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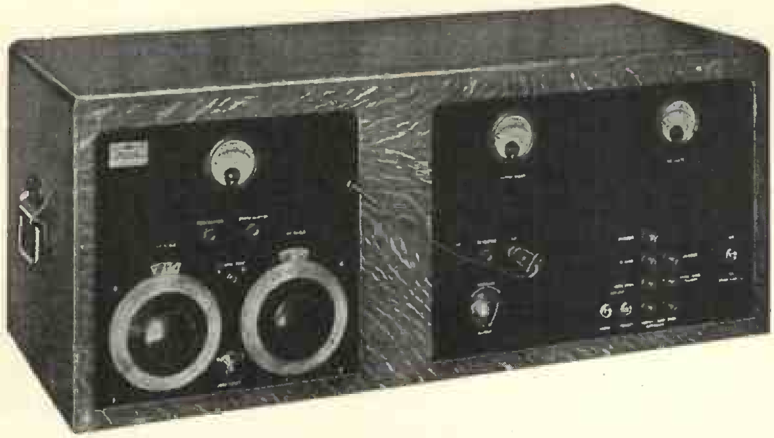

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Side-Band Phase Distortion

ELSEWHERE in this number we publish a somewhat mathematical paper by Messrs. Johnstone and Wright, entitled "A note on side-band phase distortion," and this editorial article should be read in conjunction with it.

A high-frequency current modulated sinusoidally can be represented by three vectors of different frequencies, the carrier of frequency $p/2\pi$, and the upper and lower side-bands of frequencies $(p+q)/2\pi$ and $(p-q)/2\pi$ respectively (Fig. 1*a*), but as we are mainly interested in the magnitude and not the phase of the resultant oscillation, it is convenient to assume the carrier vector to be at rest and the two side-band vectors to rotate in opposite directions with an angular velocity q (Fig. 1*b*). The two rotating vectors coincide twice per revolution, once when they are in the same direction as the carrier vector and once when in the opposite direction. If the carrier vector be taken as unity and each rotating vector as having a length $a/2$, the resultant vector will vary sinusoidally between $1 + a$ and $1 - a$.

If now the two side bands vectors suffer angular displacements of θ and ϕ respectively, so that, at the moment when they would normally have coincided with the carrier vector, they occupy the positions shown in Fig. 1*c*, their resultant will always lie along a line making an angle of $\frac{\theta + \phi}{2}$ with the carrier vector as shown in Fig 1*d*. The resultant of the three vectors will now have a phase swing about the carrier; its maximum value will be OA and its minimum OB (Fig. 2*a*) and the end of the vector will move sinusoidally to and fro between A and B along the line ACB. It is thus a simple matter to measure off the maximum and minimum amplitudes of the modulated wave for any value of a and of the angle $\theta + \phi$. These values are plotted in Fig. 1 of the paper by Johnstone and Wright, the values of the longer vector OA on the right

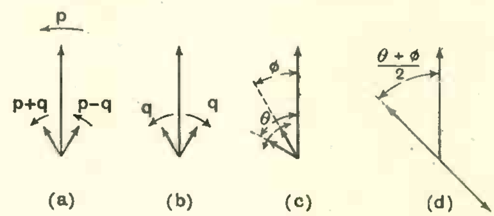


Fig. 1.

hand side of the middle line and those of the shorter vector OB on the left. When $\frac{\theta + \phi}{2}$ is made equal to 90°, ACB is horizontal and $OA = OB$ for all values of a as seen on the curves; if $a = 1$, $OC = CA = CB$ and $OA = OB = \sqrt{2}OC$.

If the length of the vector be plotted to a time base as its end moves sinusoidally along the line ACB, we get the resultant modulation envelope which is obviously no longer sinusoidal. This is plotted in Fig. 2*b*. In Fig. 2 $a = 0.5$ and $\frac{\theta + \phi}{2} = 45°$, but owing to the distortion introduced by this angular displacement, the modulation is no longer equal to a, nor is the mean amplitude equal to 1. To find the effective modulation we must find the new value of the mean height, and the amplitude of the fundamental oscillation of the curve in Fig. 2*b*;

the ratio of the latter to the former is the effective modulation. This takes into account only the fundamental, but as the original modulating voltage was sinusoidal it would not be reasonable to include distorting harmonics in measuring the resultant modulation. Measurement of Fig. 2*b* shows the mean to be increased from 1 to 1.032 and the amplitude of the fundamental to be 0.336, giving thus an effective modulation of 0.326 instead of 0.5. The R.M.S. value of the curve was found to be 1.06.

The distortion due to the presence of harmonics is usually expressed by the harmonic content, *i.e.*, the ratio of the R.M.S. value of all the harmonics to the R.M.S. value of the fundamental. Let I be the resultant R.M.S. current, I_0 the steady component and I_1, I_2, I_3, etc., the R.M.S. values of the alternating current

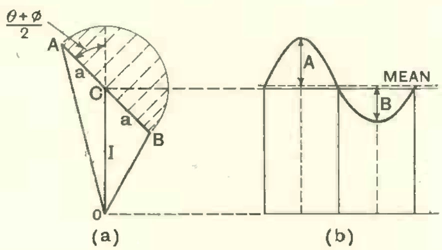


Fig. 2.

components; then $I^2 = I_0^2 + I_1^2 + I_2^2 + I_3^2$ + etc. The harmonic content R is then given by the formula

$$R = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + \ldots}}{I_1} = \frac{\sqrt{I^2 - I_0^2 - I_1^2}}{I_1}$$

Now although the latter form appears to dispense with the necessity of determining the harmonics it should be emphasised that it requires excessive accuracy in the determination of I and I_0 in order to obtain a reasonably accurate value of R. To illustrate this let $I_0 = 100$, $I_1 = 50$, $I_2 = 10$ and let us assume that there are no higher harmonics; then $R = 10/50 = 0.2$, and $I = \sqrt{100^2 + 50^2 + 20^2} = 112.22$. Now let us assume that we are ignorant of I_2 and that we make errors of only 1 per cent. in measuring I and I_0, thus taking I to be 113.34 and I_0 to be 99. Substituting these values in the above formula for R we obtain $R = 0.468$, *i.e.*, more than twice the correct value. If, on the other hand, I be taken 1 % low and I_0 1 % high, I^2 is less than $I_0^2 + I_1^2$ and I_2^2 becomes negative. It is thus seen that with an error of less than 1 per cent. in I and I_0, the error in R may amount to ± 100 per cent. It is therefore probable that a rough approximate calculation of the harmonics will give a more accurate value of the harmonic content than a fairly careful determination of the difference between the mean and R.M.S. values in Fig. 2*b*.

Fig. 2*b* suggests that the most important harmonic is the second. If it be assumed that the 2nd is the only harmonic present, the amplitude of the fundamental will be the mean of the amplitudes A and B at 90° and 270°, and the amplitude of the harmonic half their difference; the harmonic content is then $(A - B)/(A + B)$. In the present case, applying this rule to Fig. 2*b*, we obtain 11 per cent.

A more accurate method is to calculate the second harmonic of Fig. 2*b* and then determine the 3rd and 4th harmonic amplitudes by Wedmore's method. Since the positions of the maxima are known, this can be done in a few minutes. The results obtained for the amplitudes are $A_2 = 0.362$, $A_3 = 0.065$, $A_4 = 0.02$. Hence $\sqrt{(A_2^2 + A_3^2 + A_4^2)} = 0.368$ and the harmonic content $R = 10.96$ per cent. which agrees so closely with the value obtained by neglecting all but the second harmonic as to show how unnecessary any detailed analysis really is.

Fig. 2 of the paper by Messrs. Wright and Johnstone gives their calculated values of the harmonic content for different values of $(\theta + \phi)/2$ and of a. For the special case which we have considered above, viz. $\theta + \phi = 90°$ and $a = 0.5$, their calculated value is nearly 22 per cent., which is double the value which we found above. There is obviously a mistake somewhere and we do not think that it is in the simple graphical method which we have adopted.

It seems unlikely that such large phase displacements would arise in ordinary practice, as anything tending to make the one side-band lag with respect to the carrier would most probably tend to make the other side-band lead, thus making θ and ϕ of different signs and their mean approximately zero. As Messrs. Johnstone and Wright point out, however, it emphasises the importance of the phase when re-introducing a side-band or carrier which has been suppressed or specially treated. G. W. O. H.

Reproduction of Transients by Television Amplifiers*

By N. W. McLachlan

1. Introduction

THE approach of television has been heralded by valve amplifiers designed to cover a very wide frequency range. Using screened-grid valves and suitable circuits, the response characteristic of an amplifier can be made sensibly flat over a range of a megacycle or more. The circuit of Fig. 1 has been treated by Bedford and Puckle.† There is no added inductance, so the frequency of any damped oscillations (incited by a transient) associated with the inductance of the wiring, etc., will usually be above the range of frequencies to be amplified. Another circuit described by C. H. Smith‡ is illustrated in Fig. 2. In this case a small inductance L assists in offsetting the shunting effect of interelectrode and stray capacitance at the upper part of the frequency range. If in Fig. 2b $C_1 >> C_2$ and the impedance of $R_1 >>$ that of C_1 over the frequency range of the amplifier, C_2 can be considered to be in parallel with C_0. Under these conditions, the circuit of Fig. 2 can be represented by the arrangement of Fig. 3 where $C = C_0 + C_2$. This is the

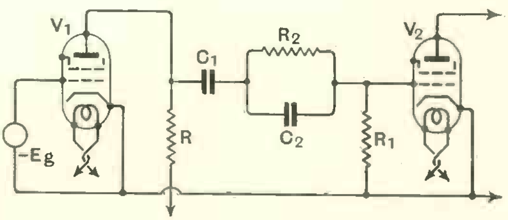


Fig 1.—*Illustrating shunted condenser corrector C_2R_2 between anode and grid of two valves.*

sum of the following capacitances; (a) anode to cathode of the valve V_1, (b) grid to cathode of the valve V_2, (c) leads and connections to the electrodes, etc.

With the circuit of Fig. 2, using values of the constants given later, each transient applied to the grid of V_1 induces a highly damped oscillation due to the LCR circuit. The frequency is very nearly

$$n = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$$

and the damping factor $\frac{1}{2}\frac{R}{L}$, provided ωC,

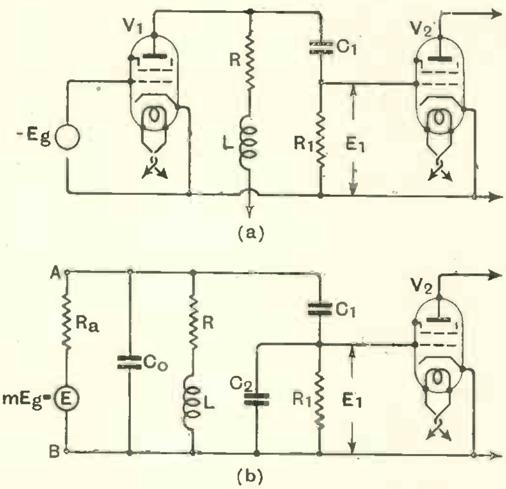


Fig. 2.—(*a*) *Illustrating circuit with inductance corrector.* (*b*) *The equivalent circuit for* (*a*). *R_a = internal A.C. resistance of valve V_1; C_0 = anode to cathode capacity of V_1, including leads, etc.; R = anode resistance; L = anode corrector inductance; C_1 = coupling condenser; R_1 = grid leak of V_2; C_2 = grid to cathode capacity of V_2 including leads, etc.*

ωL and R are small enough compared with R_1 and R_a, i.e., the two latter resistances are so large that they have no appreciable influence on the LCR circuit.

