Philips Multi-Inductance 535-A Receiver [for Short, Medium and Long Waves].—(*L'Onde Élec.*, December, 1935, Vol. 14, No. 168, pp. 834–838.)

1429. The Telefunken 586 WLK: a Nine-Circuit Six-Valve Superheterodyne Receiver for A.C. Mains.—Telefunken Company. (*Funktech. Monatshefte*, January, 1936, pp. 38–40.)

1430. The Three-Valve "Single-Span" Superhet: Experiences and Improvements.—H. J. Wilhelmy. (*Funktech. Monatshefte*, January, 1936, pp. 27–30.) *See* also 1849, 2257 and 3428 of 1935.

1431. The "By Request" Receiver [Crystal Receiver on Modern Lines].—H. F. Smith. (*Wireless World*, 7th Feb. 1936, Vol. 38, pp. 130–132.)

1432. "Funktechnische Schaltungssammlung" [with Circuits, and Data for Testing and Maintenance, of Current German Broadcast Receivers: to be extended Year by Year: Book Review].—E. Schwandt. (*E.T.Z.*, 2nd Jan. 1936, Vol. 57, No. 1, p. 31.)

1433. Measurements on Receivers: Principles and Units.—A. L. M. Sowerby. (*Wireless World*, 21st Feb. 1936, Vol. 38, pp. 196–198: to be concluded.)

1434. A Radio Receiver for the Private Plane [or as Emergency Receiver for Commercial Aircraft: Type 17A].—J. E. Corbin. (*Bell Lab. Record*, January, 1936, Vol. 14, No. 5, pp. 161–164.) *See* also 1465.

AERIALS AND AERIAL SYSTEMS

1435. The Broadcast Antenna [Field Results with Tower Aerials: Data on Their Efficiency, Base Voltage, Base Loss: Practical Design Considerations and Cost: Lighting Requirements: Directive Systems: Wire Aerials "definitely Outmoded": etc.].—A. B. Chamberlain and W. B. Lodge. (*Proc. Inst. Rad. Eng.*, January, 1936, Vol. 24, No. 1, pp. 11–35.)

1436. Some Comments on Broadcast Antennas [Constant Phase and Current preferable to Sinusoidal Distribution: Optimum Height for Non-Fading Aerial greater than 5/8ths of Wavelength and dependent on Frequency and Ground Conductivity: Suggested Combination of Vertical Constant-Phase-and-Current Aerial with High-Angle Suppressor System to eliminate High-Angle Lobe].—R. N. Harmon. (*Proc. Inst. Rad. Eng.*, January, 1936, Vol. 24, No. 1, pp. 36–47.) *See* also 3431 of 1935.

1437. A Critical Study of the Characteristics of Broadcast Antennas as affected by Antenna Current Distribution [Analysis of Vertical Wire with Sinusoidal Distribution: with Capacity Hat: "Sectionalised," "Constant Current," "Elevated," Franklin-Type and "Decreased Velocity" Aerials: "Cylinder" Aerial].—G. H. Brown. (*Proc. Inst. Rad. Eng.*, January, 1936, Vol. 24, No. 1, pp. 48–81.) Most of the results are somewhat disappointing: "for heights of the order of a half-wavelength, it is hard to find anything better than a straight vertical wire." The Franklin-type aerial seems the most promising.

1438. Radiation Resistance of Aerials.—G. W. O. H: Moullin. (*Wireless Engineer*, February, 1936, Vol. 13, No. 149, pp. 57–58.) Editorial on the paper referred to in 997 of March, and 1439, below.

1439. Radio Resistance of [Transmitting and Receiving] Aerials [Most Economical Aerial Design: Current Distribution not the same in Reception and Transmission].—E. B. Moullin. (*Nature*, 1st Feb. 1936, Vol. 137, p. 195: short note on recent I.E.E. paper.) *See* also 1438, above.

1440. On the Current Distribution in a Loop Aerial [Expression for Amplitude of Current].—D. Taylor. (*Proc. Phys. Soc.*, 1st Jan. 1936, Vol. 48, Part 1, No. 264, pp. 111–117.)

In continuation of previous work (2279 of 1935), more detailed experiments are here described, and the theory is extended. An expression for the magnitude of the current at any point in the loop is calculated and tested with a circular loop aerial. "The effect of damping is considered, and the probable value of the attenuation constant is calculated."

1441. Directional Properties of Short-Wave Frame Aerials [Variation of Current with Direction of Propagation and Wavelength: Frame Current Zero in only One Position].—L. S. Palmer. (*Nature*, 15th Feb. 1936, Vol. 137, p. 278: preliminary letter.)

1442. Discussion on "The Current-Loading Capacity of Earth Electrodes."—Taylor. (*Journ. I.E.E.*, February, 1936, Vol. 78, No. 470, p. 248.) *See* 136 of January.

1443. Vibrations of Power Lines in a Steady Wind. III—The Free Vibrations of a Heavy String.—R. Ruedy. (*Canadian Journ. of Res.*, January, 1936, Vol. 14, No. 1, Sec. A, pp. 16–24.) For II *see* 551 of February.

VALVES AND THERMIONICS

1444. The Motion of Electrons in Electric and Magnetic Fields, taking into consideration the Action of the Space Charge [Case of the Cylindrical Condenser: Application to Magnetrons].—S. J. Braude. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 8, 1935, pp. 667–674: in English.)

"The usual method for solving equations (1). . . . (4) leads, as in the plane case, to non-linear differential equations of the second and third order. Attempts to find a solution of these equations have not so far been successful. Let us use the method described in our paper" [3437 of 1935]. Equation 7 is obtained and solved by the method of successive approximations. By the first approximation the formula 12′ given by Langmuir is obtained; the second gives the wavelength formula $\lambda = 13\,150/H$, compared with Okabe's $\lambda = 13\,000/H$, while with the third approximation this becomes $\lambda = 17\,950/H$. These results are compared with the experimental results (Table 1) of Slutzkin and Steinberg, for magnetrons with diameters 10, 6 and 3 mm respectively (1929 Abstracts, p. 326). The increase of λH as the anode voltage is increased is explained by the electric field of the space charge becoming of negligible effect, at a very high anode potential, compared with the external electric field caused by the anode voltage. The data for λH obtained by the second and third approximations, compared with Table 1, show the limits of these solutions.

1445. On the Motion of Electrons in Crossed Electric and Magnetic Fields with Space Charge, *and* On the "Cut-Off" in the Plane Magnetron with Space Charge.—Tonks: Braude. (*See* 1389 and 1390.)

1446. "Die Elektronströmung in der Bremsröhre" [Electron Flow in the Brake-Field Valve].—F. H. Lange. (*Berlin Thesis*, 1935: at Patent Office Library, London: Cat. No. 75765.)

1447. Valves for Short [Ultra-Short and Micro-] Waves.—M. G. Scroggie. (*Wireless World*, 14th Feb. 1936, Vol. 38, pp. 156–158.) Including a comparative table of data of "acorn" valves (triodes and pentodes) and standard types of American valves, and of Hivac "Midget" and standard types: the X41 triode-hexode is also discussed.

1448. Diode Frequency Changers [Theoretical and Experimental Investigation: Comparison with Other Converters (*e.g.* Octodes): No Loss of Gain when Oscillator Harmonic is used for Ultra-Short-Wave Reception: etc.].—M. J. O. Strutt. (*Wireless Engineer*, February, 1936, Vol. 13, No. 149, pp. 73–80.) For more mathematical treatments *see* 1934 Abstracts, p. 614.

1449. Input Resistance of Vacuum Tubes as Ultra-High-Frequency Amplifiers.—W. R. Ferris. (*Proc. Inst. Rad. Eng.*, January, 1936, Vol. 24, No. 1, pp. 82–107.)

"The most important effect of the transit time on tube characteristics proves to be a serious in-phase or power component of the charging current to the control grid. This may be expressed as a conductance which will be shown in this paper to vary as the square of the frequency and thus to become of enormous importance as the frequency is increased [$g_g = Ks_m f^2\tau^2$]. The grid/cathode *capacity* varies scarcely at all with frequency in practical cases. This paper presents a physical explanation of the effect, an experimental verification of the theoretically derived formulas, and measurements of the magnitude of the effect in various commercial tubes." The magnitude of this input conductance g_g is such that it is the principal limitation for amplifiers at frequencies around 100 Mc/s, and it seriously affects the amplification even at 15 Mc/s. The plate resistance of s.g. valves is also found to vary with the frequency, but constitutes a negligible amount of the total loss in the circuit. This work was presented in part in the papers dealt with in 1934 Abstracts, p. 563, and 1873 of 1935.

1450. ANALYSIS OF THE EFFECTS OF SPACE CHARGE ON GRID IMPEDANCE [Extension of Existing Theory of Transit-Time Phenomena in High-Vacuum Diodes to High-Amplification Triodes and Tetrodes with Parallel Plane Electrodes].—D. O. North. (*Proc. Inst. Rad. Eng.*, January, 1936, Vol. 24, No. 1, pp. 108–136.)

The present treatment is limited to triodes with grounded plate and tetrodes with grounded screen grid. A special section deals with temperature-limited diodes (eqn. 16) : " here we have a curious reversal of the situation for space-charge-limited diodes, for which the inset of h.f. effects is manifested by a *lowering* of the conductance and a *decrease* in the cold capacity." This equation indicates how a temperature-limited diode can produce negative-resistance oscillations at very high frequencies. " Contrary to Benham's views, this author feels that a suitable theory of Barkhausen-Kurz oscillations can be built upon a basis of complete temperature limitation."

1451. THE VARIATION OF INTER-ELECTRODE CAPACITY IN THERMIONIC VALVES [Measurements by Special Bridge Circuit show Capacity Change between Any Two Electrodes to be Not Solely a Function of Magnitude of Current flowing : etc. : Application to Constant-Frequency Oscillators].—D. A. Bell. (*Marconi Review*, Nov./Dec. 1935, No. 57, pp. 18–27.)

Among the conclusions reached are the following : for stable-frequency oscillators the proper procedure is to arrange the grid coupling so that the proportion of grid-capacity change transferred to the tuned circuit balances the anode-capacity change (for this and another reason, valves of low amplification are likely to be more suitable than those of very high amplification) : a definite objection to the use of a dynatron oscillator is suggested (p. 27) : the importance of avoiding grid current, when measuring input capacity, is stressed. The reasons for using a bridge method of measurement are given and the method described : it is quite practicable to measure Miller effect on this bridge.

1452. ON THE FUNCTIONING OF THE TRIODE VALVE (INSTRUCTIONAL NOTES).—U. Ruelle. (*Alta Frequenza*, December, 1935, Vol. 4, No. 6, pp. 688–713.) A simple approximate treatment, the triode being considered in connection with practical circuits (for amplification, detection, retroaction and super-regeneration, oscillation and modulation) selected to illustrate its properties.

1453. NEW KINDS OF VALVE DESIGN : THE DANISH " RENODE " [and Its German Forerunner] : AMPLIFIER VALVES WITH ELECTRON LENSES : AMPLIFICATION BY SECONDARY EMISSION [Zworykin].—(*Funktech. Monatshefte*, January, 1936, pp. 11–12.)

The German forerunner of the " renode " was an experimental valve with an electron lens, in which the deflecting plates produced a change in the " current sharing " between two adjacent anodes : the " renode " (1011 of March) has only one anode, the deflecting plates themselves taking up some of the electron stream under the action of the signal. A new type of electron-optical amplifier valve is under development in Germany : here the cathode is enclosed in a control cylinder with two slits which pass out two sharp electron rays in opposite directions, each to its own anode. Modulation by the control cylinder alters only the electron density, not the shape, of the rays. An ideally straight characteristic is given. Such valves, " unlike the renode," could be made with current values, slope, etc., corresponding to those of the usual valves : on the other hand they offer the possibility of obtaining internal resistances down to about 200 ohms.

1454. VALVES FOR CAR RECEIVERS, WITH " COPPER-BIFILAR " CATHODES [Heating Watts reduced to 1.5 and 1.75 compared with Usual 2.6, by making use of Small Infra-Red Radiation Coefficient of Copper compared with Nickel].—(*Funktech. Monatshefte*, January, 1936, pp. 9–11.) The type numerals of these valves are followed by " Cu-Bi " (Telefunken) or " Cu " (Valvo). It is suggested that the new type of cathode will be of importance in the general field and not only for car receivers.

1455. USING THE 6L7 TO IMPROVE SUPERHET PERFORMANCE : ADAPTING PRESENT RECEIVERS TO USE THE NEW METAL-TUBE MIXER [Unlike Most Metal Valves, 6L7 and 6H6 (Duo-Diode) are Radically Different from Glass Valves and offer Special Advantages].—(*QST*, February, 1936, Vol. 20, pp. 48–49.) *See* also end of 1407.

1456. THE 307A POWER PENTODE [particularly for Mobile Transmitters : Separate Leads for All Three Grids].—E. A. Veazie. (*Bell Lab. Record*, January, 1936, Vol. 14, No. 5, pp. 150–153.)

1457. SOME THERMAL METHODS OF MEASURING LOSS OF POWER IN VACUUM TUBES [and the Comparative Merits of Air-Chamber, Thermometer, Bolometer, Thermopile and Thermocouple Indicators].—F. P. Cowan. (*Review Scient. Instr.*, January, 1936, Vol. 7, No. 1, pp. 13–16.)

" It is important to note that workers on ultra-high frequencies have used thermocouples almost exclusively for their measurements of efficiency, and without treatment of the errors due to induced currents. These are large at 16.9 megacycles and might be larger still at higher frequency."

1458. POTENTIAL RELIEFS OF HIGH-VACUUM AND GAS-FILLED DETECTORS AND RECTIFIERS.—H. Gottmann. (*Funktech. Monatshefte*, January, 1936, pp. 5–8.) Extension of work referred to in 570 and 571 of February.

1459. NOISES OF AMPLIFYING VALVES AND THEIR ACCURATE MEASUREMENT [and the Separation of the Different Components].—W. Jacobi and W. S. Pforte. (*E.T.Z.*, 2nd Jan. 1936, Vol. 57, No. 1, p. 18 : summary only.)

1460. ELECTRIC FORCE *versus* CENTRIFUGAL FORCE [Effect, on Characteristics, of Revolution of Valve about External Axis].—C. T. Dozier. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, pp. 207–208 : abstract only.)

1461. THERMIONIC EMISSION FROM TUNGSTEN AND THORIATED TUNGSTEN FILAMENTS.—W. B. Nottingham. (*Phys. Review*, 1st Jan. 1936, Series 2, Vol. 49, No. 1, pp. 78–97.)

From the author's summary :—The electron emission from pure and thoriated tungsten filaments has been investigated as a function of the applied potential over the entire range from a few volts retarding to 1 400 v accelerating, including careful studies at zero field. . . . The energy distribution of electrons was found to be deficient in slow electrons. An empirical reflection factor . . . represents the observed data for all temperatures and all states of activation for the thoriated tungsten. Analysis shows that there is no disagreement between the new results and the experiments of Germer [1925]. Zero-field Richardson plots show that the reflection effect alters both the A and b of Richardson's equation. . . . The value of A indicates a negative temperature coefficient of the work function . . . which has been verified by an independent experiment. New data on the electron emission in accelerating fields are given for many states of activation, showing that there are large deviations from the Schottky mirror image theory [1914]. Becker's patch theory [*see* 2656 of 1935] is discussed briefly and a simpler strip theory is developed which serves to represent the observed data as an empirical result. This analysis shows that the patch theory is not suitable to explain the reflection effect, since it is independent of the state of activation of the filament.