Another circuit described recently by von Ardenne§ is shown in Fig. 4. It can be regarded as a modification of Fig. 2, where a shunted condenser C_2R_2 is inserted in the cathode lead of the valve. At audio-frequencies the impedance of C_2R_2 is R_2, but at radio frequencies of the order one

* MS. accepted by the Editor, April, 1936.
† *Jour. I.E.E.*, 75, 63, 1934.
‡ *World Radio*, June, 8th, p. 834, 1934.
§ *Wireless Engineer*, 13, 59, 1936.

megacycle per second, it is negligible. Hence the voltage applied to the coupling network, i.e., between the anode of the valve and earth, steadily increases with rise in frequency, thereby compensating in part for the shunting effect of C. The shunted condenser C_2R_2 of Fig. 1 acts in much the same way as C_2R_2 in Fig. 4.

A suitable transient for consideration is one whose form is represented by a multiple of Heaviside's unit function, illustrated in Fig. 5. Prior to time $t = 0$ the system is quiescent and the applied grid voltage is zero. At time $t = 0$ the grid voltage of V_1 is suddenly reduced to the value $-E_g$. The phase of the voltage in the equivalent circuit is reversed, so its value is $+mE_g$, m being the amplification factor of the valve. In analysing the circuits of Figs. 2 and 4, the solution was first found in terms of Heaviside's operator $p = d/dt$. The operational form of solution was then interpreted in terms of the running variable t, by aid of the contour integral due to Bromwich*.

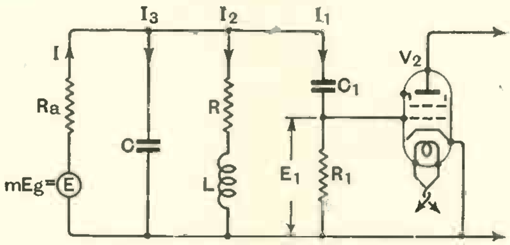


Fig. 3.—*The equivalent circuit of Fig. 2a when* $C_1 >> C_2$ *and* $R_1 >> 1/\omega C_1$.

The analysis is omitted from the present contribution, since it is rather intricate and might mask the physical aspects of the matter. It is given in full in the *Philosophical Magazine*, vol. 22, pp. 481-491, September, 1936.

2. The Circuit of Fig. 3

This circuit is equivalent to the valve circuit of Fig. 2a. A D.C. voltage $-E_g$ is applied to the grid and cathode of V_1 at time $t = 0$. We desire to know the output voltage E_1 at any subsequent time. The mathematical analysis can be simplified by using practical data, since it is found that a number of terms in the equations can be neglected. The following numerical values are based upon data given in C. H. Smith's paper: $R_a = 5 \times 10^5$ ohms; $R_1 = 10^6$ ohms; $R = 5 \times 10^3$ ohms; $L = 5 \times 10^{-4}$ henry; $C_1 = 10^{-1}\ \mu$F; $C = 30\ \mu\mu$F; m of valve 3,000. Using these values, the output voltage of V_1 can be expressed with adequate accuracy by the formula

* H. Jeffreys, "Operational Methods in Mathematical Physics," Chap. 2.

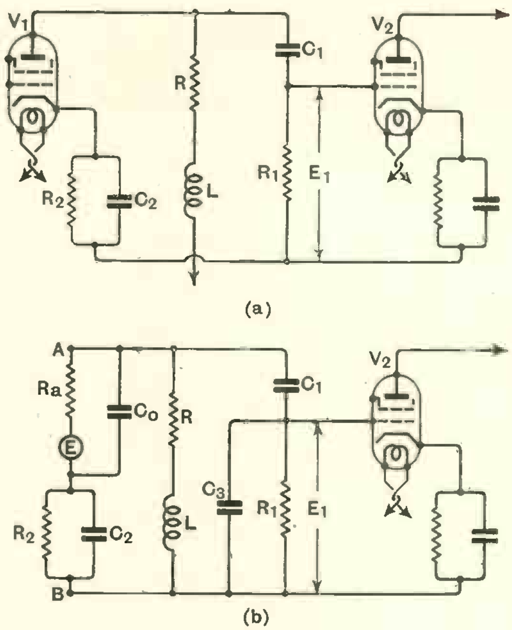


Fig. 4.—(*a*) *Coupling circuit having shunted condenser corrector in cathode lead and inductance corrector as in Fig. 2a.* (*b*) *Equivalent circuit of* (*a*).

$$E_1 = \frac{ER}{R_a}\left[e^{-t/C_1R_1} - \frac{e^{-\frac{1}{2}\frac{R}{L}t}}{\omega CR} \sin(\omega t + \alpha) \right]; \quad (1)$$

where

$$\omega = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}} = 6.46 \times 10^6;$$

$$\alpha = \tan^{-1}\omega CR/(-1 + CR^2/2L)$$

$= 1.824$ radian or $104°30'$; and $\sin\alpha$

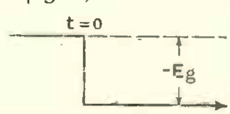


Fig. 5.—*Illustrating type of transient applied to input of amplifier.*

$= \omega CR = 0.968$. Inserting numerical values in (1) we obtain

$$E_1 = \frac{ER}{R_a}\left[e^{-10^{-6\tau}} - 1.032 e^{-\frac{1}{2}\tau} \sin(37\tau + 104.5)° \right], \quad (2)$$

where $\tau = 10^7 t$.

When the time t is of the order 1 microsecond or less $\tau \leq 10$ and the first exponential term within brackets in (2) is substantially unity.*. The second term, however, represents a highly damped oscillation due to the LCR circuit, the pulsatance and damping factor being given by $\omega = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$ and $\frac{1}{2}\frac{L}{R}$, respectively. The resistances R_a and R_1 are in parallel with the LCR circuit, but they are much too high to have any appreciable influence upon it. The wave form corresponding to formula (2) is illustrated in curve 1 of Fig. 6. The almost horizontal line of height ER/R_a represents the contribution due to the first term of (2), whilst the highly damped oscillation, of frequency about one megacycle per second,

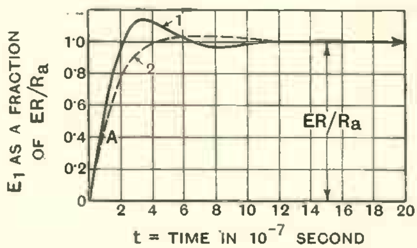


Fig. 6.—*Showing output voltage of one stage of the circuit Fig. 2a, (1) LCR circuit oscillatory, (2) LCR circuit aperiodic with damping resistance R_3 across inductance L.*

is the contribution arising from the second term. Owing mainly to the charge to capacitance C of Fig. 3, the output voltage E_1 does not attain its steady value ER/R_a until after a lapse of $\frac{1}{5}$th microsecond. This time interval is obtained from the relationship $(\omega t + \alpha) = \pi$, which corresponds to the first zero of $\sin(\omega t + \alpha)$. Having reached the value ER/R_a, E_1 overshoots by 15 per cent., owing to the oscillation of the LCR circuit. Moreover, this oscillation represents distortion of the applied transient, due to the amplifier circuit. The first maximum value of E_1 occurs after a time interval of $\frac{1}{3}$rd microsecond, this being calculated from the formula $(\omega t + \alpha - \beta) = 0$; where $\beta = \tan^{-1} 2\omega L/R = 0.911$ radian. The portion of the curve OA in Fig. 6 is linear, being given by the formula

$$E_1 = Et/CR_a. \quad \ldots \quad \ldots \quad (3)$$

If the voltage applied to the grid of V_1 is made zero after a lapse of time t_1 (the transient oscillation having subsided meanwhile†) when E_1 has substantially the value ER/R_a), the condenser C_1 discharges through the remainder of the circuit. E_1 is reduced to zero and it is very slightly negative by an amount corresponding to the factor $(-1 + e^{-t_1/C_1R_1})$. The response curve starting from the horizontal line 1.0 takes the same form as that of curve 1 Fig. 6, except that the voltage is reversed.

3. Damping Resistance across L in Fig. 3

We have seen that each transient applied to the grid of the first valve of Fig. 2 is accompanied by a highly damped sine wave oscillation. To curb the latter, a damping resistance R_3 may be connected in parallel with L in Fig. 3‡. If R_3 is the same order of magnitude or less than R, then with the above numerical data, the output voltage is given by

$$E_1 \doteq \frac{ER}{R_a}[e^{-t/C_1R_1} + e^{-\gamma t}\{t(1/CR - \gamma) - 1\}] \; ; \quad (4)$$

where $\gamma = \sqrt{\frac{k}{LC}} = 4.27 \times 10^6$; $k = R_3/R_4$;

$R_4 = R + R_3$; $1/C_1R_1 = 10$; and $1/CR = 6.667 \times 10^6$.

When t is a fraction of a microsecond, the first exponential term within brackets in (4) is very nearly unity. Thus the time taken for E_1 to reach the value ER/R_a, occurs when the second term is zero, i.e.,

$$t(1/CR - \gamma) - 1 = 0, \text{ or } t = 1/(1/CR - \gamma)$$
$$= 4.16 \times 10^{-7} \text{ second} \quad \ldots \quad \ldots \quad (5)$$

The maximum value of E_1 corresponds very closely to that of the second term within brackets in (4). Differentiating this term we have

$$\frac{d}{dt}[e^{-\gamma t}\{t(1/CR - \gamma) - 1\}] = e^{-\gamma t}[(1/CR - \gamma) + \gamma - \gamma(1/CR - \gamma)t] \quad \ldots \quad (6)$$

* This condition applies throughout the article.

† This transient corresponds to the grid voltage being increased from $-E_g$ to 0.

‡ Bedford and Puckle *loc. cit.* Another method is to increase R so that $\frac{R^2}{4L^2} > 1/LC$, but this or even the use of R_3 may be undesirable owing to loss in amplification at the upper end of the range.

The expression in (6) vanishes when

$$\gamma(1/CR - \gamma)t = (1/CR - \gamma) + \gamma,$$

$$\text{or} \quad t = 1/\gamma + (1/[1/CR] - \gamma)$$

$$= 6.51 \times 10^{-7} \text{ second} \quad .. \quad (7)$$

The value of E_1 is then 1.035 ER/R_a, so the aperiodic condition prevents the output voltage rising sensibly above its normal

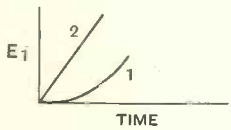


Fig. 7.—(1) *Reproduction of initial part of this transient by one stage of circuit Fig. 2a; (2) initial part of transient of form* $e^{-bt} \sin \omega_1 t$.

value. The relationship between E_1 and t is illustrated by curve 2 in Fig. 6. Initially the rise in voltage is given by $E_1 = Et/CR_a$, which is identical with that in the absence of a damping resistance. After a certain time, however, R_3 causes the rate of rise of voltage to be reduced, and the ultimate value ER/R_a is reached after an interval of 4.16×10^{-7} second or about twice that taken without R_3. The time to attain the maximum voltage is also increased by R_3, but this is of little consequence since the top of the curve is so flat.

4. Transient of the Form $E_g = E_0 e^{-bt} \sin \omega_1 t$: Circuit of Fig. 3

Using the same numerical data as before, the formula for the voltage output from the first valve is

$$E_1 = Ae^{-t/C_1R_1} + Be^{-\frac{1}{2}\frac{Rt}{L}} \sin(\omega t + \theta)$$

$$+ Ce^{-bt} \sin(\omega_1 t + a_1); \quad .. \quad (8)$$

where A, B, C θ and a_1 are constants. The first term in (8) represents the charging of condenser C_1 through resistance R_1 and its value is substantially equal to A, provided t is not too large. The second term is the damped oscillation treated previously and shown in curve 1 of Fig. 6, whilst the third term is a distorted version of the impressed wave form. If the circuit had no influence on the transient, the reproduced form of the latter would be $C_1 e^{-bt} \sin \omega_1 t$. The introduction of the angle a_1 indicates a lag due to the amplifier circuit. When t is extremely small the value of the output voltage is $E_1 = E_0 m \omega_1 t^2/2CR_a$. Thus the initial slope of the reproduced voltage waveform is zero, whereas that of the impressed transient $E_0 e^{-bt} \sin \omega_1 t$ is (see Fig. 7)

$$E_0 \frac{d}{dt}(e^{-bt} \sin \omega_1 t)_{t \to 0} = \omega_1 E_0.$$

This discrepancy is due mainly to the time taken to charge the capacitance C of Fig. 3.

5. n Identical Stages of Amplification: Circuit of Fig. 3

If the highly damped oscillations which occur in each valve stage after applying the voltage $-E_g$ to the grid of the first valve are neglected, the output voltage from the nth stage is given by the formula

$$E_n = E_g\left(\frac{R}{R_a}\right)^n \frac{m^n}{(n-1)!} \frac{d^{n-1}}{dz^{n-1}}\left[e^{zt} z^{n-1}\right]_{z = -1/C_1R_1} \quad .. \quad .. \quad (9)$$

where $\frac{d^{n-1}}{dz^{n-1}}$ signifies $(n-1)$ differentiations with respect to z before substituting $z = -1/C_1R_1$. Formula (9) is a convenient way of expressing the solution, since the differentiations are performed easily. The formula for n stages, when the damped oscillations are not discarded, is rather too complicated to be given here. If t is extremely small, however, the formula for this latter case is

$$E_n = \frac{E_g}{(CR_a)^n} \frac{(mt)^n}{n!}; \quad .. \quad .. \quad (10)$$

and

$$\frac{dE_n}{dt} = \frac{E_g m^n t^{n-1}}{(CR_a)^n (n-1)!} \quad .. \quad .. \quad (11)$$

From (11) it follows that the initial rate of rise of voltage at the output from the nth stage is retarded by increasing the number of stages. This arises from the capacitance C introducing a lag at each stage, so the steepness of the wave front is reduced progressively.

6. Circuit of Fig. 4

This circuit has been analysed when the impedance of the shunted condenser C_2R_2 is small enough compared with that of C_0 for the former to be regarded as an effective short circuit. Thus C_0 is considered to be connected across the points AB instead of having the position shown in Fig. 4b. The other conditions are identical with those already given in connection with Fig. 2.

The equivalent circuit of Fig. 4 is illustrated in Fig. 8. Since the impedances in shunt with the LCR circuit do not introduce any appreciable effect thereon, the transient of Fig. 5 induces a highly damped oscillation

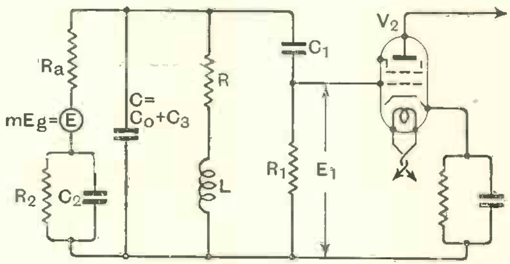


Fig. 8.—*Circuit equivalent to Fig. 4a when impedance of $C_2R_2 >> 1/\omega C_0$.*

whose pulsatance and damping factor have the values given above. The output voltage E_1 consists of three individual items, (1) an exponential term $\frac{ER}{R_a} e^{-t/C_1R_1}$ which represents the charging of C_1 through R_1, (2) a second exponential term $\frac{ER}{R_a} k_1 e^{-k_1 t/C_2R_2}$ which is associated with the charging of condenser C_2, k_1 having the value $(1 + R_2/R_a)$, (3) the highly damped oscillation aforesaid. The factor k_1/C_2R_2 will usually be very large, so that after a short time interval the contribution to E_1 arising from this term is negligible.

When the relative numerical values of the circuit constants differ materially from those used above, there will be an alteration in the formula for E_1. For example, if the internal A.C. valve resistance were reduced from 5×10^5 to 5×10^4 ohms, and the C_2R_2 value altered to suit, the behaviour of the oscillatory circuit would be different. Its natural frequency would be reduced and the damping increased.

If t is extremely small and $C_2 >> C_0$, the initial value of E_1 is given by formula (3). When the transient oscillation is taken into account, the initial part of the voltage output curve from the nth stage is given by formula (10), and its rate of rise by (11), provided $C_2 >> C_0$.

Television Receivers at Olympia

ALTHOUGH it is yet much too early for there to be any definite trend in television receiver design, an examination of the apparatus shown at Olympia revealed a distinct tendency towards the superheterodyne. This is undoubtedly because of the difficulties which confront the designer when he attempts to obtain R.F. amplification at ultra-high frequencies. Nevertheless, this system is used in the H.M.V. and Marconiphone receivers, and a gain of 40,000 times is claimed from the five stages incorporated.

The G.E.C. sets have five stages of I.F. amplification as well as one R.F. valve and one " L.F." or vision frequency amplifier. A triode-hexode frequency-changer is used, and functions as a part of both the vision and sound receivers. Gas-filled relays are used in each of the two time-bases, and each has a push-pull output stage for supplying the cathode-ray tube with the deflecting voltages.

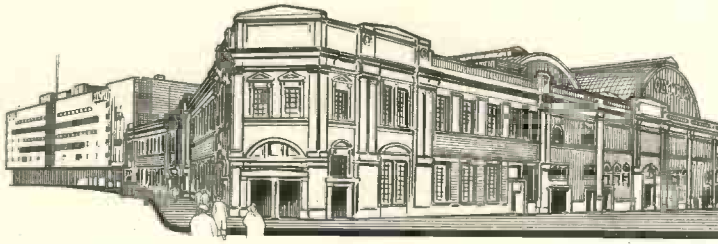
The Pye model has no R.F. amplifier but four stages of I.F. amplification ; an anode-bend detector is used and there is one vision-frequency amplifier. Electromagnetic deflection is used at the frame frequency, but electrostatic at the line ; the time-bases being of the hard-valve type.

Philips also use hard valves in their time-bases, but electrostic deflection is employed for both frame and line. In the vision receiver an R.F. stage is followed by a two-valve frequency-changer and three I.F. stages ; one VF amplifier is used.

Considerable differences were evident in the mounting of the C.R. tube. Cossor, G.E.C., Philips, Pye, and Halcyon mount the tube horizontally, whereas Bush Radio, H.M.V., and Marconiphone, have it mounted vertically for viewing through a mirror.

The Ekco-Scophony receiver differs from the others in that a C.R. tube is not used. Scanning is effected by mirror-drums, and the local light source is modulated in a special cell by passing the light through a liquid in which supersonic waves are set up by a quartz crystal.

Olympia, 1936



An Engineer's Impressions

THE engineer acquainted with the progress of design is regularly and infallibly disappointed with his annual visit to a radio exhibition. There never seems anything new to see. But it would seem that this lack of novelty is a result of the engineer's privileged position ; inevitably he knows of the theoretical possibility of all the new advances long before they are embodied in commercially made receivers.

From the point of view of the ordinary man for whom, after all, the Show is primarily intended, all the improvements offered really are new in the sense that it is only now that he can buy—at all events at an acceptable price—sets in which they are incorporated. In almost any other industry the annual improvements that we take in so matter-of-fact a spirit would be regarded as positively revolutionary.

To an engineer there is nothing excitingly novel in providing an extra set of coils to be switched into circuit when required. Yet " all-wave reception " is a thrilling novelty to the ordinary listener, who has previously been told that specially designed sets are essential for short-wave reception. So far as one can judge by such little comment as one can manage to overhear, persistent advertisement has decided the ordinary purchaser of a set that short-wave reception is very well worth while. Whether he will remain of this opinion after a month's experience of high-speed fading, intermittent distortion, and interference from motor cars is less certain. Judging from the fact that the ordinary listener obtains nearly all his entertainment from the nearest English stations, but continues to insist that every receiver he buys should be capable of picking up all the stations in Europe, it seems likely that the radio industry has saddled itself for all time with the obligation to include a short-wave tuning range on every future set, irrespective of how much it will be used once the first thrill of " seeing what the new set will do " has worn off.

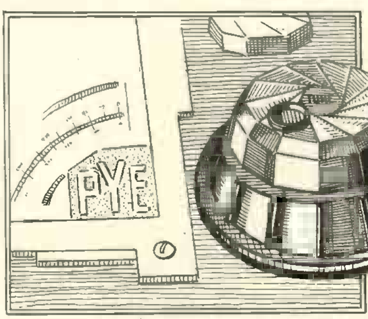
Having created this demand, there is no doubt that manufacturers are catering for it generously. In the simpler sets a single short-wave range is fitted, covering from about 18 metres up to some 55 metres. This involves the addition of only one set of coils and only one extra switch-position, so that the increase in price made necessary by the additional wave-band is not considerable. Nevertheless, as the vast majority of broadcasting stations lie within this range, very few possible programmes are lost.

There are drawbacks to this arrangement, the worst being the wide range of about 12 megacycles covered by a single swing of the condenser. If proper reception demands tuning accurate only to within 2 kc/s of the received carrier, this implies that the condenser has to be adjusted to one six-thousandth of its total travel, or about 2 minutes of arc. Besides making tuning difficult, it puts accurate logging out of the question.

A slow-motion drive of very high ratio and really smooth action, combined with a little practice on the user's part in delicate handling, satisfactorily overcomes the first difficulty, and drives of this type are almost universally used. For convenient searching and comfortable tuning on the medium and long-wave bands it is usual to provide, in addition, a drive of ratio about 8 to 1. One of the most convenient drives is that fitted to some of the Pye sets. It has an outer knob giving a normal ratio through a friction-disc drive of conventional pattern, and a centre knob which turns the outer knob through a friction-disc epicyclic gear. The total step-down ratio is 200 to 1. For rapid searching on the short waves, for which the outer knob provides rather coarse tuning, the inner knob has a cup for the finger-tip by which it can be spun quite fast, giving a condenser movement that is reasonably rapid and absolutely smooth.