1462. A LONG-LIFE ACTIVATED HOT CATHODE [75-Micron Tungsten Wire wound on Molybdenum Core (chemically removed later) : Resulting Wire wound on 450-Micron Tungsten Spiral : Whole dipped in (*e.g.*) Barium Hydroxide].—Philips Company. (French Pat. 788 959, pub. 21.10.35 : *Rev. Gén. de l'Élec.*, 25th Jan. 1936, Vol. 39, pp. 29–30 D.)

DIRECTIONAL WIRELESS

1463. VISUAL COURSE INDICATOR FOR RADIO NAVIGATION.—I. M. Vekslin. (*Izvestia Elektroprom. Slab. Toka*, No. 12, 1935, pp. 54–63.)

A theory of the operation of the Kramar type visual course indicator (see 1934 Abstracts, pp. 443–444) is given, together with an account of tests carried out on a number of models utilising this principle. As a result of this investigation a new output circuit was developed (Fig. 4) which, it is claimed, ensures a smooth movement of the pointer of the indicating instrument. In this circuit two detector valves are interposed between the secondary of the output transformer and the indicating instrument, one on each side of the instrument, which must then be centre-tapped for the return current. As a practical modification the detectors feed into a centre-tapped potentiometer, across which an ordinary centre-zero millivoltmeter is connected. It is pointed out that for satisfactory operation of the system the speed of transmission of the radio beacon signal should be increased to at least 250 dash-dots per minute. This speed is not so high as to preclude the use of aural reception as an auxiliary method of control.

1464. THREE - DIMENSIONAL DIRECTION - FINDER [Linear Aerial perpendicular to Frame : Arrangement gives Zero Deflection when Aerial is directed towards Emitter].—W. Runge : Telefunken. (*Hochf:tech. u. Elek: akus.*, December, 1935, Vol. 46, No. 6, p. 215 : German Patent 617 487, dated 24.1.1934.)

1465. A RADIO COMPASS FOR AIRCRAFT [for Use in conjunction with Type 17A Receiver].—C. B. Aiken. (*Bell Lab. Record*, January, 1936, Vol. 14, No. 5, pp. 165–168.) For the 17A receiver *see* 1434.

1466. NEW AVIATION RADIO RECEIVES 2 SIGNALS ON SAME FREQUENCY [Weather Reports and Beacon Signals on Same Wave simultaneously].—(*Sci. News Letter*, 25th Jan. 1935, Vol. 29, p. 52.) No details are given.

1467. DETRIMENTAL EFFECT OF HORIZONTAL PORTIONS OF LONG LOW LOOP AERIAL (FOR AERIAL NAVIGATION) SUPPRESSED BY ONE OR MORE IMPEDANCES SYMMETRICALLY INTRODUCED.—Philips Company. (French Pat. 789 403, pub. 29.10.1935 : *Rev. Gén. de l'Élec.*, 25th Jan. 1936, Vol. 39, pp. 30–31 D.)

1468. NEW SYSTEM FOR THE DETECTION OF OBSTACLES AT SEA [Highly Directive Transmitter and Receiver for Very Short Waves, mounted as Far Apart as possible on Port and Starboard Bows and Screened from Direct Action].—Comp. Gén. de T. S. F. (French Pat. 788 795, pub. 16.10.35 : *Rev. Gén. de l'Élec.*, 25th Jan. 1936, Vol. 39, p. 29 D.) For a micro-wave "radio feeler" tested on the linear "Normandie," see *Wireless World*, 8th Nov. 1935, p. 491.

ACOUSTICS AND AUDIO-FREQUENCIES

1469. A MAINS-DRIVEN SOUND-MEASURING INSTRUMENT WHICH CAN BE CALIBRATED [suitable for Tests on Loudspeakers, Microphones, etc.].—F. Dohnal. (*Funktech. Monatshefte*, January, 1936, pp. 1–5.)

The calibration is performed by excitation, with superposed a.c. voltage, of the perforated auxiliary electrode in front of the diaphragm of the condenser microphone. The indicating instrument is of the "profile" (end-on) type, so that readings can be made, if necessary, through a telescope, thus keeping the observer out of the sound field.

1470. Dust Figures formed by [Sound Waves from] an Electric Spark [show Interference: Constant Wavelength of Sound: Patterns regarded as Sound Maps illustrate Acoustic Phenomena, such as Directive Properties of Cones for High-Frequency Sound].—A. E. Bate. (*Proc. Phys. Soc.*, 1st Jan. 1936, Vol. 48, Part 1, No. 264, pp. 178–182: Discussion p. 183.)

1471. Parametric Coupling between Stationary Acoustic Waves [Analogous to the Coupling producing Interaction between Vertical and Angular Oscillations in Elastic Pendulum: Harmonics and Sub-Harmonics due to Acoustic Properties of Gas].—G. Gorélik. (*Tech. Phys. of USSR*, No. 2/3, Vol. 2, 1935, pp. 248–251: in French.)

1472. Transient Phenomena in Electroacoustic Transmission Systems [Apparatus for Direct Determination of Audibility and Nature of Transients].—W. Bürck, P. Kotowski, and H. Lichte. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 519–522.)

The apparatus is stated to be particularly suitable for transients due to variation of attenuation with frequency. The scheme is shown in Fig. 2. An audio-frequency note of constant amplitude is introduced into an amplifier whose amplification is varied by an automatic switch working through an adjustable time circuit; the sinusoidal note produced can thus be switched in with full amplitude or with any desired time constant. The note is received either direct or through the transmission system under investigation. The method of measurement is described (§ 2). A resonant circuit followed by a valve was first investigated (§ 3; frequency curve and transient time-constant/frequency curve Fig. 3). Systems with two or more resonance peaks are discussed; Fig. 4 shows curves for an amplifier with 24 resonant circuits, for frequencies corresponding to different positions on the resonance peaks. Echo effects can be imitated by such systems. Fig. 5 shows a frequency curve for the whole of a transmission system.

1473. Investigations of Rapidly Varying Acoustic Phenomena [with the Octave Filter].—F. Trendelenburg and E. Franz. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 513–516.)

An octave filter was used to separate the components of different frequencies in the sounds investigated: the components in each octave were recorded with an oscillograph (circuit Fig. 1). A number of examples of sounds (vowels, syllables, etc.) with the corresponding oscillograms are given. Transient phenomena for various musical instruments are also shown (Figs. 6–8).

1474. The "Audio-Frequency Spectrometer," a Frequency Analyser with Extremely High Analysis Speed and Directly Visible Spectrum.—E. Freystedt. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 533–539.)

This electrical frequency analyser has a large number of filters connected in parallel (Fig. 1). The frequency range under investigation is divided logarithmically among them; their output voltages are directly visible as an amplitude spectrum on the screen of a cathode-ray oscillograph. The time required for the analysis is reduced to about 0.1 sec., the time of the switch-on transient of the narrowest filter. The construction and action of the instrument are given in detail in § 2 (filter circuit Fig. 2). Photographic records can be made and the whole instrument (Fig. 4) can be worked off the mains. Many examples of spectra of noises, vowels, words and musical notes are given.

1475. The Filter-Coupled Inductive Glow-Discharge Oscillator.—Kock. (*See* 1383.)

1476. An Audio-Frequency Heterodyne Oscillator.—M. I. Rodman. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 5, 1935, pp. 1093–1096.) Covering a frequency range of from 1 to 850 cycles; the change in frequency after 30 minutes of operation is less than 1 cycle. The harmonic content of the output is less than 3%.

1477. Feeding Push-Pull Amplifiers: Methods of Phase Reversal.—Cocking. (*See* 1415.)

1478. A 45-Watt Low-Loading Amplifier [using DA 30 Power Triodes].—(*Television*, November, 1935, Vol. 8, No. 93, pp. 676, 678, 686 and 688.) An AC/P1, choke-coupled ("which partially accounts for the absence of hum"), forms the second stage.

1479. Output Transformer Response [for Class A Power Amplifier: Calculation of Frequency Characteristic from Turn-Ratio, Winding Resistances and Leakage Inductance: Methods of Reducing the Leakage Coefficient].—F. E. Terman and R. E. Ingebretsen. (*Electronics*, January, 1936, Vol. 9, pp. 30–32.)

1480. Long-Distance Telephony: Recent Developments and Trend of Future Advances — Eddy Current Losses in Screened Conductors.—A. C. Timmis. (*Electrician*, 24th Jan., 1936, Vol. 116, pp. 91–92: summary of I.E.E. paper.)

1481. Separation of Sound Record from Picture Record in Sound Films [Post-Synchronisation Methods to avoid Poor Sound Recording by Portable Apparatus in Open Air: "Unikat" Discs: American Use of Acetyl Cellulose for Discs: etc.].—P. Hatschek. (*Funktech. Monatshefte*, January, 1936, Supp. pp. 5–6.)

1482. The "Mechanical Klirr-Factor" [Non-Linear Distortion] in Sound-on-Film Recording and Reproduction [and Its Reduction by Film Stabilising Devices].—P. Hatschek. (*Funktech. Monatshefte*, January, 1936, Supp. pp. 3–4.)

1483. On the Self Oscillations of a Freely Supported Circular Plate.—G. Ostroumov. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 5, 1935, pp. 947–957.)

A theoretical investigation of the oscillations of a uniform isotropic circular plate freely supported round the edge. This investigation is of practical value since experiments show that sounding boards of musical instruments oscillate in a similar way. The problem has already been solved by Poisson for μ (Poisson's ratio) = $\frac{1}{4}$. In the present paper different methods are used and a general solution for various values of μ is found.

In the first part of the paper a differential equation for the oscillations of the plate is given and methods are indicated for solving this. A number of tables and graphs are prepared in order to facilitate the necessary calculations, and a table is added in which the shape of the oscillating plate is shown for various values of its mechanical constants. In the second part of the paper two important factors are calculated, one determining the volume displaced by the oscillating plate and the other the kinetic energy of the plate.

1484. THE "CELLULOPHONE" [Photocell Organ: the Synthesis of Undamped and Damped Sounds].—P. Toulon. (*L'Onde Élec.*, December, 1935, Vol. 14, No. 168, pp. 821–833.) For previous work see 199 of January.

1485. THE AUDIBILITY OF THE CONTROL PROCESSES IN AUTOMATICALLY CONTROLLED AMPLIFIERS AND FILM PURE-TONE SYSTEMS.—W. Bürck, P. Kotowski and H. Lichte. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 522–525.)

The type of circuit discussed is shown in Fig. 2, where volume control is applied to the transmission of a gramophone record. If the control is to be inaudible, its time-constants must satisfy the physiological conditions imposed by the ear (§ 2, Fig. 3; § 3, Fig. 4), which allow 0.3 and 50 msec for the control switch-on and -off time-constants respectively. Some technical control methods (*e.g.* the use of exponential valves in certain circuits) do not permit these values to be reached; the audibility of the detector effect (Fig. 5) must then be taken into account for control switch-on effects, and the non-linear distortion for the control switch-off time-constant ("klirr" factor Fig. 6).

1486. THE PROBLEM OF CONTRAST EXPANSION [for Broadcasting, Sound Films, and Gramophones].—Lamparter. (*See* 1417.)

1487. STUDY OF LEVEL REGULATORS AND "ANTI-FADING" DEVICES.—G. Espinasse. (*Ann. des Postes T. et T.*, December, 1935, Vol. 24, pp. 1098–1117.)

1488. AUTOMATIC AUDIO-FREQUENCY VOLUME CONTROL DEPENDING ON THE EXTERNAL NOISE LEVEL [for Cinemas, Public Address, Restaurants, etc.].—H. Boucke. (*Funktech. Monatshefte*, January, 1936, pp. 31–32.)

1489. COMPREHENSIBILITY OF SPEECH IN NOISY ROOMS [Difficulties of Speaking and Hearing by Telephone: Requirements of Electro-acoustic Transmission System to overcome Them].—C. A. Hartmann and W. Janovsky. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 580–584.)

Fig. 1 shows how the intensity of intelligible speech increases with the noise in the room where it is produced; Fig. 2, how the intelligibility varies with speech intensity for various degrees of surrounding noise; Figs. 3 and 4 illustrate the intelligibility of reproduced sound as a function of its strength in very noisy rooms. Matching the transmitted frequency band to the noise is discussed in § 3, and the effect of non-linear distortion in § 4. Measures for overcoming the noise difficulties must be applied at the emitter (§ 5); non-carbon microphones are preferable. Headphones are recommended for the receiving end.

1490. EXPERIMENTS ON THE IMPROVEMENT OF TELEPHONE SYSTEMS FOR NOISY ROOMS [in Ships or Aeroplanes: Microphones and Their Properties].—K. Krüger and W. Willms. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 585–590: Discussion p. 590.)

Contact microphones are discussed in § 1; oscillograms of vowels for various positions of contact with the speaker's head are given in Figs. 1–5. These indicate that the best positions to avoid the transmission of noise are on the cheek or lower jaw. The electrodynamic microphone used for the measurements is described (Fig. 6); it suffers very little from non-linear distortion. Microphones held before the mouth are also discussed (§ 2); they give a good ratio of speech to noise intensity. Screening from extraneous sound at the receiver by headphones, screening caps or complete closing of the ear is illustrated by Figs. 7, 8. In the discussion a Rochelle salt microphone is recommended.

1491. APPARENT DURATION OF SOUND PERCEPTION AND MUSICAL OPTIMUM REVERBERATION [and Application to Broadcasting Studios, etc.].—S. Lifshitz. (*Journ. Acous. Soc. Am.*, January, 1936, Vol. 7, No. 3, pp. 213–221.) The full paper, a summary of which was referred to in 3517 of 1935.

1492. THE EFFECT OF DISTANCE IN THE BROADCASTING STUDIO [Great Importance of the Ratio of Direct and Reverberant Waves, depending on Distance of Source from Microphone].—A. V. Rabinovitch. (*Journ. Acous. Soc. Am.*, January, 1936, Vol. 7, No. 3, pp. 199–20.) The great difference in the effects observed over an electrical link and by direct listening is attributed to the absence, in the former case, of the binaural effect which ordinarily enables the listener to isolate, subconsciously, the reflected waves from the direct. *See* also 1502 of 1935.

1493. ON THE OPTIMUM CONDITIONS IN SOUND FILM THEATRES.—A. I. Indlin and A. N. Kacherovich. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 5, 1935, pp. 928–938.)

An investigation into the relationship between the acoustic properties of a film studio and a film theatre, the two being parts of one acoustic system. It is suggested that in order to obtain the optimum conditions in a theatre for all films, certain standards of reverberation should be adopted for film studios.

1494. Some Remarks on the Acoustic Conditions in a Film Studio [and the Effect of Scenery].—A. I. Indlin and A. N. Kacherovich. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 5, 1935, pp. 939–946.)