The other difficulty, that of logging a station correctly to a thousandth of an inch on a six-inch scale, is bravely tackled by the Ferranti "Magnascopic" dial. A subsidiary scale of degrees, printed on a transparent celluloid disc attached to the condenser spindle, is illuminated by the pilot light, a simple optical condenser being used to ensure brilliant illumination of the required small area. By means of a lens, an enlarged image of this scale is projected on to a translucent screen above the main dial, the optical distance between lens and screen necessary for adequate enlargement of the image being obtained by the use of mirrors as shown in the illustration. The effective length of the scale is increased in this way to well over six feet, which makes it possible to identify a station with reasonable certainty by its dial reading.

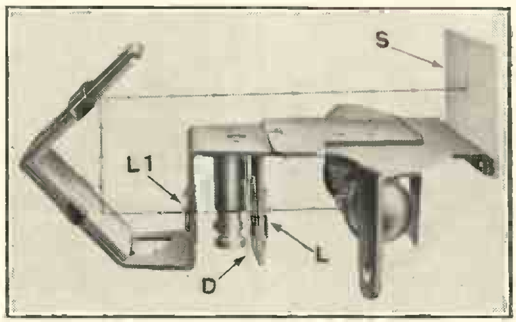
In some receivers the short-wave band of 18 to 55 metres is divided up into two ranges, thereby making tuning and logging a trifle



Pye quick-acting tuning knob, with cup for finger-tip.

easier. Further, the very unfavourable capacity-inductance ratio associated with a 0.0005-mfd. condenser in short-wave reception is avoided. In other cases the adoption of two ranges is used to extend the band covered; the Pye CAW, for example, covers 13–33 and 30–80 metres. Some few sets will tune down to as low as 7 metres, and can therefore be used to receive the sound part of the television transmissions. (Barring local interference, this should provide real "entertainment value" on the short waves.) Notable among these sets is the H.M.V. Model 801, which covers from 7 to 140 metres without a break in three bands.

Many sets offer means of "silent tuning," these consisting in the vast majority of cases



Arrangement of lamp, lenses and mirrors in the Ferranti "Magnascopic" dial. D, transparent dial, marked in degrees; L, condensing lens; L_1, lens forming image; S, translucent screen.

of manually operated controls which either silence the set by earthing some convenient point in the audio-frequency chain, reduce the output to an inoffensive but still informative whisper by connecting a large condenser from the grid of the output valve to earth, or simply bring down very considerably the sensitivity of the set, so that the strongest stations come in normally but the faint ones, and with them the background noise, can no longer be heard. Often these arrangements are described as "Q.A.V.C.," though to an engineer this term implies a silencing device automatically removed when a carrier is tuned in, and not one having to be switched out by the user.

The Pye Model CAW employs true Q.A.V.C. in this sense. In this set signal rectification takes place at the anode of a screened pentode, the grid of which is normally given a large enough bias to prevent the flow of anode current, and hence, by stopping rectification, to silence the set. The exact value of this bias is controlled by the potentiometer P shown in Fig. 1. To L_1, the secondary of the last I.F. transformer, the very sharply tuned circuit L_2 is coupled *via* two coupling coils. The metal rectifier is so connected that on receipt of a signal the voltage developed across the

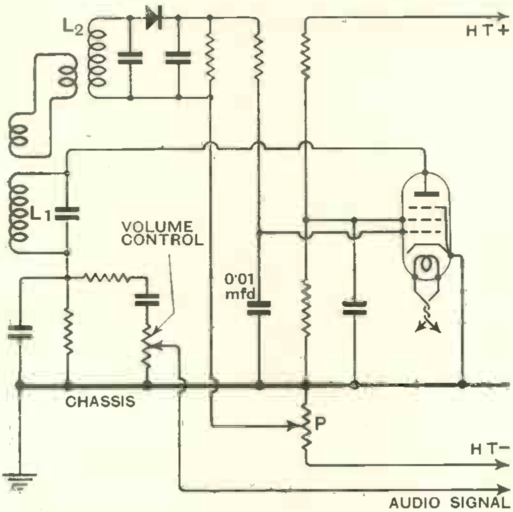


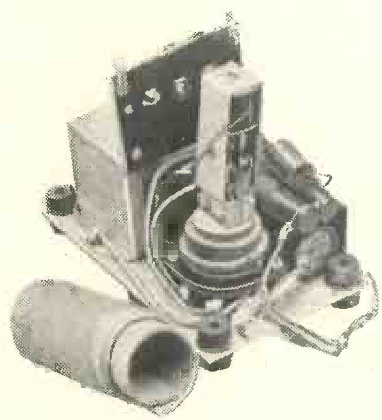
Fig. 1.—*Circuit of Pye Q.A.V.C. system, in which a screened pentode is used as a suppressed diode. The release circuit L_2 is very sharply tuned to permit release only very close to resonance.*

resistance shown offsets the negative bias applied to the grid of the valve, permits current to reach the anode, and so allows the valve to rectify the signal. Since L_2 has a much lower decrement than the coils in the signal-chain, the set is "opened" only over a very narrow frequency-range centred on the carrier, and mistuning sufficient to produce sideband screech silences the set. Adjustment of P controls the level above which stations are heard.

This set, like many others exhibited, contains provision for variable selectivity. In practically every case this adjustment is controlled by variation of coupling between primary and secondary of I.F. transformers, though resistance variation in one form or another is used in a few sets. The Ferranti sets have a mechanical arrangement by which selectivity is automatically returned to maximum as soon as the tuning-control is moved; by this means the user is practically compelled to tune accurately.

As a result of the introduction of short-wave ranges, the intermediate frequency used on superheterodynes is now very commonly fixed at 456 kc/s instead of the once-universal figure of about 128 kc/s. With the lower frequency, of course, image interference on short waves is almost impossible to avoid. The introduction of the higher intermediate frequency has resulted in the adoption of iron-core coils by a good many makers, since it is only by their use that the standards of selectivity to which 128 kc/s working has accustomed us can be attained at 456 kc/s without increasing the number of tuned intermediate-frequency circuits.

The vibratory generator, introduced originally to provide anode current for car sets, has found two new applications this year. In the Ekco Model BV 67 a self-rectifying buzzer is used to supply about 14 mA. at 130 volts. Set and buzzer together take about 1.3 amperes from a 4-volt accumulator. Direct radiation of sound from the buzzer is prevented by mounting it on rubber shock-absorbers and by a rubber surround, while electrical silence is obtained by careful screening and filtering of leads.



Ekco Vibratory H.T. Generator and associated components, rubber-lined cover of vibrator unit removed.

The reduction in running expenses and avoidance of unsatisfactory performance by eliminating the H.T. battery will doubtless render this type of power-unit very popular. It is possible that it might be even more attractive to the public if, at the cost of slightly increased consumption of current, the receiver were made to give the results of a mains rather than of a battery set.

A second use for the buzzer has been found by Philips and Mullard. These firms offer a new type of universal (A.C. or D.C.) set which gives fully satisfactory results on all mains, including direct current supplies down to 100 volts. These sets have an earthed chassis, use ordinary 4-volt 1-ampere valves, and in general are designed exactly as an

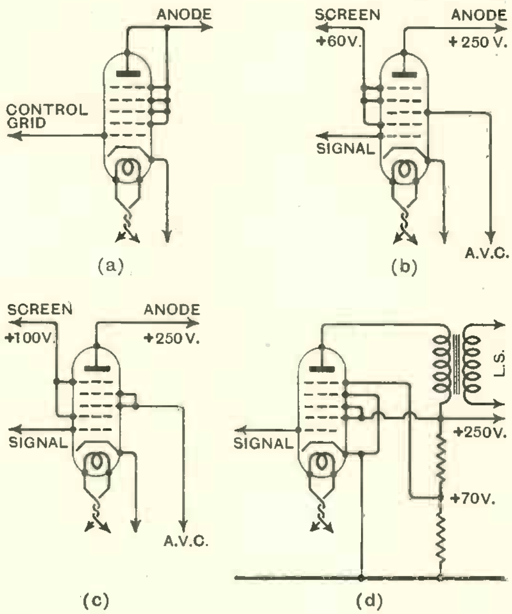


Fig. 2.—*Harries All-Stage Valve connected for various uses. (a) Triode. (b) and (c) Screened voltage amplifier. (d) "Critical-distance" output tetrode.*

A.C. set would be. Current from the D.C. supply is interrupted by the buzzer, giving an alternating current (of very peaky waveform) which is led to the primary of a mains transformer of more or less standard pattern, through which the set is energised in the ordinary way. As in the case of the "H.T.-less" Ekco set, the buzzer is silenced both mechanically and electrically by rubber mounting, metal screening, and suitable high-frequency chokes and condensers in the various leads.

The set is adjusted for alternating current by simple withdrawal of a plug through which the convertor is connected into circuit; such switching as is necessary is performed automatically when the plug is inserted or withdrawn. The distinction between these sets and a "Universal" set of the usual transformerless pattern is that the latter are essentially D.C. sets with the addition of a rectifier to look after the H.T. supply when used on A.C. mains, while the new sets are essentially A.C. sets with the addition of a convertor to enable them to be used on D.C. mains.

The outstanding novelty in valves was the Harries "All-Stage" valve, of which samples were shown by Harries Thermionics, Ltd. Essentially, this is an elaboration of the "critical distance tetrode" which was originally produced as an output valve to replace the pentode. In the new valve there are five grids between cathode and anode, and by suitably connecting these the valve can be given characteristics suitable for any stage in a receiver. Fig. 2 (*a*), in which all but the control-grid are connected to anode, gives an ordinary triode.

As a screened tetrode at least four different connections are possible, each conferring on the valve slightly different characteristics. Two connections are shown at *b* and *c* in Fig. 2, that at *b* giving a higher A.C. resistance and a higher mutual conductance than that at *c*. This latter arrangement can be varied by connecting G_3 to cathode, which lengthens the A.V.C. base a little. By connecting G_4 to cathode and applying the A.V.C. to G_3 only, the A.V.C. base can be lengthened still more. In all cases the signal is applied to the innermost grid of all, for this is fully screened from the anode by G_2 and later grids, and is brought out through the top cap of the valve. It is especially to be noticed that A.V.C. is in no case applied

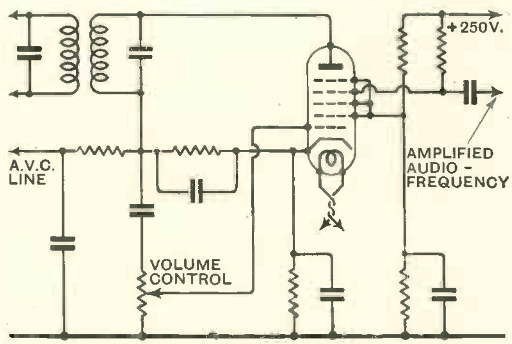
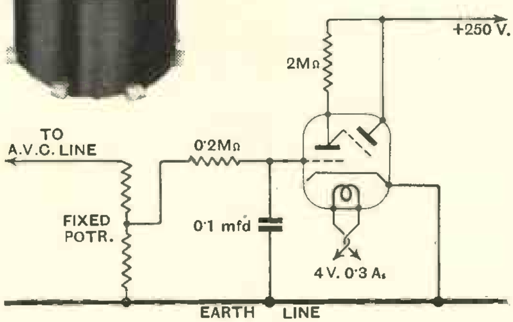


Fig. 3.—*Harries All-Stage Valve as diode-tetrode for detector-amplifier providing A.V.C.*

to the signal grid, but always to one of the others. It is claimed that by this means it is possible to work the valve at all times on the straight part of the $E_g - I_a$ characteristic, the application of A.V.C. reducing the mutual conductance of the valve without causing the working characteristic to take on curvature. Cross-modulation, modulation-rise, and other forms of distortion are by this means avoided, and the valve can quite safely be used as a gain-controlled L.F. amplifier if desired.

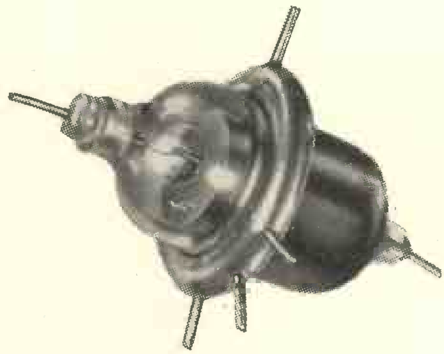
As a detector-amplifier a recommended circuit is that shown in Fig. 3, where the anode is used as the rectifying electrode, a "virtual cathode" being provided by suitable choice of the voltage applied to G_5. The rectified signal is led to G_1, and taken from G_4 after amplification. G_2 and G_3 act as screen, making a tetrode amplifier. The A.V.C. delay depends on the voltage of the cathode of this valve relative to the cathodes of the valves to be controlled; adjustment can be made by returning grids to tapping-points on cathode resistors where necessary. The flow of grid-current into the A.V.C. line before the delay is overcome does not matter, since A.V.C. is not applied to the same grid as the signal. In this way a distortionless A.V.C. system is obtained. By connecting G_2 and G_3 to G_4, the valve becomes a diode-triode.

Fig. 4.—*Mullard TV4 Cathode-Ray Tuning Indicator and (below) circuit in which it is used. For full brightness only 4 volts at the grid of the built-in triode amplifier is required.*



Finally, the valve can be used either as a frequency-changer, for which its pentagrid-like construction obviously fits it, or as a critical-distance output tetrode, the connections in the latter case being as shown in Fig. 2 (*d*). The voltage applied to G_5 is important, for it controls a species of electron-beam focusing by which, in effect, the electron-velocity is adjusted so that the fixed anode distance is correct for critical-distance operation.

The writer was privileged to see some



A Mullard "Acorn" valve nearly twice natura lsize.

unpublished research work on the distortion given by a pentode when amplifying a complex wave-distortion which is absent alike with a triode and with a critical-distance tetrode.

Another comparative novelty of valve-like nature is the Mullard TV 4 tuning indicator. In this a 4-volt 0.3-amp. heater supplies a cathode which is common to a triode amplifying valve and a small cathode-ray tube having a metal anode coated with fluorescent material. The connections, both internal and external, of this device are shown in Fig. 4. The grid of the triode is connected, through a filter sufficient to remove audio-frequency signals, to a high-resistance potentiometer connected across the A.V.C. system. As the A.V.C. voltage makes the triode grid negative, the anode, and with it the accelerating electrode of the cathode-ray tube, becomes more positive. The visible result is that the arms of a small luminous cross on the screen broaden out as the carrier of the station is tuned in. The full broadening is obtained by applying 4 volts to the grid of the triode portion of the TV 4; the potentiometer in Fig. 4 must therefore be so dimensioned that this voltage is not exceeded if the indication given on the screen is to remain well-defined.

For portable receivers of small dimensions, and possibly for laboratory apparatus, the new Acorn valves of Osram and Mullard, and the Hivac midget valves, will have their uses. The Hivac valves are specially noteworthy in view of the fact that they can be obtained with ceramic bases of low dielectric loss, which is likely to make quite a considerable difference to their performance on television wavelengths, where the bulk of losses in a tuned circuit are probably due to the dielectrics. Unlike the Acorn valves, the Hivac midgets have not got the exceptionally short electron-paths necessary to prevent the transit time of the electrons from being comparable with that occupied by one cycle of the frequency with which the valve is trying to deal at ultra-short wavelengths in the region of a metre or less.

Of the measuring instruments seen at Olympia the most ambitious—and the one most coveted by the writer—was the Standard Modulated Signal Generator made by R.M. Radio, Ltd. This instrument is entirely mains-operated, robustly made, and very thoroughly screened. The maximum output that can be induced into a standard artificial aerial varies from 0.5 to 2 volts according to the frequency, which can be adjusted to any value from 50 to 1,500 kc/s (or higher, at an extra charge). The attenuator, which depends on a continuously variable coupling device in place of the conventional variable resistance, allows the output to be reduced below the maximum by any amount up to 180 db., the scale of the attenuator being strictly linear throughout. In spite of its extreme range, the attenuator-scale can quite conveniently be read to the nearest decibel.

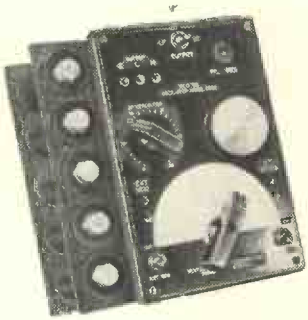
Hivac midget valve.

The signals can be modulated from an external source, which may, of course, be set to any desired frequency, and the depth of modulation obtained can be set to any desired figure, the exact percentage modulation at any instant being indicated directly on a scale on the face of the instrument. In view of the fact that measurements of the overall distortion of a receiver require a modulated signal of extreme purity (which is well known to be difficult of attainment, especially at deep modulation) it is very interesting to learn that in the R.M. generator the problem of modulation has received very special attention. As a result, modulation up to 90 per cent. may be used without introducing into the envelope any harmonic at amplitude greater than 1 per cent. of the fundamental, while the modulation-frequency characteristic is flat within half a decibel from 50 to 10,000 cycles per second. The cost of the generator complete, but without beat-frequency L.F. oscillator, is £168.

R.M. Radio Signal Generator.

Smaller and less ambitious generators, of more interest to the service-man than to the laboratory worker engaged in research, were offered by several makers. Of these the Weston oscillator Model E 692 at £19 19s.

is notable in that the screening is good enough to permit the output to be reduced to below a microvolt. The continuously variable attenuator covers two ranges,



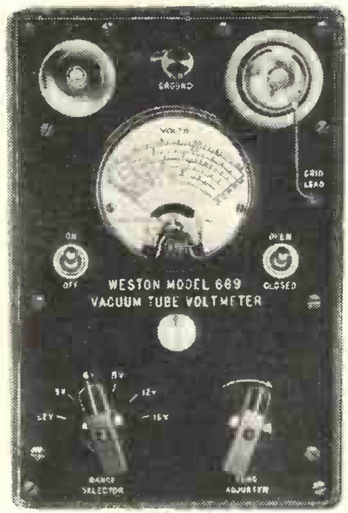
Weston Oscillator.

selected by choice of output sockets, and the maximum output is about 200 millivolts. Plug-in coils are used, which provide, in six ranges, signals at wavelengths from 12 to 3,000 metres. An audio-frequency oscillator, permanently set to about 400 cycles, is included in the generator, and provides fixed-depth modulation of about 50 per cent. at all wavelengths. This can be switched out if a plain carrier is required, or if preferred modulation can be provided from an external L.F. generator. Incidentally, the audio-oscillator supplied can be used as a source of signals for testing audio-amplifiers; it provides an output of about 1 volt. The generator is self-contained, being driven from batteries contained within the case.

Wearite mains-driven Signal Generator, Type TD 6.

The Wearite TD 6 generator, at £33, is all-mains driven. It has self-contained coils tuning from 12 to 3,000 metres, and has a six-inch dial permitting really accurate frequency-settings to be made. The output attenuator is adjustable in six steps, minimum and maximum output being 10 μV. and 200 mV. respectively. Except that the audio-frequency output available is some 20 volts, this generator offers the same facilities with regard to modulation as the Weston instrument just described. An unusual feature is the inclusion of an output voltmeter, of ranges 50 V. and 500 V., by the aid of which the output from any set that may be under examination can be determined. This is, of course, very thoroughly screened off from the generator proper.

The same makers offer also a "Serviceman's Oscillator-Unit" at £6 15s., giving optionally modulated signals at frequencies



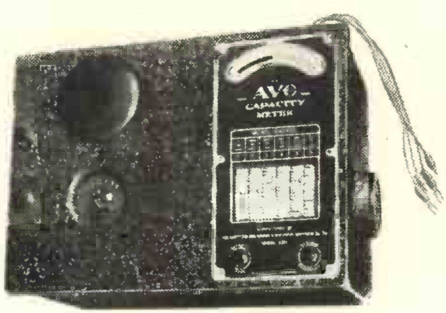
Weston Valve Voltmeter.

from 1,500 to 100 kc/s at three fixed outputs of about 50, 2,000, and 100,000 microvolts, together with about 200 millivolts at 1,000 cycles from the modulating oscillator.

A similar instrument, but with a continuously variable output attenuator approximately calibrated to 40 db. below the maximum output (about 200 mV.) is offered by Everett Edgcumbe at the same price.

On the Weston stand an advance model of a valve voltmeter was available for inspection. It is a six-range instrument giving a very readable deflection on the lowest range (0–1.2 v.) for 400 mV., and running up on its highest range to 16 volts. It uses an anode-bend detector, the valve being one in which the grid is taken to the top cap. This means that dielectric losses, and with them the input capacity, can be reduced to an absolute minimum, and so makes the voltmeter eminently suitable for work in connection with tuned circuits—probably the most exacting work that such an instrument is called on to perform. The meter is of the single-valve type, indicating on a backed-off milliammeter connected in the anode circuit of the valve. To prevent accidental damage to the meter when making connections, a safety-resistance from grid to cathode is provided inside the case; this is switched out of circuit, or the clip-lead connecting it to the grid is removed, when all is ready for making readings.

The instrument is noteworthy in that it is supplied entirely from A.C. mains, the necessary rectifier being located within the case. A neon-tube stabiliser, mounted so that its glow acts as a reminder that the instrument is switched on, is used to render the voltmeter immune from mains-voltage fluctuations. If the voltmeter valve fails, or gets broken, it is not necessary to return the voltmeter to its makers for recalibration. After fitting a new valve, the instrument only has to be connected to a transformer-winding giving 16 volts at mains frequency and adjusted, by means of a recalibrating



Avo Capacity Meter.

device, to read exactly 16 volts. The valve voltmeter sells, complete, at £24.