An investigation into the effect of scenery on the acoustic properties of a studio. It is stated that it is not correct to treat the scenery as an additional damping factor, but that the studio and the scenery should be regarded as acoustically coupled rooms.

1495. Modern Solutions of Acoustic Problems of Rooms and Construction in Buildings erected for Broadcasting.—H. J. von Braunmühl. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 571–575.)

Some ideas for the attainment of any required degree of resonance in broadcasting studios are here described. Fig. 1 shows the acoustic intensity reached by various forms of performance, which the walls between studios must therefore be capable of reducing to an intensity below that of the lowest sound to be transmitted. Fig. 2 shows the paths by which sound from one studio can reach another; the best insulation is given by elastic (*i.e.* non-rigid) connection of the walls. Figs. 3 and 4 illustrate how this may be attained for rooms vertically above and below one another (floating construction, on springs); photographs of constructional details are given (Figs. 5–8) and described. Fig. 9 gives curves of attenuation obtained in this way; Fig. 10 shows how footsteps are silenced by different methods of floor construction. The remaining figures illustrate the effects of different wall coverings.

1496. Theory of the Absorption of Sound by Wall Coverings.—E. Wintergerst. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 569–571.)

It is shown theoretically that homogeneous materials cannot absorb all frequencies equally. An arrangement of a plate of absorbing material, containing slits or holes, at a finite distance from a solid wall (Fig. 1), is found however to give equal high absorption of all frequencies over a large range. The necessary dimensions and properties of the arrangement can be determined theoretically if the desired frequency curve is given.

1497. The Vertically Stratified Wall as an Acoustic-Mechanical Choke.—E. Meyer. (*E.N.T.*, December, 1935, Vol. 12, No. 12, pp. 393–400: abstract only in *Zeitschr. f. tech. phys.*, No. 12, Vol. 16, 1935, pp. 565–566.)

The wall and its equivalent electrical circuit (Fig. 1) are described in § 1; the individual strata correspond to the inductances, the air cushions between them to the capacities. Internal friction is neglected. The voltages at input and output of the filter circuit correspond to the pressures before and behind the wall respectively. Experimental tests of the correctness of the equivalent circuit are described in § 2. Condenser microphones are used to measure the energy density in the diffuse acoustic fields before and behind the wall; the acoustic attenuation is then measured in decibels by the usual formula. The circuit scheme of the apparatus used is shown in Fig. 2; Fig. 3 shows the logarithmic valve voltmeter. Fig. 4 gives a typical record of the attenuation as a function of frequency. The attenuation produced by various types of wall is considered in § 3 (Figs. 5, 6); the formula given in § 1 for the limiting frequency is verified. For sufficiently high frequencies the wall behaves as if its density were uniform. The phase velocity of sound propagation is discussed in § 4 and illustrated by Fig. 7; the low frequencies are transmitted more rapidly than the high ones.

The limiting frequency is not sharply defined; this is explained in § 5 as due to transversal resonances in the air cushions. Introduction of an absorbing material in the place of air improves the sharpness of the frequency curve (Fig. 8, which may be compared with Fig. 9 for an electrical choke). A lattice (Fig. 10) placed in the air cushion gives the attenuation curves of Fig. 11. Another method of reducing the transversal resonances is to insert absorbing material round the rim of the wall only (Fig. 12). To obtain walls of efficient insulation but light weight the limiting frequency must be made as low as possible, either by increasing the mass of the separate walls or the thickness of the air cushions.

1498. Theory of Transmission of Plane Sound Waves through Multiple Partitions [explaining the Much Higher Loss than through Corresponding Single Partition].—A. L. Kimball. (*Journ. Acous. Soc. Am.*, January, 1936, Vol. 7, No. 3, pp. 222–224.)

1499. The Physical Bases and New Results of the Fight against Noise [Summarising Report].—K. W. Wagner. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 544–554.)

Subjects included in this general survey of the present position are :—§ 2 : Hearing in the healthy and the deaf. § 3 : Fundamentals of noise measurement. §§ 4, 5 : Intensity of sound and the sensation of loudness. § 6 : Intensity of composite sounds. § 7 : Noise meters. § 8 : Traffic noise. § 9 : Noise in dwelling-houses. § 10 : Absorption of sound. § 11 : Noise in machines and workshops.

1500. "Klänge and Geräusche" [Tones and Noises] *and* "Sound."—F. Trendelenburg : F. R. Watson. (*Journ. Acous. Soc. Am.* January, 1936, Vol. 7, No. 3, p. 231 and 232 : Book Reviews.)

PHOTOTELEGRAPHY AND TELEVISION

1501. A Sealed Cold-Cathode Oscillograph for Low Exciting Voltages [8–10 kV : Application to Television].—F. A. Becker. (*Arch. f. Elektrot.*, 20th Dec. 1935, Vol. 29, No. 12, pp. 873–876.)

An auxiliary discharge is used to provide ions for the main discharge so that it starts at a low voltage. The intensity of the light spot can be controlled without distortion by inserting a stop before the cathode. Electrostatic lenses are used for beam concentration (Malsch & Becker, 290 of 1935). Fig. 1 shows an oscillograph incorporating these features; Figs. 2 and 3 show external photographs taken with it. A recording velocity of 250 km/sec.

can be attained. The tube is suitable for television reception (intensity characteristic Fig. 4) and as a scanning emitter; Fig. 7 shows a photograph of a fluorescent screen obtained with it. The new features referred to above may also be used for oscillographs with divided vacuum.

1502. RECENT DEVELOPMENTS OF THE CATHODE-RAY OSCILLOGRAPH [for use with Mains: Methods of Eliminating Mains Disturbances].—J. Dantscher. (*Arch. f. Elektrot.*, 20th Dec. 1935, Vol. 29, No. 12, pp. 833–841.)

The conditions under which the oscillograph may be worked off the mains are shortly given in § 2; fluctuation of mains and accidental deviation of the spot by the mains connection are the chief sources of trouble. In § 3 the time-base for use with mains is discussed (*see* also 1933 Abstracts, p. 635); a screened-grid valve (characteristics Figs. 1, 2) is used as the charging valve to prevent mains fluctuations from reaching the electrodes. Fluctuation and stabilisation of mains voltage are dealt with in § 4 and illustrated in Fig. 3; the arrangement and screening of the mains transformer is described in § 5. Fig. 4 shows the circuit of the AEG-oscillograph as built for connection to the mains. The calibration of the time-base is shortly discussed in § 6.

1503. THE IMPORTANCE OF THE CHOICE OF SUITABLE FLUORESCENT MATERIAL FOR TELEVISION SCANNING WITH THE CATHODE-RAY-LIGHT SCANNER.—W. Schnabel. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 17, 1936, pp. 25–27.)

When a film is scanned by the light of the spot on a cathode-ray-tube screen, the fluorescence decay process must have ended by the time the cathode ray has advanced by the amount of the spot diameter; with a system of 40 000 picture elements and 25 frames/sec. this means by the end of 10^{-6} sec. A screen material already exists with a decay time just over 10^{-6} sec. (815 of 1935—see Fig. 24, Schleede's preparation), and the writer has now examined whether, with this and other commercial materials, the spot-light film-scanning system is practicable for high-definition television; using for his tests a cold-cathode-tube scanner with which, for a pass-band of 700 kc/s, a change from white to black produced a voltage difference of 15 volts.

To his surprise he found that the effect of after-glow on the resulting picture was not so marked as might be expected. Thus with the Schleede preparation referred to above the image shown in Fig. 2 was obtained, for 650 000 elements/second: the slight defects in this image are attributed to inadequate sharpness of receiver spot and to motion of the film during the taking of the photograph, as well as to the effect of after-glow: the lens employed produced, moreover, marked distortion at the edges. Even a zinc sulphide material with a total decay time of several minutes gave the image shown in Fig. 4 with 200 000 elements/second, and though this image is obviously unworkable owing to the after-glow effect, it nevertheless shows that here again that component of the fluorescent light which is active in the scanning process *has a far more rapid decay than the visible component.* Further investigations are in progress in the Aachen Institute. Several other suitable materials have already been found.

1504. THE GOLDMARK ELECTRON-OPTICAL PROJECTION SYSTEM, *and* TRANSMISSION AND SYNCHRONISATION WITH THE GOLDMARK ELECTRON-OPTICAL SYSTEM.—P. C. Goldmark. (*Television*, Nov. and Dec. 1935, Vol 8, Nos. 93 and 94, pp. 661–664 and 675: pp. 703–704 and 705.)

A combination of cathode-ray and mirror-drum technique. The principle is as follows:—the picture is scanned in (say) five vertical zones, each zone being made up of horizontal lines, as long as the width of the zone, produced by a cathode-ray tube of only 1 inch screen diameter whose fluorescent spot moves only in the horizontal direction. A lens projects the moving spot through a mirror-drum on to the viewing screen. The mirror-drum has at least as many mirrors as there are zones in the picture. Each mirror is tilted differently so that the rotating drum spreads the moving spot into zones joining each other. Thus the very small cathode-ray tube provides the necessary high scanning frequency, while "the projecting drum enlarges the image to any desirable size at comparatively small loss of light." The intrinsic screen brightness is calculated and compared with that for ordinary direct enlargement.

1505. REPORT ON ELECTRON-OPTICAL QUESTIONS CONNECTED WITH TELEVISION.—E. Brüche and W. Schaffernicht. (*E.N.T.*, December, 1935, Vol. 12, No. 12, pp. 381–392.)

A review of the part played by electron-optics in television (*see* these Abstracts, *passim*); emphasis is laid on a clear exposition of fundamental principles rather than on technical details. The subdivisions are: § 2. The cathode-ray oscillograph and its electrode system. § 3. Its application to television. § 4. The "image transformer" (which transforms an optical image into an electron image) as a photographic instrument. § 5. Comparison of the recent electron photographic methods (at the emitter) of Zworykin (*e.g.* 1934 Abstracts, p. 101) and Farnsworth (*e.g.* 207 of 1935). A comprehensive list of literature references is given.

1506. ON THE CONCENTRATION OF ELECTRON BEAMS IN GAS-FILLED TUBES.—I. L. Sokolskaya. (*Tech. Phys. of USSR*, No. 1, Vol. 3, 1936, pp. 28–38: in English.)

It has been observed that while electrons emitted from a cathode in a vacuum tube travel towards the anode in a divergent stream, the stream of electrons in a tube filled with gas at a low pressure is concentrated into a narrow beam and takes the shape of a standing wave with well-defined nodal points. In this paper an account is given of experiments carried out with tubes filled with argon and, alternatively, mercury vapour.

The object of the experiments was to determine the effect on the focal length of the beam (distance between the nodal points) of the following factors: gas pressure, electron-current intensity, velocity of the electrons, and potential acquired by the walls of the tube. A number of experimental curves are shown and a theoretical interpretation of the results obtained is given. One of the conclusions reached is that the main requirement imposed on these tubes when used in television, namely that the size of the light spot on the screen must remain constant while the intensity of light is varying, cannot be met, since the focal length of the beam varies with the intensity of the electron current.

1507. ELECTRON-OPTICAL BENCH [for investigating Performance of Experimental Electrode Systems and facilitating Design of Television Tubes].—G.E.C. Research Laboratories. (*Nature*, 15th Feb. 1936, Vol. 137, pp. 281–282: short note only from Physical Society Exhibition.)

1508. TYPE 6001 CATHODE-RAY TUBE FOR TELEVISION.—Mullard Company. (*Wireless Engineer*, February, 1936, Vol. 13, No. 149, p. 64: paragraph only.)

1509. CATHODE-RAY TELEVISION WITH AUTOMATIC SYNCHRONISATION.—R. Barthélémy. (*L'Onde Élec.*, December, 1935, Vol. 14, No. 168, pp. 794–803.) For a *Comptes Rendus* Note *see* 2717 of 1935.

1510. SYNCHRONISATION IN TELEVISION, AND RESISTANCE-CAPACITY AMPLIFIERS [Survey, with Mathematical Analysis of Amplifiers for Synchronising or Image Signals].—S. Bertolotti. (*Alta Frequenza*, January, 1936, Vol. 5, No. 1, pp. 5–41.)

Generation of the synchronising signals both for mechanical and electronic scanning, including a disc generator developed by the E.I.A.R. for use with the latter type of scanning, designed for 180-line pictures but applicable (without increasing the diameter) to 240 lines: calculation, for known valve data, of resistance-capacity amplifiers, using the Poisson probability summation, with oscillograms showing various distortions of the synchronising signals resulting from inappropriate values of the amplifying circuit constants (*e.g.* Fig. 21, where the effect of an inductance of 10 mH in series with the anode resistance R_1, in Fig. 22, is illustrated): the modern system of superposed synchronising and image signals, methods of separation at the receiver, and the synchronisation of the receiving cathode-ray tube (with photographs of results of false synchronisation). The writer concludes that if the sight and sound waves are always separated by a definite frequency difference, it should be possible to construct a receiver to tune to the composite programme by a single adjustment, all other adjustments, including synchronisation, being made once and for all inside the receiver.

1511. TELEVISION: PROGRESS [in 1935] TOWARDS A REGULAR HIGH-DEFINITION SERVICE.—L. E. C. Hughes. (*Electrician*, 31st Jan. 1936, Vol. 116, p. 141.)

1512. HIGH-DEFINITION TELEVISION FOR THE ALEXANDRA PALACE: DETAILS OF THE SIGNALS RADIATED BY THE BAIRD AND THE MARCONI-E.M.I. TRANSMITTERS.—(*Television*, November, 1935, Vol. 8, No. 93, pp. 631–636 and 688.) *See* also 239 and 240 of January.

1513. THE LONDON TELEVISION TRANSMITTER [Description of Marconi-E.M.I. Apparatus at Alexandra Palace].—(*Wireless World*, 31st Jan. 1936, Vol. 38, pp. 103–104.)

1514. THE OPENING CEREMONY FOR THE NEW BERLIN TELEVISION TRANSMITTER, DECEMBER, 1935.—(*Funktech. Monatshefte*, January, 1936, Supp. pp. 1–2.)

1515. TELEVISION ABROAD [" Mechanical-Optical " *versus* " Electrical " Scanning in U.S.A.: Plans in Great Britain].—(*Funktech. Monatshefte*, January, 1936, Supp. pp. 4–5.)

1516. TELEVISION RECEIVER FOR HIGH DEFINITION *and* TELEVISION RECEIVER FE IV [First Commercial Type offered by Telefunken for Berlin Ultra-Short-Wave 180-Line Programmes].—H. O. Roosenstein: P. Besson. (*Wireless World*, 14th Feb. 1936, Vol. 38, pp. 160–162: *L' Onde Élec.*, December, 1935, Vol. 14, No. 168, pp. 783–793.)

1517. THE TELEVISION RECEIVER OF THE FERNSEH A. G.—G. Schubert. (*Funktech. Monatshefte*, January, 1936, Supp. pp. 2–3.)

1518. TELEVISION IN NATURAL COLOURS [possible by Combination of Kerr Cell and Prisms with Photocells of Various Spectral Sensitivities?].—B. Bennett. (*Television*, December, 1935, Vol. 8, p. 739.)

1519. A CHECK ON QUALITY: A NOTE ON THE [B.B.C.] HIGH-FREQUENCY TEST CARD.—(*Television*, December, 1935, Vol. 8, No. 94, p. 706.)