Capacity-meters were shown by a few firms. The Avo capacity meter (Automatic Coil Winder and Electrical Equipment Company) is a valve-driven oscillator in the same case as a standard condenser. The method used is one of comparison. The capacity to be measured is attached to a pair of terminals and then, with the main dial set at zero, a trimmer is adjusted till resonance is indicated on the meter which is part of the instrument. Then the capacity is removed, and the main tuning dial turned

Radiolab All-Purpose Tester; a 29-range laboratory instrument for A.C. or D.C., with subsidiary scales for resistance and capacity.

until resonance is once more attained, when the required capacity can be read off directly. There are six ranges, the lowest being 0–500 μμF. and the highest 0–0.1 μF. A capacity of 1 μμF. can be detected with certainty on the lowest range. The cost of the instrument is £21, exclusive of the batteries or power-unit required to drive it.

A combined capacity and resistance bridge was offered by Radiometers, Ltd. A 600-cycle oscillator is used to energise the bridge, the output from which is amplified by a pentode and passed to a small output meter. It measures resistances from 100 ohms to 4 megohms in two ranges, and capacities from 50 μμF. to 25 μF. in three ranges. The whole, including batteries, sells at £6 6s.

Valve-testers consisting essentially of switching devices permitting the measurement of valve-currents and voltages while the valve is actually in the set were offered by Everett Edgcumbe, Weston, Avo, Wearite, and others. For laboratory work, involving the detailed examination of valves, such instruments as the Everett Edgcumbe "Visual Valve Tester" are more suitable. At the price of £19 19s. there is provided a mains-driven power-pack supplying all the necessary currents at voltages up to 200, together with means for adjusting each voltage independently. All voltages and currents are read on a single six-inch meter, which is connected into the various circuits by switches. A complete set of curves of any valve can be taken with this instrument, and no " hook-up " connections or other make-shifts have to be used in changing from one type of valve to another, for every known type of valve is catered for and has a socket, ready wired, waiting for it on the tester.

Besides complete curves, " spot readings " of mutual conductance can instantly be made at any set of operating conditions by switching one volt of A.C. on to the grid of the valve and reading directly in milliamps. the A.C. component of the anode current, this being picked up by a small current transformer and delivered to the meter. Means for testing inter-electrode insulation and detecting grid-current are also provided, and an oscillatory circuit is included for rapidly

Everett Edgcumbe Visual Valve Tester.

checking whether the oscillator-section of a frequency-changer valve is in fact capable of maintaining oscillations.

A simpler valve-tester, operating at fixed anode voltages of 100 and 200 volts only, and fitted for the measurement of mutual conductance by a D.C. test, is available at £10 10s. from the same makers.

The newest multi-range Avometer, with 46 ranges.

Another instrument on which complete valve-curves can be taken is the valve-tester offered by Radiometers; this offers the very considerable convenience of simultaneous readings of various voltages and currents on the five meters included in it. This extra convenience is reflected in the price, which is £60 complete. On this instrument voltages up to 600 are available for testing small transmitting valves (for which sockets are provided) and output valves of the public-address type.

One of the most powerful weapons in the hands of the wireless engineer is the cathode-ray oscillograph, with the aid of which it is possible instantly to diagnose many faults that can otherwise only be discovered by inspired guesswork. Tubes by themselves are offered, in various patterns and sizes, by Cossor, Ediswan, G.E.C., and Mullard, to whose lists those wishing to make up their own time-base and power-unit are referred. Complete oscillographs in three forms are offered by Cossor.

The simplest of these, costing £20 complete with tube and rectifying valve, uses the A.C. mains to provide a sinusoidal time-base, the amplitude of which is controllable over a very wide range. Although a linear time-base is preferable for most purposes, the sinusoidal base sets very much less limitation to the use of the instrument than one would at first suppose, this being so largely because it is possible to increase the sweep to several times the width of the screen, so making the visible part practically linear. The return sweep can be modulated out to avoid the superimposition of two patterns that would otherwise result. The slowness of the time-base precludes the examination of any phenomenon of frequency higher than about 5,000 cycles (this figure, obviously, is a matter of opinion) but for most audio-frequency purposes, and especially where it is possible, as when using a beat-frequency generator, to adjust the audio-frequency under examination to an exact multiple of 50 cycles to obtain a stationary picture, this simple oscillograph will meet all needs. For measurement of voltages an accurately known voltage, supplied from the instrument itself, can at any instant be thrown on it, enabling the exact sensitivity in terms of millimetres per volt to be ascertained. The voltage sensitivity is of the order of ½ mm/v., and the maximum sweep-velocity at 50 cycles is one screen-diameter in 1.2 milliseconds.

A more ambitious oscillograph again using a gas-focused tube is offered by the same makers at £30 complete under the description "Linear Portable Mains Oscillograph."

Cossor Oscillograph.

It contains a linear time-base of frequency variable from 2½ to 10,000 cycles per second, and means are provided by which this can be semi-automatically synchronised with the work-voltage to obtain a stationary picture. The amplitude of the sweep is fixed at approximately one screen-diameter. This model is suitable for the full examination of phenomena of frequency up to some 100 kc/s, and some information at least may be obtained with phenomena of much higher frequency than this. As the tube is gas-focused, the image begins to lose definition at very high writing-speeds, and sharp pictures cannot be expected at frequencies over about 400 kc/s.

Wearite Oscillograph units, screened in metal cases.

The Cossor high-vacuum oscillograph is capable of dealing with any problem for which a cathode-ray tube can be used. Individual cycles may be examined at frequencies up to 6 megacycles per second with the time-base (2 cycles to 300 kc/s) included in the instrument; the limit may be extended to perhaps 100 megacycles per second if a radio-frequency oscillator is attached in its place. The instrument includes valve amplifiers of very wide frequency-range, these increasing the sensitivity to 2.4 mm/v. at full anode voltage; at a lower voltage the sensitivity is, of course, greater still. The time-base may be set for continuous or single-stroke operation at will, and a number of other refinements are included, making the apparatus extremely flexible. The price is £75 complete.

The Wearite oscillograph uses a gas-focused tube and sells at £29 complete. It is built in three units, comprising tube (screened in mu-metal housing), power unit, and linear time-base. The latter is adjustable for frequencies from 1 cycle per second up to a maximum of about 30 kc/s, thus permitting examination of the fastest phenomena with which a gas-focused tube can be expected to deal without losing definition.

A Note on Side-Band Phase Distortion*

By D. M. Johnstone and E. E. Wright

(Baird Television, Limited)

1. Introduction

IT has hitherto been generally considered that if, in the process of amplifying or transmitting a modulated radio-frequency carrier, the system is free from non-linear devices, and every precaution is taken to ensure that the various frequency components of the signal are maintained at their initial relative amplitudes, then the received signal will, after linear detection, be free from amplitude or frequency distortion.

However, it is quite possible for a carrier amplification or transmission system which is entirely free from non-linear distortion, and has absolutely uniform frequency response, to give rise in certain circumstances to considerable amplitude distortion if the phases of the side-bands and carrier are mutually displaced. The importance of this effect was first realised as a result of work on suppressed carrier transmission, when the greatest difficulty was experienced in securing distortionless reconstitution on account of the necessity for accurate synchronising of the locally generated carrier at the receiving end with the suppressed transmitter carrier.

The problem has been investigated experimentally by oscillographic methods and results of a qualitative nature, giving an indication of the order of magnitude of the distortion as a function of the phase displacement and modulation coefficient, have been obtained. It was with the object, however, of providing an analytic basis for a precise quantitative estimation of the effect that the following theoretical investigation was carried out.

2. Evaluation of Side-band Distortion Function

A sinusoidally modulated carrier wave may be expressed in the form,

$$E(1 + a\cos qt)\cos pt$$
$$= E[\cos pt + \tfrac{1}{2}a\{\cos(p+q)t + \cos(p-q)t\}] \quad (1)$$

Now let it be assumed that the upper and lower side-bands have phase displacements θ and ϕ respectively, then the wave is of the form,

$$E[\cos pt + \tfrac{1}{2}a\{\cos(\overline{p+q}\,.\,t + \theta) + \cos(\overline{p-q}\,.\,t + \phi)\}]$$
$$= E[\cos pt + a\{\cos(pt + \tfrac{1}{2}\,.\,\overline{\theta+\phi})\,.\,\cos(qt + \tfrac{1}{2}\,.\,\overline{\theta-\phi})\}] \quad \ldots \quad \ldots \quad (2)$$

This may be expressed as the sum of sine and cosine functions of pt, thus

$$E[\{1 + a\cos\tfrac{1}{2}(\theta+\phi)\,.\,\cos(qt + \tfrac{1}{2}\,.\,\overline{\theta-\phi})\}\cos pt - a\sin\tfrac{1}{2}(\theta+\phi)\,.\,\cos(qt + \tfrac{1}{2}\,.\,\theta-\phi)\,.\,\sin pt] \quad \ldots \quad \ldots \quad (3)$$

This may be written

$$-e\sin(pt - s) \quad \ldots \quad \ldots \quad (4)$$

where

$$e = E[1 + 2a\cos\tfrac{1}{2}(\theta+\phi)\cos(qt + \tfrac{1}{2}\,.\,\overline{\theta-\phi}) + a^2\cos^2(qt + \tfrac{1}{2}\,.\,\overline{\theta-\phi})]^{\frac{1}{2}} \quad \ldots \quad (4a)$$

and

$$\tan s = \{1 + a\cos\tfrac{1}{2}(\theta+\phi)\cos(qt + \tfrac{1}{2}\,.\,\overline{\theta-\phi})\} / \{a\sin\tfrac{1}{2}(\theta+\phi)\cos(qt + \tfrac{1}{2}\,\overline{\theta-\phi})\} \quad \ldots \quad (4b)$$

Comparison of equation (4a) with the original expression for the undistorted modulated carrier wave shows that the effect of the phase shift in the side-bands is to change the modulation coefficient from the linear form $(1 + a)$ to the non-linear form

$$\{1 + 2a\cos\tfrac{1}{2}(\theta+\phi) + a^2\}^{\frac{1}{2}}.$$

This is equivalent to the distortion produced by a non-linear system the characteristic curve of which is given by this last expression. A series of such curves, corresponding to different values of $(\theta + \phi)$, is given in Fig. 1.

Much useful information can be obtained from these curves before resorting to a more extensive analysis. For example, it will be noticed that for modulation percentages approaching 100 the distortion is quite serious even for low values of $(\theta + \phi)$. Of

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

course, when $(\theta + \phi)$ is zero there is no harmonic distortion, although a phase shift $\frac{1}{2}(\theta - \phi)$ is produced. Possibly the most remarkable feature is that when $(\theta + \phi) = 180°$ the signal is completely rectified

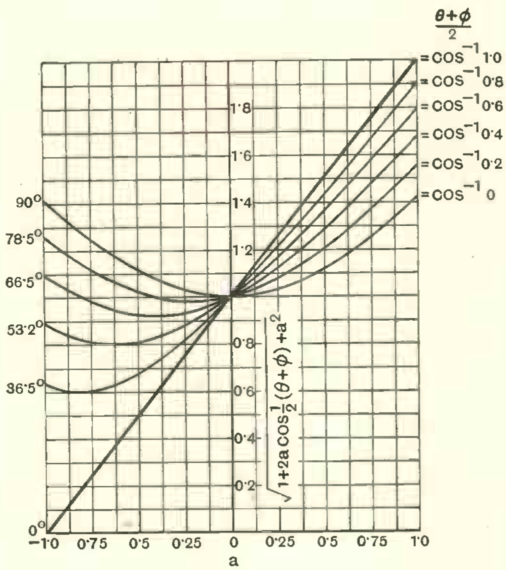


Fig. 1.

and greatly attenuated for low modulation, whilst the signal is free from distortion but negative when $(\theta + \phi) = 360°$.

3. Harmonic Analysis

The harmonic content of the complex wave represented by equation (4a) may be expressed by

$$R = \{(\sum_{n=2}^{\infty} A_n^2)/A_1^2\}^{\frac{1}{2}}$$

where A_n is the amplitude of the n^{th} Fourier component of the complex wave. It is not necessary to find the components individually since R may also be expressed in the form

$$R = \{(M - A_0^2 - \tfrac{1}{2}A_1^2)/\tfrac{1}{2}A_1^2\}^{\frac{1}{2}} \quad .. \quad (5)$$

where M is the mean square of the complex wave. That is, in the present case $(1 + \frac{1}{2}a^2)$.

The complex wave may be written

$$(1 - 2ga\cos\psi + a^2\cos^2\psi)^{\frac{1}{2}}$$
$$= (1 - 2ga\cos\psi + a^2\cos^2\psi)(1 - 2ga\cos\psi + a^2\cos^2\psi)^{-\frac{1}{2}}$$
$$= (1 - 2ga\cos\psi + a^2\cos^2\psi)\sum_{\mu=0}^{\infty} P_\mu(g)a^\mu\cos^\mu\psi$$
$$= \sum_{\mu=0}^{\infty} P_\mu(g)(a^\mu\cos^\mu\psi - 2ga^{\mu+1}\cos^{\mu+1}\psi + a^{\mu+2}\cos^{\mu+2}\psi)$$

where $P_\mu(g)$ is the Legendre Polynomial of degree μ.

This last series is a power series in $\cos\psi$ but since any power of $\cos\psi$ is immediately expressible as a short Fourier series (see Loney's Trigonometry 2 Chapter 4) the series is effectively the Fourier expansion of the complex wave and the amplitude of any component may easily be picked out. For the present purpose it is necessary to determine only the constant and fundamental terms.

Now the constant term in the expansion of $\cos^n\psi$ is zero if n is odd and $\underline{|n}/2^n(\underline{|\tfrac{1}{2}n})^2$ if n is even (see Loney).

Hence, the constant term of the complex wave is

$$(1 + \tfrac{1}{2}a^2)P_0(g) - ga^2P_1(g) + (\tfrac{1}{2}a^2 + \tfrac{3}{8}a^4)P_2(g)$$
$$- \tfrac{3}{4}ga^4P_3(g) + (\tfrac{3}{8}a^4 + \tfrac{5}{16}a^6)P_4(g) - \tfrac{5}{8}ga^6P_5(g)$$
$$+ (\tfrac{5}{16}a^6 + \tfrac{35}{128}a^8)P_6(g) - \tfrac{35}{64}ga^8P_7(g) + .. \quad (6)$$

Also, the coefficient of $\cos\psi$ in the expansion of $\cos^n\psi$ is zero if n is even and $\underline{|n}/2^{n-1}\,\underline{|\tfrac{1}{2}(n-1)}\,\underline{|\tfrac{1}{2}(n+1)}$ if n is odd.

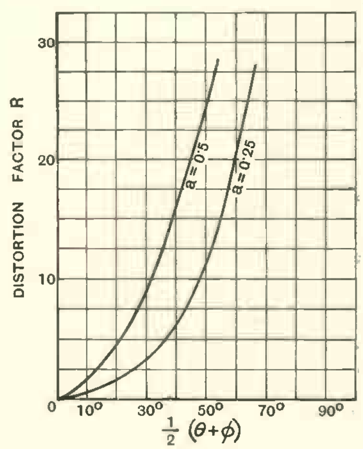


Fig. 2.

Hence, the amplitude of the fundamental of the complex wave is

$$- 2gaP_0(g) + (a + \tfrac{3}{4}a^3)P_1(g) - \tfrac{3}{2}ga^3P_2(g)$$
$$+ (\tfrac{3}{4}a^3 + \tfrac{5}{8}a^5)P_3(g) - \tfrac{5}{4}ga^5P_4(g)$$

$$+ (\tfrac{5}{8}a^5 + \tfrac{35}{64}a^7)P_5(g) - \tfrac{35}{32}ga^7P_6(g)$$
$$+ \tfrac{35}{64}a^7 + \tfrac{63}{128}a^9)P_7(g) - \quad \ldots \quad \ldots \quad (7)$$

It will be noted that g is a cosine function and tables of P_n (cos x) (known as Zonal Spherical Harmonics) are published, for example, in the Smithsonian Physical Tables, so that R may easily be calculated.

4. Conclusions

In Fig. 2 is shown the variation of harmonic distortion with phase angle for 25 per cent. and 50 per cent. modulation, as calculated from expressions (5), (6), (7), of the preceding section. Curves for higher levels of modulation are not shown owing to the slow convergency of the higher terms, in expressions (6) and (7) making the calculation laborious.

It is of importance to note that for normal values of modulation such as these, distortion can be appreciable even for small phase angles such as might easily occur with cascaded circuits. Thus for a phase angle of 30 deg. with 50 per cent. modulation, the distortion (7 per cent.) is in excess of the normal tolerance, and increases as the modulation becomes higher.

Probably the chief importance of these results is their bearing on the design of circuits for amplifying a radio frequency modulated carrier, especially intermediate frequency circuits in superheterodyne receivers, and it is hoped that these remarks will bring the attention of designers to this matter.

The Conversion of Optical Images from One Region of the Spectrum to Another by the Formation of Electron-Optical Images of Photocathodes

BARON MANFRED VON ARDENNE contributes to *E.N.T.* of July, 1936, an interesting paper on the development of "image transformers"—that is, devices for transforming an optical image in (say) infra-red light into an image in light visible to the eye, without any of the complications involved in the "point-by-point" conversion by ordinary television scanning methods. The first published information about such image transformers was contained in the *Physica* paper by Holst, de Boer, Teeves and Veenemans (*Wireless Engineer* Abstracts, 1934, p. 331) and the corresponding patent applications; but von Ardenne was simultaneously attacking the problem on slightly different lines, and his patent application was filed in the same month that saw the *Physica* paper appear. Whilst in the Dutch device the semi-transparent photocathode and the anode took the form of two parallel plates a short distance apart, with an accelerating voltage of some thousands of volts between them so that the electrons followed approximately the lines of the field between the plates, von Ardenne employed an electron lens to form an image of the photocathode on the fluorescent screen—an arrangement which, as he says, avoided certain fundamental defects in the other method.

Later on came Schaffernicht's paper on the AEG results (*W.E.* Abstracts, 1949 of 1935) and Heimanns article on the quality of images attainable with various electron-optical arrangements (Abstracts, 1951 of 1935); while the important paper by Zworykin and Morton in America (Abstracts, 2354 of 1936: see also 3492 of 1936) appeared when the present article—which is of interest not only as giving the author's experimental results but also as presenting some new points of view on certain aspects of the problem—was already in the hands of the publisher.

Transparent *versus* Opaque Photocathodes

Whether transparent cathodes, eminently desirable from the optical point of view, actually come into practical use depends on whether they can be developed to give a sensitivity reasonably near that of the opaque, front-illuminated cathode.

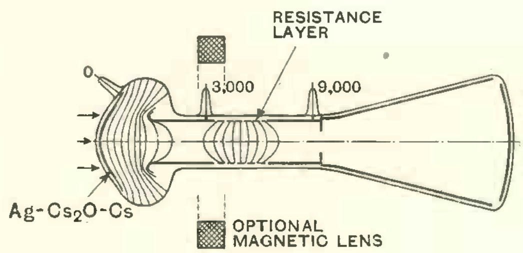


Fig. 1.—*Diagram of image transformer.*

Kluge's paper on the comparison of the two types (Abstracts, 1950 of 1935) is discussed, and the hope of obtaining a carrier layer thin enough to be sufficiently transparent, and yet retaining a good conductivity, is suggested as depending on the fact that the abnormally high specific resistance of very thin metallic layers can be avoided if they are prepared by condensation at low temperatures, provided that the subsequent heat process does not cause too much loosening of the packing. Results up to the present suggest that even in the most unfavourable parts of the spectrum the useful output of a transparent cathode can be at least 20-30 per cent. of that of the front-illuminated type. As regards spectral sensitivity, to-day's highly developed photocell-technique provides cathodes with a high electron output from the extreme ultra violet to wavelengths of 1 000 mμ; it provides also films with the extreme uniformity of structure necessary for faultless image production.

Some Points on Electron-Optical Systems

Papers referred to in this section include those of Henneberg and Recknagel on chromatic aberration (*W.E.* Abstracts, 3555 of 1935), Stabenow (in connection with magnetic lenses and image rotation—Abstracts, 306 of 1936), and Brüche and Schaffernicht (1505 of 1936). An early type of von Ardenne tube is shown diagrammatically in Fig. 1. Here the cathode is of the transparent type, and Fig. 2 shows a fluorescent-screen photograph "transformed" from an infra-red image by such a tube. Fig. 3 illustrates a similar transformation, but in this case an opaque cathode, illuminated from the front, was employed: the noticeable distortion is due to the consequently slanting incidence of the light. Fig. 4 shows a later type of Ardenne tube; the resistance layer forming part of the electrostatic lens can be seen in the form of a closely wound spiral deposited on the inner wall.

Fig. 2.

Fig. 3.

Fluorescent-screen images transformed from the infra-red region.

The Fluorescent Screen

For the standard image transformer, whose image is to be viewed by the eye, the screen material must be chosen to give maximum output on the wavelengths to which the eye is most sensitive. For information on this point the reader is referred to the author's paper dealt with in *W.E.* Abstracts, 1947 of 1935. As regards the effect of grain size, it is pointed out that the images in Figs. 2 and 3 show a certain graininess; this fault can be avoided by the use of very fine-grained screens (von Ardenne, Abstracts, 3550 of 1935).