1520. MEASURING DELAY ON PICTURE-TRANSMISSION CIRCUITS.—E. P. Felch. (*Bell Lab. Record*, January, 1936, Vol. 14, No. 5, pp. 154–157.)

1521. THE EFFECT OF OXYGEN, CARBON DIOXIDE, NITROGEN AND MERCURY ON BARIUM AND POTASSIUM PHOTOCELLS.—A. V. Afanasjeva and J. I. Lunkova. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 5, 1935, pp. 1000–1006.)

An account of experiments carried out with barium and potassium photocells in order to determine the relationship between the photoelectric current and the amount of gas absorbed by the light-sensitive surface. A number of experimental curves are shown and a theoretical interpretation of the results obtained is given. It was found that when oxygen or mercury vapour act on a barium surface the photoelectric current rises with the increase of the gas absorption, passes through a maximum, and falls off; under the influence of nitrogen the current increases up to the saturation point, while carbon dioxide has the opposite effect and causes a decrease in the current. In the case of a potassium surface the current passes through a maximum with any one of the above gases with the exception of mercury vapour, the effect of which is to decrease the current.

1522. EFFECT OF OXYGEN UPON THE PHOTOELECTRIC THRESHOLDS OF METALS.—H. C. Rentschler and D. E. Henry. (*Journ. Opt. Soc. Am.*, January, 1936, Vol. 26, No. 1, pp. 30–34.) Extension of the work dealt with in 1933 Abstracts, p. 169.

1523. PHOTOELECTRIC WORK FUNCTION OF BARIUM [Measured by Fowler's Method of Reflection Coefficient of Barium deposited on Glass].—R. J. Cashman and N. C. Jamison. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, pp. 195–196: abstract only.)

1524. THE PHOTOELECTRIC WORK FUNCTION OF CA AND PHOTOEMISSION FROM NONHOMOGENEOUS SURFACES [measured by Fowler's Method with Layers produced by Single Distillation: Surface rendered Nonhomogeneous by Heating].—N. C. Jamison and R. J. Cashman. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, p. 201: abstract only.)

1525. ON ALKALI FILMS OF ATOMIC THICKNESS ON PLATINUM [Method of Deposition and Exact Measurement: Measurement of Change of Photoelectric Sensitivity of Platinum with Increasing Thickness of Potassium Film].—H. Mayer. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 451–454.)

1526. THE OPTICAL CONSTANTS AND PHOTOELECTRIC EMISSION OF POTASSIUM [Confirmation of Ives's Theory].—H. E. Ives and H. B. Briggs. (*Science*, 6th Dec. 1935, Vol. 82, p. 541: summary only.)

Optical constants of potassium, recently obtained, strikingly confirm the theory (1932 Abstracts, p. 102) that the photo-emission from thin films on a specular metallic base is conditioned by the optical absorption of the photo-active material. The sharp maximum of emission in the ultra-violet is predicted at the right wavelength, and the enormous enhancement of emission, for polarisation with the electric vector parallel to the plane of incidence, "is an immediate consequence of the unusual optical properties of the alkali metal."

1527. CONTRIBUTION TO THE MEASUREMENT OF SPHERICAL CADMIUM CELLS USED FOR REGISTRATION [of Solar and Sky Radiation].—M. Bender. (*Physik. Zeitschr.*, 1st Feb. 1936, Vol. 37, No. 3, pp. 107–110.)

Continuation of previous work (*see* 1934 Abstracts, p. 374, r-h col.—Bender & Krüger). Here the behaviour of various cells of different spectral sensitivities is described and records of the daily variation of ultraviolet solar and sky radiation in the Black Forest are given (Fig. 1). It is found that the cadmium vapourises, probably owing to the effect of the radiation. This may be the cause of the inconstancy of the cells. Argon cells do not show this phenomenon.

1528. BARRIER LAYERS AND PHOTOELECTRICITY [Rectifying Action and Photoelectric Effect increase with and are connected by Contact Resistance].—J. Roulleau. (*Comptes Rendus*, 10th Feb. 1936, Vol. 202, No. 6, pp. 470–472.)

For previous work *see* 1214 of March. The writer now points out that in a copper-oxide rectifier the photoelectric effect and the rectifying action at the contact surface are independent of the specific resistance of the mass of Cu_2O. Curves are given to demonstrate that they each increase with the contact resistance, and it is deduced that they are connected by means of that resistance. Explanations are given for the different result obtained by other authors (*see* 1933 Abstracts, p. 400—Borissow, S. & W., and 2048, 3583 of 1935—Jusé).

1529. THE INTERNAL PHOTOELECTRIC EFFECT IN SEMI-CONDUCTORS [Calculation of Electron Distribution Function under Illumination by Monochromatic Light: Calculation of Dember Effect].—H. Fröhlich. (*Physik. Zeitschr. der Sowjetunion*, No. 5, Vol. 8, 1935, pp. 501–510: in German.)

1530. THE DEPENDENCE OF SENSITIVITY OF THE SELENIUM-SULPHUR RECTIFIER PHOTOELECTRIC CELL ON THE OBLIQUITY OF THE INCIDENT LIGHT, AND A METHOD OF COMPENSATION THEREFOR.—G. P. Barnard. (*Proc. Phys. Soc.*, 1st Jan. 1936, Vol. 48, Part 1, No. 264, pp. 153–162: Discussion pp. 162–163.)

"When a restricted portion only of the surface of the cell is illuminated, it is found that the sensitivity increases as the centroid of the illuminated area is displaced from the centre of the cell." The method of compensation comprises "the use of a central stop arranged at a suitable distance above the surface of the cell." Details of the apparatus and method used are given and distribution curves for cells under various conditions are shown.

1531. BECQUEREL EFFECT AND PHOTOCHEMICAL SENSITIVITY OF SOME FLUORESCENT COLOURING MATTERS [depend on Oxidation and Reduction].—Cécile Stora. (*Comptes Rendus*, 5th Feb. 1936, Vol. 202, No. 5, pp. 408–410.) *See* also 1115 of March.

1532. THE YIELD OF QUANTA IN THE FORMATION OF COLOUR CENTRES IN KBR-CRYSTALS [with Absorption of Light in U-Centres: Temperature Effect: Connection with Saturation Value of Stationary Photoelectric Primary Currents].—R. Hilsch and R. W. Pohl. (*Göttinger Nachrichten, Math.-Phys. Kl.*, No. 19, Vol. 1, 1935, pp. 209–214.)

1533. THE KERR EFFECT OF NITROBENZOL [Improved Purification Method and Use of Glass and Rustless Steel Cell, without Packing Material, gives Undistorted and Cleaner Interference Pattern, Kerr Constant 5% Greater and Conductivity over 10 Times Less than Previous Best].—F. Gabler and P. Sokob. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 17, 1936, pp. 11–17.)

MEASUREMENTS AND STANDARDS

1534. MEASUREMENTS OF WAVELENGTHS AND POTENTIAL WITH A LECHER SYSTEM WITH VARYING CHARACTERISTIC IMPEDANCE.—N. N. Malov. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 8, 1935, pp. 595–601: in German.)

A two-part, telescopic Lecher system, with the thermoammeter permanently at the end of the thinner, movable pair of tubes, has certain advantages such as the elimination of the open-end effect. Measurements, however, show that the geometrical length of such a system is always smaller than a quarter-wavelength. This discrepancy is attributable to the differing characteristic impedances of the two parts, and seems likely to invalidate the usual formula for the input voltage (= product of characteristic impedance W and ammeter current J). The theory of such a system is therefore investigated, with the result that a factor p is found, less than unity, by which the product must be multiplied in order to give the input voltage. The constitution of p is shown in eqn. 23, and input voltages thus measured, for four different Lecher systems, agreed reasonably well with measurements made by a special voltmeter (3591 of 1935); for accurate measurements the ammeter correction at very high frequencies should have been known.

Another equation (15) is derived, for finding the relation between the wavelength and the total length x of the system: here $m = 2\pi/\lambda$ and $x = x_1 + x_2$, and for equation 15 to hold good x_2, the length of the movable part, must be less than $0.75x_1$ if, as is assumed, the ratio W_2/W_1 of the characteristic impedances of the moving and fixed parts respectively is 1.4 : 1. If this ratio is made smaller the proportion of x_2 to x_1 can be increased. This equation, and also equation 21 for the input impedance, is tested for the four systems mentioned by comparison with measured values (dotted curves in Figs. 3–6): agreement is very good.

1535. An Absolute Method for the Measurement of the Equivalent Resistance of an Oscillatory Circuit [and Its Possible Application to High Resistance Measurement at Ultra-High Frequencies].—M. Boella. (*Alta Frequenza*, December, 1935, Vol. 4, No. 6, pp. 647–656.)

The method consists in observing the capacity change necessary to reduce the voltage of the resonant circuit to $1/\sqrt{2}$ of its resonance value, the circuit being inductively coupled to a constant-frequency generator. Possible errors and their avoidance are discussed. *See* also 1536, below.

1536. Measurement of the Equivalent Resistance of Oscillatory Circuits [Negative Resistance (Dynatron) Method satisfactory only up to 3 Mc/s unless with Specially Designed Tetrode, Short Connections, etc.].—M. Ferrario. (*Alta Frequenza*, December, 1935, Vol. 4, No. 6, pp. 657–667.)

The dynatron-method results were compared with measurements by the reactance-variation method proposed by Boella (1535, above). Above 3 Mc/s several phenomena enter into the former method and produce values lower than those given by the latter, the errors increasing with increase of frequency and also with increase of the equivalent resistance: at 18 Mc/s, for a resistance of 20 000 ohms, they may be 20% or more.

1537. Determination of Small Temperature Coefficients [of Coils and Condensers] at High Frequencies [Automatic Recording].—L. Rohde. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 635–637.)

The scheme of this arrangement for recording temperature variations of coils and condensers at high frequencies is shown in Fig. 1 and described. An interference method is used; the frequency of beats due to changes in the adjustment is used to make the record; the conversion of this frequency into a current depending entirely on frequency and not on amplitude is made by a direct-reading frequency-meter. The sensitivity can be adjusted to that required for the measurement in progress. The method of measurement is given in § 2 and some records are shown (§ 3, Figs. 3, 4).

1538. Automatic Adjustment of Complex Compensation- and Bridge-Circuits with Varying-Phase Null Motor [with Application to Tests of Condensers, Cables and High-Voltage Apparatus: Measurement of Impedances of Coils and Mutual Inductances: Circuit Diagrams].—W. Geyger. (*Arch. f. Elektrot.*, 20th Dec. 1935, Vol. 29, No. 12, pp. 842–850.)

1539. An Adjustable Precision Standard of Phase Difference.—G. B. Engelhardt. (*Bell Lab. Record*, January, 1936, Vol. 14, No. 5, pp. 158–160.)

1540. A Transmission Line Impedance Measuring Set.—A. L. Drabkin. (*Izvestia Elektroprom. Slab. Toka*, No. 12, 1935, pp. 66–72.)

A description of a set developed for the purpose of measuring the various constants of a transmission line (or aerial) for wavelengths between 13 and 100 metres. The set comprises (Fig. 3) a push-pull oscillator inductively coupled to a push-pull amplifier, the output circuit of which is connected either to the circuit to be measured or to an equivalent circuit. Methods are indicated for measuring the sending-end resistance and reactance of the line, the resistance per unit length, and the ratio of the velocities of propagation of electromagnetic energy in the air and in the line. Formulae are also derived for calculating the characteristic impedance and the attenuation constant of the line from the above data *plus* the capacity per unit length, which has to be determined separately.

1541. Errors of Commercial High-Frequency Ammeters [10 mA–20 A, at Ultra-Short Wavelengths down to 3 m].—H. Kruse and O. Zinke. (*E.T.Z.*, 2nd Jan. 1936, Vol. 57, No. 1, p. 12: summary only.)

Commercial types of thermo-ammeters and hot-wire and hot-strip instruments were checked against an "optical" ammeter (in which the light radiation from a vacuum-enclosed wire, with low skin effect and heated by the current under measurement, was measured by photocell and galvanometer). The natural frequencies of all the thermo-ammeters were found to be in the micro-wave region, so that they had no important effect for the wave-range in question; this applied also to hot-wire and hot-strip meters with one heating element. The question of the errors due to skin effect was examined, for round, strip, and tubular heating elements. The latter should have their walls as thin as possible, at any rate thinner than the penetration depth at the highest frequency involved. In the practically important region of small errors the strip was inferior to the wire, but superior in the region of large errors. The errors calculated from skin-effect considerations agreed well with the measured over-all errors, so that it was concluded that these thermal instruments had errors due only to skin effect, provided they had no potential with regard to their surroundings (in the tests they were all earthed on one side). " These errors can be reduced, in a wide-range instrument, by the use of tubular elements, and in a narrow-range instrument by the use of high-frequency current transformers."

1542. Discussion on "A Valve Ammeter for measuring Small Alternating Currents of Radio Frequency" [Extension of Frequency Range above $10^{6.5}$ c/s by Air-Cored Choke].—Barlow. (*Journ. I.E.E.*, February, 1936, Vol. 78, No. 470, p. 193.) *See* 274 of January: also *Electrician*, 31st Jan. 1936, Vol. 116, p. 130, for paragraph on a commercial model.

1543. The Compensated Thermocouple Ammeter [Mathematical Analysis of Temperature Distribution and Heat Flow in Electrical Conductors: Development of the Electrothermic Ammeter of Thermocouple Type: Application of Theory to Shunt Design].—W. N. Goodwin. (*Elec. Engineering*, January, 1936, Vol. 55, No. 1, pp. 23–33.)

1544. The Direct-Current Measuring Transformer [a New Device giving More Accurate Measurement of Large Continuous Currents, including Currents with Rapid Variations and with Superposed A.C.].—O. E. Nölke. (*E.T.Z.*, 9th Jan. 1936, Vol. 57, No. 2, pp. 37–39.)

1545. A New, High-Sensitivity Mains-Driven Valve Voltmeter with Two Ranges [covering 0.03–3.0 V_{eff}: Input Capacity only 15 $\mu\mu$F: Input Resistance 5×10^6 Ohms: 25 c/s—30 Mc/s].—M. von Ardenne. (*Elektrot. u. Masch:bau*, 19th Jan. 1936, Vol. 54, No. 3, pp. 30–32.)

The second, " insensitive " range is obtained by voltage-division, without the disadvantages usually attributed to this process—namely the reduction of high input resistance (the main advantage of the valve voltmeter) and non-uniform behaviour to different frequencies. The success of the circuit adopted is due to the use, as grid leak, of the two very high resistances R_1 and R_2 with the switching arrangement (using a special low-capacity switch) shown in the diagram. In the " sensitive " position 1 of the switch the voltage to be measured is applied directly to the grid, and the unwanted capacity of the grid circuit is not appreciably increased by the very small capacity C_1 (of the order of 5 cms) or by the switch capacity: moreover, the path to the grid, whose length has a predominant influence on the upper frequency limit, can be kept very short. In the " insensitive " position 2 there is a two-fold voltage division; for the lower frequencies an ohmic division (depending on the ratio of R_1 to R_2) and for the higher a capacitive division by the capacities C_1 and C_2 *plus* the grid capacity. C_1 is so chosen that the input capacity remains unchanged on switching from one range to the other, and C_2 so chosen that the voltage division at high frequencies is the same as the ohmic voltage division at low frequencies. The new-type valves with separate grid lead-out can be used to their best advantage, since only the grid capacity has to be kept small and not, as in some other arrangements, the anode capacity as well.

1546. Voltage Measurement at Very High Frequencies—I [Investigation of the Series Condenser/Diode Method: Calculation of Leakage, Impedance, and Electron-Inertia Errors].—E. C. S. Megaw. (*Wireless Engineer*, February, 1936, Vol. 13, No. 149, pp. 65–72.) The method should give accurate measurements up to about 100 Mc/s and useful estimates up to about 1 000 Mc/s (voltages about 10 v or higher).

1547. An Electrostatic High-Voltage Voltmeter from 0.5 to 35 kV with Pointer Indication [on Balance Principle].—W. Steubing. (*Physik. Zeitschr.*, 1st Jan. 1936, Vol. 37, No. 1, pp. 32–35.)

1548. A New Construction of the Vacuum Duant Electrometer.—G. Hoffmann: B. Zipprich. (*Physik. Zeitschr.*, 1st Jan. 1936, Vol. 37, No. 1, pp. 35: 36–38.)

1549. Some Thermal Methods of measuring Loss of Power in Vacuum Tubes.—Cowan. (*See* 1457.)

1550. Error-Free Thermal Power Meters.—W. Bader. (*Arch. f. Elektrot.*, 20th Dec. 1935, Vol. 29, No. 12, pp. 809–833.)

A general account, with diagrams, of circuits which contain two thermoelements and make power measurement without error possible is given in § II. The properties of these circuits are investigated theoretically; the conditions are found which govern the adjustment of the magnitudes of the elements for maximum sensitivity and minimum absorption of power by the meter itself (§§ III, IV). The theory of the measurement of voltage and current, in addition to that of power, is described in § V. § VI refers to an arrangement for switching in various measurement ranges; § VIII gives data of experimental tests, including one of frequency independence at audio frequencies.

1551. The Influence of the Relative Humidity of the Air on the Loss Angle of Insulating Materials at High Frequencies [explaining Discrepancies between Different Measurements of Same Material].—H. Schwarz. (*E.T.Z.*, 2nd Jan. 1936, Vol. 57, No. 1, pp. 7–9.)

Author's summary:—" Loss factor measurements on various insulating materials [including ceramic types, mica, etc.: frequencies 10^5–10^7 c/s] give, in the presence of a relative humidity higher than 50%, higher values of loss factor than those generally accepted. The additional losses increase to varying extents with increasing relative humidity and with decrease of frequency. Conductivity measurements show that only a small part of the additional loss can be attributed to surface leakage over the test samples; it is chiefly a question rather of true dielectric processes. The 'finish' of the surface of the sample is also of considerable importance. The writer urges that when a loss factor is given the external conditions in which the test is made should be mentioned." In high relative humidities, even the time elapsing between taking the sample out of the drying oven and carrying out the measurement has a considerable influence on the result.

1552. Measurements of Dielectric Loss from 5×10^8 to 1×10^8 c/s.—L. Rohde. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 637–639.)

The method used is an extension of one previously given for lower frequencies (Rohde & Schwarz, 1934 Abstracts, p. 509). The circuit is shown in Fig. 1; the theory of the method is discussed. The sensitivity can be adjusted at will. Results for various materials are tabulated; solids show no difference in behaviour from that at lower frequencies, but some liquids, particularly mixtures, show anomalous behaviour, with absorption in certain ranges of frequency. Pure organic liquids have sometimes very small loss. A method of measurement in which the frequency is continuously variable is being developed.

1553. The Accurate Measurement of the Breakdown and Current/Voltage Characteristics of Liquid Dielectrics with Direct Potentials [Equipment measuring from 10^{-16} to 10^{-3} Ampere at Voltages 0–40 kV].—Baker and Boltz. (*Review Scient. Instr.*, January, 1936, Vol. 7, No. 1, pp. 50–52.)

1554. The Variation of the Dielectric Constants of Anisotropic Liquids with Field Strength and Frequency.—W. Kast. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 475–479.)

1555. A Method for Measuring High Resistance [of Order of 10^{10} ohms: Bridge Method using Rapidly Charged-and-Discharged Condenser as Balancing Resistance].—Van den Akker and G. M. Webb. (*Review Scient. Instr.*, January, 1936, Vol. 7, No. 1, pp. 44–46.)

1556. [Theoretical] Investigations on the Natural Elastic Vibrations of Quartz Plates excited Piezoelectrically.—R. Bechmann. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 525–528.)

For previous work *see* 503/4 of 1935. Here the moduli of elasticity, their temperature coefficients, and the piezoelectric moduli of quartz are calculated for four plane sections through the elastic wave surface, using the known numerical values of the corresponding principal moduli. Three different velocities of propagation of elastic waves are found for each direction, and in general also three natural elastic vibrations of thin plates, depending on the orientation of the plates to the wave surface. This surface has two curves along which the temperature coefficient of the elastic moduli becomes zero. Fig 1 shows curves illustrating the variation of the different quantities discussed.

1557. X-Ray Studies of Crystals vibrating Piezoelectrically [Difference in Effect between X-Cut and Y-Cut Crystals: Effect of Polishing and Etching: Microphotograms].—C. V. Bertsch. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, pp. 128–132.)

1558. Passage of X-Rays through Oscillating [Piezoelectric] Crystals [Inhomogeneous Crystal Distortion widens Multiply-Reflected Portion of Beam: Enlargement of Central Spot].—R. M. Langer. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, p. 206: abstract only.) For relevant work *see* Fox & Carr, 1931 Abstracts, p. 570; *also* 3188 of 1935 and 285 of January.

1559. Frequency/Thickness Constants of Thin Quartz Plate cut Parallel to the Electrical Axis, *and* Thin Quartz Plate of Zero Temperature Coefficient.—H. Yoda. (*Journ. I.E.E. Japan*, November, 1935, Vol. 55 [No. 11], No. 568, pp. 1000 and 1001: Japanese only.)

1560. The Quartz Clocks of the Physikalisch-Technische Reichsanstalt [Recent Observations: Detection of Variation in Earth's Rotation].—Adelsberger. (*Zeitschr. V.D.I.*, 8th Feb. 1936, Vol. 80, pp. 147–148.)

1561. Standard Frequency Radio Broadcasting Service [Details of Times, Frequencies, Modulation, etc.].—Nat. Bureau of Standards. (*Journ. Franklin Inst.*, November, 1935, Vol. 220, No. 5, pp. 657–659.)

1562. The Variation of Inter-Electrode Capacity in Thermionic Valves [and Conclusions regarding Frequency Stabilisation].—Bell. (*See* 1451.)

1563. Measuring Instruments: Noteworthy Developments of the Past Year.—A. C. Jolley. (*Electrician*, 31st Jan. 1936, Vol. 116, pp. 130–131.)

1564. The Ballistic Galvanometer and the Measurement of Impulses of Exponential Form.—I. Lucchi. (*L'Elettrotec.*, 10th Nov. 1935, Vol. 22, No. 21, pp. 747–750.)

1565. Frequency Division by the Vibration of a Mechanical Oscillating System.—Rusakov and Ryabinina. (*Tech. Phys. of USSR*, No. 1, Vol. 2, 1935, pp. 48–60.) German version of the work dealt with in 682 of February.

1566. Low-Inertia Pointers for Measuring Instruments [Specially Drawn Thin-Wall Glass Tubes: Composite Pointers with Moment of Inertia about 8 Times Smaller than Aluminium Tube Pointer].—Miehlich. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 17, 1936, pp. 27–31.)

SUBSIDIARY APPARATUS AND MATERIALS

1567. DEMONSTRATION OF THE IMAGE ERRORS OF ELECTRON LENSES WITH IMAGES OF A POINT.—K. Diels and M. Knoll. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 617–621.)

Authors' summary :—The following errors in electron-optical images have been produced in the image of a point, in analogy to the corresponding errors in ordinary optics : 1. *Astigmatism of an obliquely incident beam,* investigated with a c-r tube with a skew electric or magnetic lens and an electron beam of relatively small diameter (Fig. 1–7). 2. *Astigmatism of lenses malformed at the side,* investigated with a c-r tube with elliptical electric or magnetic lens (Figs. 8, 9). Similar errors (due to the deviating plates) are caused by the electron-optical field of the cylinder lens of the deviating plates of a c-r tube (Figs. 10, 11). 3. *Aperture errors* of electric tube lenses, investigated by observing the caustic in the path of the beam of a c-r tube with a lens electrode of diameter small compared with that of the beam (Figs. 12–15). 4. *Coma,* aperture error of obliquely incident beam, investigated with a c-r tube with a skew electric tube lens and a beam of relatively large diameter (Fig. 16). The form of every electron-optical error showed good agreement with the corresponding errors of ordinary optics.

1568. RELATIONS BETWEEN ELECTRON LENS, ELECTRON MIRROR AND CONTROL [of Beam Intensity].—W. Henneberg and A. Recknagel. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 621–623.)

Authors' summary :—The single electric lens with negative lens voltage becomes an electron mirror when the energy of the incident electrons is sufficiently small. As the energy decreases, the lens acts successively as a collecting lens, a collecting mirror and a scattering mirror (Fig. 1). The path of the electron beam (Fig. 2) and the curve of focal length of the mirror (Fig. 3) are given for a potential field already investigated as a lens. During the change from lens to mirror, the intensity of the transmitted beam is controlled.

1569. REPORT ON ELECTRON-OPTICAL QUESTIONS CONNECTED WITH TELEVISION.—Brüche and Schaffernicht. (*See* 1505.)

1570. ELECTROSTATIC FOCUSING AT RELATIVISTIC SPEEDS [Power Series for Quick Computation of Focal Properties of Common Electron Lenses even when Electron Speed approaches that of Light].—Hansen and Webster. (*Review Scient. Instr.*, January, 1936, Vol. 7, No. 1, pp. 17–23.). *See* also 1571.

1571. ION OPTICS OF EQUAL COAXIAL CYLINDERS [Potential Distribution along Axis expressed empirically in Terms of Radius and Separation].—Kirkpatrick and Beckerley. (*Review Scient. Instr.*, January, 1936, Vol. 7, No. 1, pp. 24–26.) Combined with the theoretical lens equation of Hansen and Webster (1570), this empirical expression " yields an algebraic formula for lenses of this type directly relating object and image distances to readily measurable quantities."

1572. ON THE CONCENTRATION OF ELECTRON BEAMS IN GAS-FILLED TUBES.—Sokolskaya. (*See* 1506.)

1573. A SEALED COLD-CATHODE OSCILLOGRAPH FOR LOW EXCITING VOLTAGES [with Auxiliary Discharge to provide Ions), *and* RECENT DEVELOPMENTS OF THE CATHODE-RAY OSCILLOGRAPH [and the Elimination of Mains Disturbances].—Becker : Dantscher. (*See* 1501 and 1502.)

1574.—A CATHODE-RAY OSCILLOGRAPH FOR THE DIRECT MEASUREMENT OF HIGH-VOLTAGE TRANSIENTS [for 100 kV Operating Voltage without Use of Potential Divider : with Delayed Impulse Circuits : etc.].—Nuttall. (*Journ. I.E.E.*, February, 1936, Vol. 78, No. 470, pp. 229–234.)

The general features of the tube itself are similar to those of the Burch & Whelpton tube (1933 Abstracts, pp. 51 and 339) except for the special high-voltage plates. The variable-capacitance potential divider shown is used only with the low-voltage plates, when frequent and wide variation of voltage of applied impulse is necessary.

1575. CATHODE-RAY RECORDER " REMEMBERS " BY MEANS OF FLUORESCENCE DELAY.—Hull. (*Electronics*, January, 1936, Vol. 9, p. 36.) *See* also 715 of February.

1576. THE ELECTRON TELESCOPE [Zworykin " Electron Copying Camera " working with Infra-Red, Visible or Ultra-Violet Light : Description : Applications].—Zworykin and Morton. (*Electronics*, January, 1936, Vol. 9, pp. 10–13.) Based on demonstration to American Association for the Advancement of Science (1092 of March). Among other things, the avoidance of " pin-cushion " distortion by the use of a spherically curved cathode is described.

1577. USE OF A RADIAL-DEFLECTION CATHODE-RAY OSCILLOGRAPH AS A TIME COMPARATOR [with Spiral Time-Base : Time Microscope].—Dowling and Bullen. (*Nature*, 15th Feb. 1936, Vol. 137, p. 279.)

1578. A NEW METHOD FOR THE APPLICATION OF LUMINESCENT SCREENS TO GLASS SURFACES [Objections to Liquid Binder and Sintering Methods : New Method using Sulphur Coating (from Carbon Disulphide Flame) to pick up Fluorescent Powder and leave it fixed when Sulphur is driven off].—Kohl. (*Canadian Journ. of Res.*, December, 1935, Vol. 13, No. 6, Sec. A, pp. 126–132.) The mechanism may be that the sulphur charges the glass surface and causes the binding of the powder by electrical forces : or the powder may be held by surface forces, the sulphur acting as cleaning agent.

1579. THE ABSORPTION OF GASES BY MERCURY [New Results of Interest for Vacuum Technique].—Ptizin. (*Tech. Phys. of USSR*, No. 1, Vol. 2, 1935, pp. 66–78 : in English.)

1580. On the Liberation of Gases from Glass under the Influence of a High Frequency Discharge.—V. I. Romanov and N. A. Tsvetkov. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 5, 1935, pp. 996–999.)

An account of experiments with glow-discharge tubes subjected to the action of h.f. currents. It has been found that under certain conditions large quantities of CO_2 and H_2 are liberated from the glass walls of the tubes.

1581. Oscillograph Amplifiers for Very Wide Frequency Ranges [0.2 c/s to 3×10^6 c/s and 2×10^4 c/s (the latter with Voltage Amplification 10^5)].—von Ardenne. (*Wireless Engineer*, February, 1936, Vol. 13, No. 149, pp. 59–64.) More extensive account of the amplifiers dealt with in 231 of January.

1582. Production and Applications of Short Current Impulses with a Valve Circuit [Use of Hydrogen Discharge Tube in "Trip" Circuit].—Drewell. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 614–617.)

Large condensers at a high voltage can be discharged across grid-controlled discharge tubes filled with hydrogen ("trip" circuit Fig. 1). Short intense pulses of current can thus be produced (circuit Fig. 3) which may be applied to excite inductors or to feed a mercury lamp for stroboscopic observations.

1583. The Positive Ion Current to the Incandescent Cathode of a Gaseous Discharge [Possible Objection to Gvosdover's Method of Determining the Relation between Electron and Ion Current: Reply].—Druyvesteyn: Gvosdover. (*Physik. Zeitschr. der Sowjetunion*, No. 5, Vol. 8, 1935, pp. 579–581: 582–583: in German.) *See* 3465 of 1935.

1584. Potential Reliefs of High-Vacuum and Gas-Filled Detectors and Rectifiers.—Gottmann. (*Funktech. Monatshefte*, January, 1936, pp. 5–8.) Extension of work referred to in 570 and 571 of February.

1585. The Operating Characteristics of Small Grid-Controlled Hot-Cathode Arcs or Thyratrons.—French. (*Journ. Franklin Inst.*, January, 1936, Vol. 221, No. 1, pp. 83–102.)

An investigation of the magnitude and nature of the current in the grid circuit of a thyratron before starting. This is found to depend theoretically upon the shape of the grid current characteristic before starting, as well as on the grid circuit constants. The method of measuring the grid current and impedance at the starting point is described. Three types of thyratron were investigated; certain anomalies occurring at low anode potentials are described in detail. Emphasis is placed on the significance of the magnitude and sign of the grid impedance. Grid resistances of 100 to 1 000 megohms are essential in certain cases. *See* also Nottingham, 1931 Abstracts, pp. 269 and 500.

1586. High-Voltage Low-Current Rectifier Type U16, primarily for Television Cathode-Ray Tubes.—Osram. (*Wireless Engineer*, February, 1936, Vol. 13, No. 149, p. 64: paragraph only.)

1587. The Electric Discharge in Gases and the Debye-Hückel Theory.—Chiplonkar. (*Current Science*, Bangalore, January, 1936, Vol. 4, No. 7, p. 481.) "In view of the remarkable success of the theory in the field of the kinematics of ions in liquid media, it is not a little surprising that but little use of its methods has been made in the analysis of the phenomena in discharge tubes. . ."

1588. Nomographic Representation of the Saha Equation [of Thermal Ionisation].—Unsöld. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 450–461.)

1589. The Copper Oxide Rectifier [Formation: Interface Structure: Characteristics: Thermal Conductance].—Starr. (*Physics*, January, 1936, Vol. 7, No. 1, pp. 15–19.)

The conditions of formation of the Cu_2O-rectifier are controlled by the equilibrium diagram of the component substances, which is first discussed. The structure of the interface is investigated with polarised light. The rectifier characteristics are determined by a method free from error due to current heating at the interface. Measurement of the thermal conductance of the rectifier showed asymmetry in the direction to be expected from the electron theory of heat conduction.

1590. Silicate Research and Engineering.—Eitel. (*Zeitschr. V.D.I.*, 11th Jan. 1936, Vol. 80, pp. 37–41.)

1591. Some Investigations of the Temperature Variations of the Dielectric Properties of Titanium- and Tin-Dioxide [used as Ceramics in Condenser Construction: Method of Measurement: Curves for Wavelengths 90–1500 m: Impurities cause Dispersion of Dielectric Constant].—Schusterius. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 640–642: Discussion p. 642.)

1592. The Passage of Current through Thin Films of Aluminium Oxide in Electron Tubes.—Kessel. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 506–508.)

The Al_2O_3-films were produced electrolytically and studied in a high vacuum, using an "electron-gas" cathode (Fig. 1). The current/voltage characteristics were investigated under various conditions as regards the adsorbed gas in the film. Curves taken at room temperature are shown in Fig. 2 and described; Fig. 3 shows anode-current density curves (a) with the electron-gas cathode and (b) in an electrolyte, for comparison of "dry" and "wet" conditions. The results show considerable agreement; the passage of current through the film in the two cases seems to be determined by conditions in the film itself, its exact chemical composition and variation with time. The various reasons for this conclusion are shortly given.

1593. THE BEHAVIOUR OF ELECTROLYTIC OXIDE FILMS [Hypothesis of Electrolytic Barrier-Layer and Varied Amounts of Adsorbed Oxygen].—Störmer. (*Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 508–512: Discussion pp. 512–513.)

A sudden switch-over of the polarity of the electrodes of an aluminium electrolytic cell showed that a delay occurred before the conductivity reached its final value (§ 1). The current/voltage characteristics of the dry electrolytic oxide film and the effect on them of various treatments of the cathode were also investigated (§ 2). An explanation of the results is found (§ 3) in the hypothesis of an electrolytic barrier-layer and the variation in the quantity of oxygen adsorbed thereon.

1594. ON THE ROTATION OF DIPOLES IN ELASTIC AND VISCOUS MEDIA [Application of Dipole Theory to Amorphous Solids: Couple acting on Rotated Rigid Sphere in Elastic Medium deduced from Stokes' Result for Rotation in Viscous Fluid].—Yates-Fish. (*Phil. Mag.*, February, 1936, Series 7, Vol. 21, No. 139, pp. 226–233.) *See* Gemant, 2087 of 1935.

1595. ON DIELECTRIC LOSSES IN CERTAIN HETEROGENEOUS DIELECTRICS.—M. N. Mikhailov and M. M. Stolyarov. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 5, 1935, pp. 1007–1010.)

An investigation into the losses which occur in heterogeneous dielectrics consisting essentially of a liquid with non-polarised molecules and an insoluble solid constituent. The systems investigated were: talc powder in paraffin oil, rubber in hexane, and paper impregnated with paraffin oil. The angles of loss of each constituent taken separately and of the above systems were measured, at frequencies of 50 and 10^6 c/s and at temperatures varying from -100 to $+50$°C. The results obtained are shown in a number of curves and a tentative explanation is offered of the various effects taking place when two dielectrics are combined together.

1596. TECHNICAL MASTERY OF THERMAL BREAKDOWN [of Dielectrics: Physical Expression of Theory of Thermal Characteristics].—Lueder, Schottky and Spenke. (*Naturwiss.*, 24th Jan. 1936, Vol. 24, No. 4, p. 61.)

1597. THE INFLUENCE OF THE RELATIVE HUMIDITY OF THE AIR ON THE LOSS ANGLE OF INSULATING MATERIALS AT HIGH FREQUENCIES.—Schwarz. (*See* 1551.)

1598. THE BREAKDOWN OF OIL-IMPREGNATED CARDBOARD.—Quittner. (*Tech. Phys. of USSR*, No. 1, Vol. 2, 1935, pp. 21–23: in German.)

1599. NEW PRODUCTIONS OF THE NUREMBERG SCREW FACTORY AND REPETITION TURNERY [Rotary and Fixed Condensers: Temperature-Independent Material with Very Small Loss Angles: Smoothing Circuit for Television High-Voltage Potentiometer.]—(*Hochf: tech. u. Elek:akus.*, December, 1935, Vol. 46, No. 6, pp. 215–216: Industry Review.)

1600. ELECTROLYTIC CONDENSERS FOR BROADCAST RECEIVERS [Investigation of Capacity and Loss Angle, Temperature Effect, etc.].—Linder. (*E.T.Z.*, 2nd Jan. 1936, Vol. 57, No. 1, p. 15: summary only.)

The writer's representation of the electrolytic condenser, and its complex equivalent circuit of series-parallel capacities and resistances, explains two phenomena: (i) that the layer thickness (and consequent weight of oxide) calculated from the measured capacity is too small, and (ii) that condensers with smaller peak voltages always give a larger loss angle; this is attributed to a greater influence of the capacity of the "outer" layer (partly permeated by the electrolyte, whereas the "inner" layer is practically free from electrolyte). It also explains the rising capacity with rising temperature: the loss angle decreases with rising temperature but later increases slightly on account of increasing losses in the outer layer (Fig. 3). As the frequency increases the loss angle increases steadily and almost linearly, chiefly under the influence of the series resistances in the porous outer layer and the electrolyte.

The magnitude of the a.c. or superposed d.c. voltage has little immediate effect on the capacity: but over a long period of time the d.c. voltage and the temperature are important factors. The closer the impressed voltage comes to the original forming voltage, the greater will be the slight additional forming process and the consequent gradual decrease in capacity (of the order of 5% in a year). The temperature is of importance in that the higher it is, the more inclined is the oxide layer to pass into solution. But in dry electrolytic condensers this dissolving process is extremely small, and the writer considers that these condensers already form reliable components for broadcast receivers and, along the lines of future development which he briefly discusses, should have an increasing field of application.

1601. ON THE SETTING OUT OF SCALES AND GRATINGS ON THE DISCS AND BARRELS OF MEASURING INSTRUMENTS [*e.g.* Goniometers] BY A PHOTOGRAPHIC METHOD.—F. L. Burmistrov. (*Journ. of Tech. Phys.* [in Russian), No. 6, Vol. 5, 1935, pp. 1109–1112.)

A method has been developed, making use of convex and concave conical mirrors, by means of which the drawing of a scale wrapped on a cylinder can be reproduced on the outer or inner surface of another cylinder, covered with a sensitised layer. For a French version of this paper see *Tech. Phys. of USSR*, No. 1, Vol. 2, 1935, pp. 61–65. The photographic method has always been recognised as the cheapest but hitherto there have been difficulties in getting precision with curved surfaces.

1602. A Relay for Operating Two Circuits Alternately with Delayed Action [Detailed Description with Diagrams].—Perfect. (*Proc. Phys. Soc.*, 1st Jan. 1936, Vol. 48, Part 1, No. 264, pp. 203–207: demonstration.)

1603. Graphical Harmonic Analysis [General Method for Waves containing Sine Components of Odd Harmonics and Cosine Components of Even: by Measurement of Ordinate Differences between Dynamic Characteristic and Straight Line joining Its Ends].—Hutcheson. (*Electronics*, January, 1936, Vol. 9, pp. 16–18 and 34.)

1604. A Tube-Controlled Motor [" Synchronous Motor with Electronic Connection between Field Coils forms Mechanically-Coupled Variable-Frequency Oscillator of Interesting Uses "].—King. (*Electronics*, January, 1936, Vol. 9, pp. 14–15.)

1605. Polaroid, a Glass with the Property of Polarising Light.—(*Sci. News Letter*, 1st Feb. 1936, Vol. 29, p. 77.)

1606. Optically Perfect Lithium Fluoride Crystals large enough for Lenses [Very Transparent to Ultra-Violet and Infra-Red Light].—Stockbarger. (*Science*, 6th Dec. 1935, Vol. 82, Supp. p. 10.) *See* also *Electronics*, January, 1936, Vol. 9, p. 38.

1607. An Iron-Free Coil for the Production of Strong Magnetic Fields [with Water-Cooling System: Constructional Details].—Gerloff and Löwe. (*Zeitschr. f. Physik*, No. 9/10, Vol. 98, 1936, pp. 559–560.)

1608. Permanent Magnet Materials [particularly the " Oxide " Material].—Williams: Kato and Takei. (*Elec. Engineering*, January, 1936, Vol. 55, No. 1, pp. 19–23.) Discussion of nickel-aluminium-iron, cobalt-molybdenum-iron and cobalt-tungsten-iron alloys, and of the non-metallic material composed of cobalt and iron oxides described by Kato and Takei (1933 Abstracts, p. 579).

1609. Ferromagnetic Materials for High Frequencies [Analysis of Requirements and Survey of Methods].—Weis. (*Arch. f. tech. Mess.*, October, 1935, pp. T 139–140.)

1610. Alnico—New Magnetic Material.—Mishima. (*Electronics*, January, 1936, Vol. 9, p. 40.) *See* also 741 and 742 of February.

1611. [Reversible and Irreversible] Thermal Effects of Magnetisation [of Ferromagnetics].—Okamura. (*Nature*, 8th Feb. 1936, Vol. 137, p. 241: short note only.)

1612. Paramagnetic Relaxation [Heat developed in Alternating Magnetic Field: Large Effect at Low Temperatures: Relaxation Time of Magnetic Vector].—Gorter. (*Nature*, 1st Feb. 1936, Vol. 137, p. 190.)

STATIONS, DESIGN AND OPERATION

1613. Doubling the Available Radio Channels [Transmission of Two Programmes on One Carrier by Simultaneous Amplitude and Frequency Modulation: Local Synchronised Oscillator as Only Addition to Receiver Equipment].—Woodyard. (*Proc. Inst. Rad. Eng.*, January, 1936, Vol. 24, No. 1, p. 8: summary only.)

1614. Broadcasting: Principal Developments in 1935.—Ashbridge. (*Electrician*, 31st Jan. 1936, Vol. 116, p. 140.)

1615. The Centre of British Broadcasting: Droitwich, near Birmingham.—Adam. (*Génie Civil*, 1st Feb. 1936, Vol. 108, pp. 101–105.)

1616. Organisation and Technique of the World Radio Link of 27.10.1935 [" Youth Sings across the Frontiers "].—Weil. (*T.F.T.*, November, 1935, Vol. 24, No. 11, pp. 289–292.)

1617. New 41-Mc W8XH [New WBEN 100-Watt Ultra-Short-Wave Broadcasting Transmitter with Flat Characteristic 30–17 000 c/s: " Turnstile " Aerial Array: 25–30 Mile Range].—Kingsley. (*Electronics*, January, 1936, Vol. 9, p. 19.) For a previous article *see* 2456 of 1935. " Does the high-fidelity, high-frequency WBEN transmitter presage a new broadcast service? "

1618. Micro-Ray Communication. Effect of Weather on Transmission: Possible Future Uses of Wavelengths below 50 cm.—McPherson and Ullrich. (*See* 1341.)

1619. Radio Telephony: New Long and Short Distance Links [in 1935: including Ultra-Short Waves].—Gill. (*Electrician*, 31st Jan. 1936, Vol. 116, pp. 139–140.)

1620. Locomotive to Caboose Radio Communication [on Ultra-Short Waves: Results of Westinghouse Tests: Commercial Equipment].—Ellis. (*Elec. Engineering*, January, 1936, Vol. 55, No. 1, pp. 109–113.)

GENERAL PHYSICAL ARTICLES

1621. The Nature of Light [Photon may consist of Train of Circular Lines of Force].—J. J. Thomson. (*Nature*, 8th Feb. 1936, Vol. 137, pp. 232–233.)

1622. The Equations of Motion [of the Lorentz Electron] in the New Electrodynamics.—Chraplywy. (*Comptes Rendus*, 5th Feb. 1936, Vol. 202, No. 5, pp. 396–397.)

1623. Absolute Values of the Electron Mobility in Hydrogen [Electrical Grid-Shutter Method for Mobility Measurement].—Bradbury and Nielsen. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, p. 205: abstract only.)

1624. Interrelationships of e, h/e and e/m [Discussion of Discrepancies: Latest Values].—Birge. (*Nature*, 1st Feb. 1936, Vol. 137, p. 187: abstract only in *Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, p. 204.)

1625. New Investigations of Lines of Helium and Hydrogen with Crossed Electric and Magnetic Fields [Interconnection of Stark and Zeeman Effects].—Steubing. (*Zeitschr. f. tech. Phys.*, No. 11, Vol. 16, 1935, pp. 428–431.)

1626. The Influence of a Magnetic Field on the Dielectric Constants of Gaseous and Liquid Nitrogen and Oxygen [Positive Result with Liquid Oxygen, explained by Increased Pressure].—Young. (*Canadian Journ. of Res.*, December, 1935, Vol. 13, No. 6, Sec. A, pp. 111–119.)

1627. Investigation of the [Inappreciable] Magnetic Change of the Dielectric Constant of Liquids in a Field of 20.4 Kgauss.—Piekara. (*Comptes Rendus*, 20th Jan. 1936, Vol. 202, No. 3, pp. 206–207.) *See* also 342 of January.

1628. Ionisation by Neutral Atom Beams [studied by Balanced Space Charge Method: Energy available for Ionisation is very near True Ionisation Potential of Gas].—Varney. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, p. 204: abstract only.)

1629. A Problem in Potential Theory [Methods for Calculating Potential Distributions in Two Regions of Different "Conductivities" separated by Movable Surface of Unknown Shape].—Muskat. (*Phys. Review*, 15th Jan. 1936, Series 2, Vol. 49, No. 2, p. 195: abstract only.)

MISCELLANEOUS

1630. The Large Roots of $\cos z = az + c$.—Cooper and Todd. (*Phil. Mag.*, February, 1936, Series 7, Vol. 21, No. 139, pp. 249–262.)

1631. Notes on the Asymptotic Evaluation of Operational Expressions [Extension of Heaviside's Rule: Use of Watson's Lemma].—Koizumi. (*Phil. Mag.*, February, 1936, Series 7, Vol. 21, No. 139, pp. 265–274.)

1632. Introduction to the Applications of the Heaviside Symbolic Calculus to the Problems of Electrotechnics.—Blondel. (*Rev. Gén. de l'Élec.*, 18th, 25th Jan. and 1st, 8th Feb. 1936, Vol. 39, Nos. 3–6, pp. 83–99, 133–146, 179–191, and 219–229.)

1633. Fractional Calculus: Fractional Contour Integration.—Fabian. (*Phil. Mag.*, February, 1936, Series 7, Vol. 21, No. 139, pp. 274–280.)

1634. Bessel Product Functions [of Order n: Formulae: Expansions].—Costello. (*Phil. Mag.*, February, 1936, Series 7, Vol. 21, No. 139, pp. 308–318.)

1635. On the Combination of Observational Data [Method for Combination of Curves derived by Different Experimenters into Unique Curve: Formulae for Calculation of Ordinates].—Levy and Gascoigne. (*Proc. Phys. Soc.*, 1st Jan. 1936, Vol. 48, Part 1, No. 264, pp. 79–84.)

1636. On the Significance of Slopes and Other Parameters estimated by Least Squares.—Deming. (*Phys. Review*, 1st Feb. 1936, Series 2, Vol. 49, No. 3, pp. 243–247.)

1637. Probability for the Differential Composition of the Accidental Errors, and Its Application [to Cross-Talk in Cables].—Goto. (*Journ. I.E.E. Japan*, November, 1935, Vol. 55 [No. 11], No. 568, pp. 990–994: English summary pp. 125–126.)

1638. New Infra-Red "Eye" pierces through Haze and Smoke: Combined with Telescope or Microscope, will find Many Scientific and Other Uses.—Zworykin. (*Sci. News Letter*, 11th Jan. 1936, Vol. 29, pp. 21–22.) *See* also 1576.

1639. The "Petoscope" [Photocell Apparatus for detecting Moving Objects in Full Daylight: *e.g.* Aircraft in Flight].—Lancaster: Fitzgerald. (*Wireless World*, 10th Jan. 1936, Vol. 38, p. 39: *Electronics*, October, 1935, Vol. 8, pp. 26–29.)

1640. Phototubes perforate U.S. Stamps.—Church. (*Electronics*, September, 1935, Vol. 8, pp. 27 and 29.)

1641. The Colour-Matching of Tungsten-Filament Lamps by means of a Single Photocell and Colour Filters [Use in Checking Calibration of Standards of Colour Temperature].—Preston. (*Proc. Phys. Soc.*, 1st Nov. 1935, Vol. 47, Part 6, No. 263, pp. 1012–1018.)

1642. A Photoelectric Colorimeter with Logarithmic Response.—Müller and Kinney. (*Journ. Opt. Soc. Am.*, October, 1935, Vol. 25, No. 10, pp. 342–346.)

1643. Apparatus for Darkfield Photometry and Densitometry.—Williams and Scott. (*Journ. Opt. Soc. Am.*, October, 1935, Vol. 25, No. 10, pp. 347–349.)

1644. An Electrophotometer with Barrier-Layer Cells for the Practical Measurement of Opacity.—Meunier. (*Comptes Rendus*, 23rd Dec. 1935, Vol. 201, No. 26, pp. 1371–1373.)

1645. The Employment of "Photoemissive" Cells in Photometry.—Fleury and Boutry. (*Rev. Gén. de l'Élec.*, 7th Sept. 1935, Vol. 38, No. 10, pp. 323–333.)

1646. The Selectivity of Photometric Integrators, with Particular Reference to the Photometry of Gaseous Discharge Tubes [Theoretical Treatment of Errors in Determination of Luminous Outputs: Experimental Verification].—Buckley. (*Phil. Mag.*, November, 1935, Series 7, Vol. 20, No. 135, pp. 745–760.)

1647. The Photo-Relays.—Mikhailov. (*Elektritchestvo*, No. 19, 1935, pp. 23–32.)

1648. Photocell Monitoring of a Chemical Maturing Process in Explosive Chemicals.—Zesch. (*E.T.Z.*, 6th Feb. 1936, Vol. 57, No. 6, p. 155.)

1649. The Spectral Emission Region of Chemical Reactions [Measured with Suitable Sensitive Photocathodes: Region 2000–2200 Å].—Audubert. (*Comptes Rendus*, 13th Jan. 1936, Vol. 202, No. 2, pp. 131–133.) *See* also 1934 Abstracts, p. 54, and 1310 and 1997 of 1935.

1650. Photoelectric Colour-Measuring Device used for Process Control [Sugar and Oil Refining, Heat Treatment, etc.].—(*Electronics*, January, 1936, Vol. 9, pp. 36–37.)

1651. A New High-Speed High-Sensitivity Photoelectric Potentiometer [for the Measurement, Recording and Controlling of Physical Quantities].—Gilbert. (*Review Scient. Instr.*, January, 1936, Vol. 7, No. 1, pp. 41–44.)

1652. Photocell Detector [registering Presence of Candle at 7 miles without Telescope] to be used with New 200-inch Telescope Mirror.—(*Electronics*, January, 1936, Vol. 9, p. 40.)

1653. Photoelectric Half-Shadow Method for the Determination of Rotatory Dispersion.—Schönrock and Einsporn. (*Physik. Zeitschr.*, 1st Jan. 1936, Vol. 37, No. 1, pp. 1–12.)

1654. Photocell Controls [Special Number of *Elektrotechnische Zeitschrift*].—(*E.T.Z.*, 6th Feb. 1936, Vol. 57, No. 6, pp. 137–154.)

Including papers by Sewig (fundamental considerations): Tuczek (some applications, including high-sensitivity methods): Kluge (latest developments of alkali cells): Seidelbach (control of sound-film amplifiers): Johannsen (latest alkali cells and their conquest of the prejudice against photoelectric devices in rolling mills): Richter (photocells as "twilight switches" and photocells in the service of water works).

1655. "Die Photoelemente und ihre Anwendung" [Book Review].—Lange. (*Zeitschr. f. tech. Phys.*, No. 1, Vol. 17, 1936, pp. 31–32.)

1656. High-Frequency Method of Registering the Equilibrium Position of the Beam of a Microbalance.—Santo Rini. (*Comptes Rendus*, 30th Dec. 1935, Vol. 201, No. 27, pp. 1468–1470.) For previous work *see* Abstracts, 1932, p. 361: *also* 1934, p. 54.

1657. The Speed-Time Electrograph [for Tests on Electric Railway Motors, etc.].—Cromwell. (*Elec. Engineering*, September, 1935, Vol. 54, No. 9, pp. 923–930.)

1658. Instrument for the Location of Faults on Overhead Lines [High-Frequency Method without Use of Cathode-Ray Oscillograph].—Allen and Gross. (*E.T.Z.*, 14th Nov. 1935, Vol. 56, No. 46, pp. 1255–1256: summary only.)

1659. Traffic Control Systems [and the Electromatic and Autoflex Timing Circuits].—Vause. (*P.O. Elec. Eng. Journ.*, January, 1936, Vol. 28, Part 4, pp. 301–309.)

1660. The Drying of Wood by Ultra-High-Frequency Oscillations [Russian Work].—Frolov. (*Zeitschr. V.D.I.*, 21st Dec. 1935, Vol. 79, No. 51, p. 1531: summary only.)

1661. Homogeneous Vulcanisation [by H. F. Furnace and Short-Wave Electric Field].—Leduc. (*Recherches et Inventions*, January, 1936, pp. 20–25.)

1662. Industrial High-Frequency Power [7–10 kc/s, for Induction Furnaces, Welding, etc.: Design of 20 kW Generator].—Noble. (*Electronics*, October, 1935, Vol. 8, pp. 22–24.)

1663. Radio Waves act as Tamper-Proof Burglar Alarm [Micro-Waves lace Room by Repeated Reflection from Wall to Wall: Possible Application to Aircraft Detection].—(*Sci. News Letter*, 4th Jan. 1936, Vol. 29, p. 14.)

1664. New Radio Device [Microphone/Amplifier Combination] detects Leaks in Water Mains.—Pies. (*Sci. News Letter*, 28th Dec. 1935, Vol. 28, p. 407.)

1665. Radioactivity by Bombardment [and the Apparatus used by Lawrence and Livingston].—Livingood. (*Electronics*, November, 1935, Vol. 8, pp. 7–9 and 60.)

1666. Ultra-Speed in Motion Pictures [3 000 Pictures/Sec., with Electronic Timer: analyses High-Speed Industrial Processes, etc.].—(*Electronics*, December, 1935, Vol. 8, pp. 6–10.)

1667. Electronics in Oil [Applications to Finding, Refining, Analysing, etc.].—(*Electronics*, December, 1935, Vol. 8, pp. 15–17.)

1668. Industrial Applications of the Grid-Controlled Current Director [Photoelectric Counting of Objects: Galvanometer Protection: Safety Device for Looms: Loss-Free Regulation of A.C.: Control of X-Ray Equipments: Motor Speed Regulation].—Hauffe. (*Zeitschr. V.D.I.*, 7th Dec. 1935, Vol. 79, No. 49, pp. 1475–1478.)

1669. "Industrial Electronics" [Book Review].—Gulliksen and Vedder. (*Electronics*, December, 1935, Vol. 8, p. 35.)

1670. Monitoring a Welder [Diode Circuit measuring Total Heat Energy of Weld].—RCA Radiotron. (*Electronics*, January, 1936, Vol. 9, p. 38.)

1671. Experiments on the Frequency Modulation of a Wien [Toothed-Wheel] Generator: Application to Study of Periodic Speed Variations in Motors.—Rytov. (*See* 1395.)

1672. Electro-Magnetic Tests for Work-Hardening Steel Wires [from Used Steel Wire Ropes : Magnetostriction and Travelling Surge Methods].—Wall. (*Engineer*, 13th Sept. 1935, Vol. 160, pp. 260–263.)

1673. A Electromagnetic Fatigue Tester [excited by Variable-Frequency Oscillator].—(*Engineering*, 11th Oct. 1935, p. 406.)

1674. Some Dynamic Methods for Determination of Young's Modulus [particularly an Electrostatic Method].—Ide. (*Review Scient. Instr.*, October, 1935, Vol. 6, No. 10, pp. 296–298.)

1675. [Measurements of] Infra-Red Radiation from Otto Cycle Engine Explosions.—Nat. Bureau of Standards. (*Journ. Franklin Inst.*, January, 1936, Vol. 221, No. 1, pp. 158–159 : short note only.)

1676. A Piezoelectric Indicator for High Speed Internal-Combustion Motors [Complete Equipment with Cathode-Ray Oscillograph and Camera].—Jungnickel. (*Zeitschr. V.D.I.*, 18th Jan. 1936, Vol. 80, pp. 80–81.)

1677. The Standard-Sunbury Engine Indicator [Design of Engine Pick-Up Unit, and Electrical Amplifying and Integrating Circuits].—Beale and Stansfield. (*Engineer*, 27th Dec. 1935, Vol. 160, pp. 667–669.)

1678. Cathode-Ray Oscillograph Engine Indicator [and the Distortion produced by Photography of Curved Image].—Dodds. (*Engineering*, 8th Nov. 1935, p. 508.)

1679. Electrical Indicator for High-Speed Internal-Combustion Engines [Three-Plate Condenser Principle].—Fieber. (*Zeitschr. V.D.I.*, 9th Nov. 1935, Vol. 79, No. 45, pp. 1368–1369.) For Reisch's "potential-dividing" system for ultra-micrometers, on which this indicator is based, *see* 1932 Abstracts, pp. 53 and 109.

1680. The Measurement of Vibration.—Sell. (*Zeitschr. V.D.I.*, 16th Nov. 1935, Vol. 79, No. 46, pp. 1401–1402.) Siemens & Halske apparatus.

1681. An Electrodynamic Vibration Meter [for Mechanical Vibrations] and Its Application to the Investigation of Vibrations of Buildings [with Circuits of Amplifier and T-Filter Sections for Measurement of Acceleration and Movement : Oscillograms of Switch-On Transients : Frequencies below 100 c/s].—Meyer and Böhm. (*E.N.T.*, December, 1935, Vol. 12, No. 12, pp. 404–414 : abstract only in *Zeitschr. f. tech. Phys.*, No. 12, Vol. 16, 1935, pp. 567–568.)

1682. On the Measurement of Weak Mechanical Oscillations [by Movement of One Mirror of Optical Interferometer].—Seleznev and Knopfer. (*Journ. of Tech. Phys.* [in Russian], No 6, Vol. 5, 1935, pp. 1113.)

1683. Seismic Prospecting Method uses Electronic Recorders.—(*Electronics*, January, 1936, Vol. 9, p. 40.)

1684. Experiments on Conducting Laminae in Periodic Magnetic Fields [Secondary Magnetic Field increases with Dimensions of Conducting Circular Disc, Conductivity, Frequency : Phase Changes : Application to Location of Mineral Lodes].—Bruckshaw. (*Proc. Phys. Soc.*, 1st Jan. 1936, Vol. 48, Part 1, No. 264, pp. 63–74.)

1685. An Electrovibrator with Combined [Low and] High Frequency [Nerves resonate to Ultra-Short Waves].—Boursin. (*Comptes Rendus*, 6th Jan. 1936, Vol. 202, No. 1, pp. 95–96.)

1686. Discharge Tube Circuit used in Study of Brain [Steep-Wave-Front Impulses induced in Coil in Ape's Skull].—Chaffee and Light. (*Electronics*, October, 1935, Vol. 8, p. 37.)

1687. Cosmic Rays and the Origin of Species [Mutations might be caused by High Energy Particles striking Chromosomes : Great Variety of Crop Plants at High Altitudes].—Thomas. (*Nature*, 11th and 18th Jan. 1936, Vol. 137, pp. 51–53 : 97–98.)

1688. Oscillations due to Corona Discharges on Wires subjected to Alternating Potentials [One Type resembling Relaxation Oscillations : Effect of Cosmic Rays : etc.] —Tykociner & others. (*Univ. of Illinois Bull.*, 17th Sept. 1935, Vol. 33, No. 3, 53 pp.)

1689. Thermal Measurements in Short-Wave Diathermy [satisfactorily made by Benzene Thermometers in Quartz].—Bessemans, Rutgers and van Thielen. (*Comptes Rendus*, 13th Jan. 1936, Vol. 202, No. 2, pp. 157–159.)

1690. Methods of Enhancing X-Ray Action [by Radiothermy with Ultra-High Frequencies : Possible Use of Steel Needles heated by Radiothermic Induction, to cause Tissue Necrosis].—Delario. (*Sci. Abstracts*, Sec. A, 25th Jan. 1936, Vol. 39, No. 457, pp. 76–77.)

1691. The Apparatus used for Medical Applications of Electricity.—Lemoine. (*Génie Civil*, 8th and 15th Feb. 1936, Vol. 108, pp. 131–133 and 157–159.)

1692. An Apparatus for Recording Systolic Blood Pressure [using Piezoelectric Microphone].—Omberg. (*Review Scient. Instr.*, January, 1936, Vol. 7, No. 1, pp. 33–34.)

1693. A Recording Electrocardiograph [Pre-Amplification by D.C. or Very Low Frequency A.C. Amplifier, Modulation by 1 000 c/s Note, then A.F. Amplification].—Portier. (*Génie Civil*, 1st Feb. 1936, Vol. 108, p. 119 : summary only.)

1694. 1935—In Review : 1936—Prospects.—(*Electronics*, January, 1936, Vol. 9, pp. 7–9 and 33.)

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.

TRANSMISSION CIRCUITS AND APPARATUS

437 671.—Oscillation-generator on which the grid and anode potentials are maintained substantially in exact anti-phase in order to stabilise frequency.

Marconi's W. T. Co. and E. B. Moullin. Application date 4th May, 1934.

439 747.—Wired "broadcasting" system using high-frequency carrier-currents, so as to provide alternative programmes.

P. P. Eckersley and R. E. H. Carpenter. Application date 26th June, 1934.

440 238.—Feed-line for ultra-short waves made up of a number of repeated units which are, at least approximately, tuned to the working frequency.

N. V. Meaf. Convention date (Germany) 27th April, 1934.

2 000 584.—Frequency modulating system in which the applied signal varies the resistance of a valve shunted across a part of the main oscillatory circuit.

C. Fichandler.

2 000 685.—Stabilising the frequency of the oscillations generated in a circuit of the multivibrator type.

V. J. Andrew (assignor to Westinghouse Electric and Manufacturing Co.).

2 012 018.—Piezo-electric master-oscillator unit designed to be immersed in an oil-tank for cooling purposes.

M. Osnos (assignor to Telefunken Co.). Convention date (Germany) 14th January, 1931.

RECEPTION CIRCUITS AND APPARATUS

437 442.—Wireless receiver fitted with fine-tuning means which automatically comes into operation when the controls have been roughly tuned to a desired station.

H. Jackson. Application date 24th February, 1934.

437 460.—Single-valve super-regenerative amplifier with electron coupling between the quenching and signal frequencies.

D. W. Pugh and Baird Television.

437 305.—Homodyne receiver with means for varying the degree of modulation of the received signal.

Marconi's W.T. Co. and G. M. Wright. Application date 28th April, 1934.

437 569.—Arrangement of the illuminating lamp for the tuning dial of a wireless receiver.

E. K. Cole. Convention date (Sweden) 26th April, 1934.

437 643.—Detector valve with two grids fed in phase-opposition so as to balance out the carrier-wave component, particularly in television systems.

Radio Akt. D. S. Loewe. Convention date (Germany) 2nd March, 1933.

438 010.—Tuning dial in which the received station is indicated by light of a different colour or intensity from the general illumination.

N. V. Philips. Convention date (Germany) 21st July, 1934.

438 014.—Wireless receiver fitted with two loud-speakers, one or other of which is brought into circuit according to the setting of the volume control.

E. K. Cole (Aga Baltic Radio). Application date 25th June, 1935.

438 670.—Suppressing inter-station "noise" in tuning without using an extra valve for this purpose.

E. K. Cole and others. Application date 25th June, 1934.

438 797.—Wireless receiver with adjustable band-pass selector interlocked with the tuning control.

Hazeltine Corporation (assignees of H. A. Wheeler and N. P. Case). Convention date (U.S.A.) 7th November, 1933.

439 047.—Heptode valve used in a reflex circuit, as a tetrode high-frequency stage and a triode low-frequency amplifier.

Marconi's W.T. Co.; N. M. Rust; and O. E. Keall. Application date 28th May, 1934.

439 288.—Superhet circuit particularly suitable for "midget" sets.

Marconi's W.T. Co. (assignees of R. M. Smith). Convention date (U.S.A.) 30th June, 1933.

440 451.—Direct-current or zero-frequency amplifier designed to suppress fortuitous voltage-variations in the grid, filament, or anode supply.

G. Krawinkel. Convention date (Germany) 25th October, 1933.

440 607.—Tuning indicator designed to display a large number of stations within a limited space.

J. A. Wiegand and P. R. Weenink. Convention date (Holland) 8th May, 1934.

1 989 394.—Balanced Wheatstone bridge arrangement for preventing the D.C. component in the output circuit of a valve amplifier from passing through the windings of inter-stage coupling transformers or chokes, or through the windings of a loud-speaker.

W. Aull.

1 998 479.—Circuit for automatically matching the two valves of a push-pull amplifier.

R. O. Wise (assignor to Bell Telephone Laboratories).

2 015 191.—Wave-band switching system with a minimum number of tapped coupling and reaction coils.

R. M. Planck (assignor to Radio Corporation of America).

2 000 677.—All-wave type of receiver fitted with interchangeable plug-in inductance coils, arranged in units for changing over from one wave-band to another.

B. Trevor (assignor to Radio Corporation of America). Application date, 12th February, 1932.

VALVES AND THERMIONICS

436 533.—" Renode " valve with means for concentrating the electron stream and subsequently controlling its passage through perforated electrodes.

C. A. S. Jensen. Convention date (Denmark) 12th April, 1933.

436 606.—Electrode assembly in a thermionic valve designed to minimise any looseness created by such vibration as may arise in transport.

E. Y. Robinson and another and Associated Electrical Industries. Application date 19th June, 1934.

436 636.—Thermionic-valve base designed to permit the soldering of the electrode leads in a plunge bath.

Delta Co. Convention date (Switzerland) 5th May, 1934.

437 726.—Multi-grid frequency-changing valve utilising electron-coupling.

Marconi's W.T. Co. (assignees of J. C. Smith). Convention date (U.S.A.) 31st January, 1933.

437 594.—Rigid electrode-assembly forming the electron gun of a cathode-ray tube.

L. F. Broadway and W. F. Tedham. Application date 26th March, 1934.

437 624.—Cathode-ray tube in which the electrodes are correctly spaced apart by means of a number of insulated distance pieces.

General Electric Co., L. C. Jesty and G. W. Seager. Application date 17th August, 1934.

437 924.—Valve for ultra short-wave working in which the grid lead is taken to the centre of that electrode through an opening formed in the anode.

Radio Akt. D. S. Loewe. Convention date (Germany) 13th March, 1934.

438 343.—Indirectly-heated cathode construction for a cathode-ray tube designed to minimise heat-losses.

British Thomson-Houston Co. Convention date (Germany) 21st July, 1934.

439 851.—Electrode assembly for high-powered valves designed to maintain uniform spacing and to be proof against mechanical shocks.

Standard Telephones (assignees of J. E. Clark and V. L. Ronci). Convention date (U.S.A.) 1st November, 1934.

439 879.—Gas-filled amplifier or detector in which the quantitative relation between input and output is determined by the grid-cathode spacing and by the use of an ionizable metallic vapour containing cadmium and mercury.

S. Ruben. Convention date (U.S.A.) 16th December, 1933.

440 146.—Short-wave valve in which the cathode consists of two parallel bands or strips with an interposed space-charge grid.

N. V. Meaf. Convention dates (Germany) 9th and 13th January, 1934.

1 991 387.—Modulating valve fitted with control electrode comprising two sets of parallel plates which deflect the electron stream away from the anode.

R. Gunn.

DIRECTIONAL WIRELESS

2 002 181.—Method of marking out a predetermined route by overlapping radio beams, both of which are radiated from dipole aerials set slightly out of the focal line of a common reflector.

W. Ilberg (assignor to Telefunken Co.).

ACOUSTICS AND AUDIO FREQUENCY CIRCUITS AND APPARATUS

437 973.—Portable public-address unit in which a vibration-absorbing medium is interposed between the microphone and loud-speaker.

A. C. Snell. Application date 21st June, 1934.

438 824.—Arrangement of nested loud-speakers designed either for dual or independent operation.

W. T. Tennant (communicated by the Rola Co.). Application date 5th October, 1934.

439 561.—Loud-speaker with a two-coil drive, only one of the coils responding to the lower frequencies.

Marconi's W.T. Co. (assignees of A. S. Ringel). Convention date (U.S.A.) 17th March, 1933.

440 612.—Class B push-pull amplifier arranged to offset the effect of variations in the plate supply voltage.

Telefunken Co. Convention date (Germany) 29th May, 1934.

2 008 701.—Sound reproducing system in which the range of volume is expanded automatically by varying the gain of the amplifiers in step with the instantaneous intensity of the applied signals.

J. H. Hammond.

2 016 402.—Push-pull amplifier operated with a fixed positive grid bias, substantially half-way to maximum plate current, so as to increase the power-sensitivity of the circuit.

C. Travis (assignor to Radio Corporation of America).

2 017 515.—Shunt volume control with automatic tone compensation for the pick-up of a radiogram.

C. M. Sinnett (assignor to Radio Corporation of America).

TELEVISION AND PHOTOTELEGRAPHY

436 809.—Television system in which series of synchronising impulses are sandwiched between the picture signals and in which the first impulse is made greater in amplitude than any others in the same series.

T. M. Constable and Baird Television. Application dates 1st May and 31st August, 1934.

437 021.—Television system in which the production of a kinema film or record forms an intermediate stage in the process of transmission.

J. C. Wilson and Baird Television. Application date 23rd January, 1934.

437 340.—Electro-optical system for synchronising television signals.

P. V. Reveley and Baird Television. Application date 26th June, 1935.

437 602.—Television scanning system in which the source of light is an electric discharge moving along the track of a pair of " rail " electrodes.

Communications Patents Inc. Convention date (U.S.A.) 21st June, 1933.

437 656.—Construction of television scanning-disc with particular reference to the formation of the light-apertures.

Electrical Research Products (assignees of H. E. Ives). Convention date (U.S.A.) 24th May, 1933.

437 731.—Superhet circuit for the simultaneous reception of sound and television signals.

Electric & Musical Industries and C. S. Agate. Application date 5th April, 1934.

437 988.—Light-polariser, as used in television, of the type in which the unwanted ray is suppressed by total internal reflection.

P. V. Reveley and Baird Television. Application date 28th August, 1934.

438 386.—Means for adjusting the terminal positions of the electron beam on the fluorescent screen of a cathode-ray tube when used for television scanning.

General Electric Co. and L. C. Jesty. Application date 24th July, 1934.

438 424.—Television system in which a rotating ring of cylindrical lenses co-operate with a fixed prism to scan a continuously-moving cinema film.

Scophony, Ltd.; J. H. Jeffree; and G. Wikkenhauser. Application date 18th April, 1934.

439 121.—Interlaced scanning system in which a beam of light is swept by a rotating mirror over a set of inclined mirrors and then on the screen.

C. O. Brown. Application date 29th May, 1934.

439 164.—Reproducing the background or average intensities of a televised scene as well as the instantaneous light and shade values.

Radio Akt. D. S. Loewe. Convention date (Germany) 25th February, 1933.

439 225.—Interleaved scanning system in which the frame-repetition frequency is an exact self-multiple of the line-scanning frequency.

Electrical Research Products (assignees of F. Gray). Convention date (U.S.A.) 19th May, 1934.

439 236.—Scanning system based on the use of a light-cell containing a transparent liquid which is subjected to high-frequency mechanical vibrations as the light-ray to be modulated passes through.

Scophony Ltd. and J. H. Jeffree. Application date 3rd March, 1934.

439 414.—Electrostatic lens system for focusing the electron beam in a cathode-ray tube.

Fernseh Akt. Convention date (Germany) 13th June, 1934.

439 737.—Electron-optical system applied to a cathode-ray tube with the object of enlarging the normal size of a televised picture.

L. Schiff. Application date 9th April, 1934.

439 813.—Time-base circuit for television with magnetic synchronising control of the gas-filled discharge valves.

Marconi's W.T. Co. and R. J. Kemp. Application date 14th June, 1934.

439 990.—Electrode arrangement for preventing undesired variations in the size of the spot projected on to the screen in a cathode ray tube of the gas-filled type.

Telefunken Co. Convention date (Germany) 2nd August, 1933.

439 994.—Framing the picture by moving the electron stream into proper phase on the fluorescent screen of a cathode-ray television receiver.

T. E. Bray and Baird Television. Application date 24th August, 1934.

440 386.—Cathode-ray viewing-screens on which the picture is reproduced partly by incandescence and partly by fluorescence or phosphorescence.

J. L. Baird and Baird Television. Application date 13th October, 1934.

SUBSIDIARY APPARATUS AND MATERIALS

436 407.—Method of cutting a piezo-electric crystal so that it has a zero temperature coefficient.

Telefunken Co. Convention date (Germany) 21st July, 1933.

437 294.—Piezo-electric crystal cut so as to have a zero temperature-coefficient and no fortuitous mode of vibration.

Standard Telephones. Application date 27th April, 1934.

437 605.—Electro-dynamic microphone in which the moving coil is supported wholly by the diaphragm and is capable of movement in more than one direction.

S. L. Price and J. E. G. Parritt. Application date 27th April, 1934.

1 984 312.—Photo-electric cell with a control electrode connected to a valve amplifier which feeds back energy in phase with the photo-electric emission.

A. J. McMaster (assignor to G-M Laboratories).

2 000 026.—Valve-maintained magnetostrictive oscillator made of an alloy of cobalt chromium, nickel and iron so as to have a constant temperature coefficient.

J. M. Ide.

2 014 786.—Photo-electric cell of the gas-filled type which is operated at maximum anode-cathode voltage and is coupled to a valve amplifier which automatically prevents the applied voltage from rising beyond the " glow " point.

F. H. Shepard (assignor to Radio Corporation of America).

2 015 836.—Piezo-electric crystal mounting in which one of the electrodes is curved or shaped so as to prevent the formation of standing air-waves which tend to damp the crystal vibrations.

R. Bechmann and others (assignors to the Telefunken Co.).

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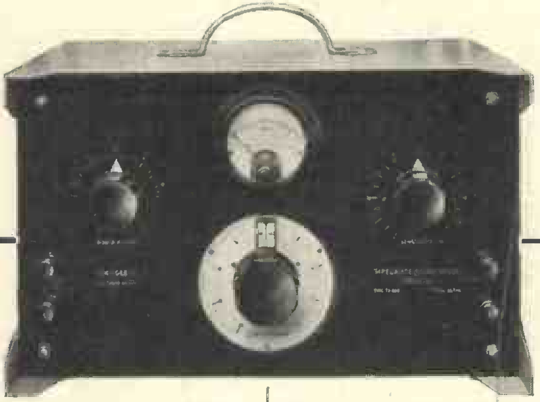

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