The Amplification of Light

Section II*d* is particularly interesting. Here the author states that theoretical considerations and experimental work with these tubes indicate that

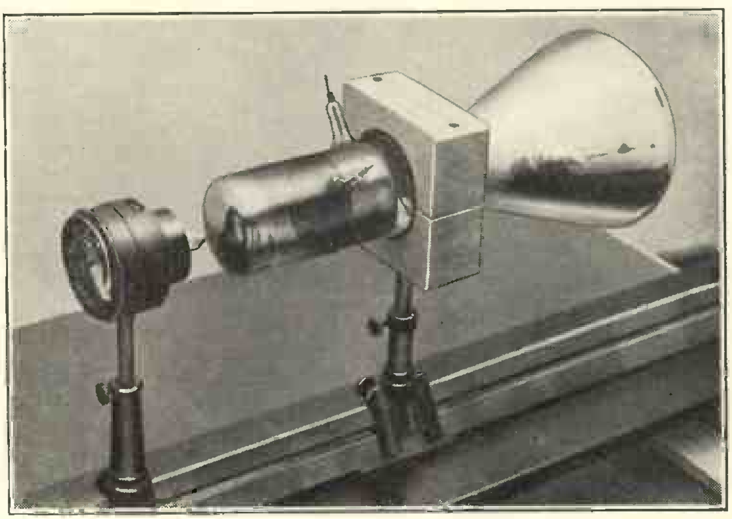


Fig. 4.—*Recent type of von Ardenne image transformer.*

apart from their usefulness as wavelength transformers, they offer the possibility of an *amplification* of light (when the incident light is itself in the visible region) either by a series connection of several tubes or by a type of back-coupling from the "secondary" image to the "primary." The measurements represented in Fig. 5 show that in spite of the well-known low efficiency of photocathodes and the 15–140 per cent. efficiency of the fluorescent screen, the amplification of a single tube is greater than unity for an anode voltage of only 5 500 volts, while for 9 000 volts it is over three. This good result is due to the great increase of kinetic energy given to the photoelectrons by the anode potential, and to the fact that all the electrons from the illuminated zone reach the screen.

Unwanted "Retroaction" and Background Glow

In the final section the author mentions that in spite of the distance between photocathode and screen the efficiency of the tube is so high that, if the image is a bright one, the fluorescent light often re-radiates on to the cathode and causes a lightening of the dark parts of the image. This "retroaction" cannot be entirely avoided by a careful choice of cathode and screen as regards sensitivity maxima, but it can be eliminated completely by the suitable arrangement of a homogeneous electric or magnetic field. Even when all extraneous light is shut out with photocathodes of the silver-caesium-oxide-caesium type and anode voltages of a few thousand

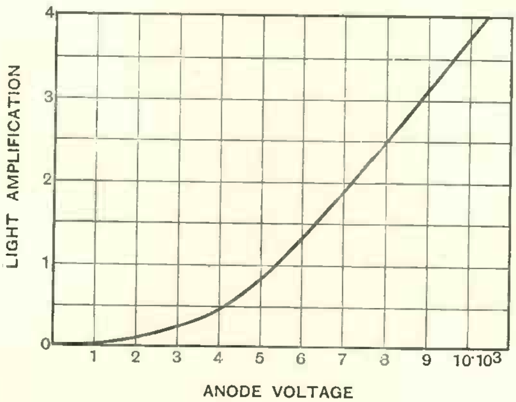


Fig. 5.—*Ratio of secondary to primary light for approximately similar spectral intensity distribution and various anode voltages.*

volts the image transformer displays a certain "background" or residual light which would tend to limit its use at low light intensities. This is chiefly due to the "dark" current of the photocathode, produced—as Schulze showed for alkali cells (*W.E.* Abstracts, 1934, p. 568)—by thermally freed electrons. This explanation is confirmed by the experiment illustrated by Fig. 6, where the bright spot in the middle of the screen appeared a few seconds after the glass wall at the back of the photocathode had been slightly warmed in the middle by being touched with the finger. Conversely, a comparatively small amount of artificial cooling will abolish the dark current and greatly extend the working range of the image transformer in the direction of weak infra-red images.

Applications

Both as image transformers and as light amplifiers, the author concludes, these tubes have a wide

Fig. 6.—*Background light due to dark current of photocathode.*

field of application, including ultra-violet microscopy, astronomical and spectroscopic work, the observation of photographic developing processes, and certain medical investigations.

The Industry

A WELL-PRODUCED booklet describing the uses of bakelite varnish (stoving type), which is widely used for the impregnation of windings, is available from Bakelite Ltd., 68, Victoria Street, London, S.W.1.

The makers of Westinghouse metal rectifiers have appointed as Scottish representative Mr. G. Gibb, c/o J. E. Robson & Co., 11, Bothwell Street, Glasgow, C.1.

A specialised catalogue containing full information about Dubilier condensers and resistors has been produced for manufacturers, designers, etc. Copies are available from Dubilier Condenser Co. (1925) Ltd., Ducon Works, Victoria Road, North Acton, London, W.3.

Multi-contact rotary switches of various types are described in a leaflet issued by F. W. Lechner & Co., Ltd., 61, Spencer Street, London, E.C.1.

U.S. Radio Ltd., of 138, Southwark Street, London, S.E.1, have been appointed sole distributors of the American "Arcturus" valves. A stock of both glass and metal types is maintained.

Frequency Stability of Valve Oscillators*

The Influence of Grid Current

By D. A. Bell, B.A., B.Sc.

IT has long been known empirically that, other things being equal, a valve oscillator in which a large amount of grid current flows is of less constant frequency than one with negligible grid current ; but the very large effect of grid current in certain cases cannot be explained by the hypothesis of simple resistive damping which is usually adopted. For a clear understanding of the problem it is essential first to consider briefly the manner in which various valve and circuit characteristics cause the frequency of a valve oscillator to differ slightly from the natural frequency of the tuned circuit employed : given fixed values of tuning inductance and capacity, it is only in these departures from the resonant frequency of the tuned circuit that instability can occur. We are here discussing certain effects due to the valve, and shall therefore assume stability of the tuned circuit.† Valve effects are of course liable to alteration through (a) ageing or replacement of the valve, (b) fluctuation in operating potentials on filament or anode ; it will be found also that they are affected by the resistance, including external loading, of the tuning system.

In dealing with the equations of an oscillating valve it will be convenient to divide the system into two parts : the valve, and the external circuit. This is preferable to other possible modes of division (e.g. grid circuit and anode circuit), since in the majority of cases the whole of the external circuit can be defined by simple algebra, while the valve is non-linear, so that it may need to be represented by an empirical function ; working is simplified if this function is as far as possible kept separate from other terms in the equations. The most convenient expression for the valve is

$$I_a = f(\mu V_g + V_a) \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where I_a is the alternating component of anode current, V_g and V_a the alternating potentials of grid and anode respectively (measured from the cathode) ; $(\mu V_g + V_a)$ is then known as the "lumped voltage." As an approximation we shall assume linearity of valve characteristic, when equation (1) reduces to

$$I_a = (\mu V_g + V_a)/\rho \quad \ldots \quad \ldots \quad \ldots \quad (1a)$$

where ρ is the anode slope resistance of the valve. (The effect of non-linearity is considered in the Appendix.) From the algebra of the external circuit, certain relations can be deduced between I_a, V_g, and V_a ; for this purpose let the vector Z denote the impedance of the external circuit connected between anode and cathode, and the vector T the anode to grid "transfer impedance," i.e. T is the potential difference resulting between grid and cathode for unit anode current. Since there is no external source of alternating E.M.F. in a self-oscillating valve circuit, we may write

$$V_a = -ZI_a \quad \ldots \quad \ldots \quad \ldots \quad (2a)$$

(V_a is negative w.r.t. I_a, a rise in anode current of a valve, whether amplifier or oscillator, being accompanied by a fall in anode potential due to the voltage drop across the load ; in fact, of course, there are constant battery voltages to be added to both V_a and V_g, but we are here considering only alternating components.) Similarly the grid potential is

$$V_g = TI_a \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2b)$$

Following the method of Abélès[1] one can then substitute (2a) and (2b) in (1a) to give

$$I_a = I_a\,(\mu T - Z)/\rho \quad \ldots \quad \ldots \quad (3)$$

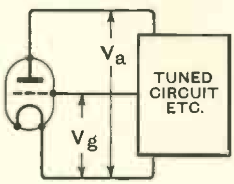
* MS. accepted by the Editor, October, 1935.

† The tuned circuit is liable to variation through (a) temperature coefficient of inductance and capacity, (b) mechanical instability of the components, and (c) change of total capacity resulting from variation in the valve inter-electrode capacity. The last, though strictly speaking a valve, rather than a circuit, function, is too large a subject to be discussed here.

Assuming $I_a \neq 0$, this is equivalent to

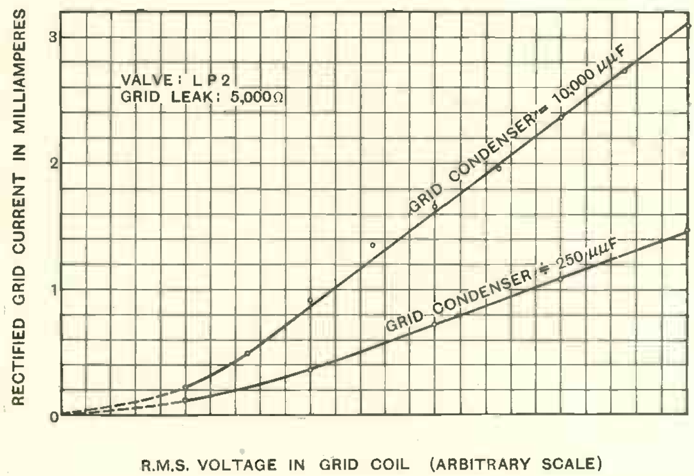
$$\mu T - Z = \rho \quad \ldots \quad \ldots \quad \ldots \quad (3a)$$

Since T and Z are vectors, this equation in general resolves into two, for resistive and reactive components, and these will usually be found to give separately the "maintenance" and "frequency" conditions respectively. When Z and T are not pure resistances, the anode and grid voltages are not in phase with the anode current; but as long as ρ remains a pure resistance, the lumped voltage must of necessity be in phase with the anode current, as is shown by equation (3). In the most usual arrangements Z is a tuned circuit, by a reactance in the anode lead, between the valve and the tuned circuit proper: see reference (2).) Now the more heavily a tuned circuit is damped, the flatter is its phase/frequency curve; hence for a given change of phase angle, a heavily damped tuned circuit will result in a greater frequency change than one of little loss. This is one reason for decrease of stability with increased loading of an oscillator. But in addition resistance at certain points within the tuned circuit will change the phase angle of the transfer impedance T; it is for this reason desirable to use a tuned circuit of low loss even if it is to be heavily loaded externally.



(*Above*) Fig. 1.

(*Right*) Fig. 2.



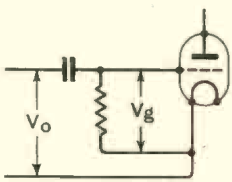
which behaves as a pure resistance at resonance, but can be caused to have any leading or lagging phase angle by changing the frequency. The mechanism by which a valve oscillator adjusts itself to the steady state is therefore as follows:—

(*a*) The effective value of ρ is a function of amplitude of oscillation; so that the "maintenance" condition can be met by change of amplitude until ρ has the requisite value.

(*b*) The frequency must take up such a value as to produce zero reactive component in the lumped voltage. Clause (*b*) means that the reactive components of Z and μT must cancel each other, so that the frequency depends upon the amplification factor of the valve except in the special case of Z and T both pure resistances. (A *fixed* phase-angle, such as arises from the inevitable resistance of circuit components, may be compensated

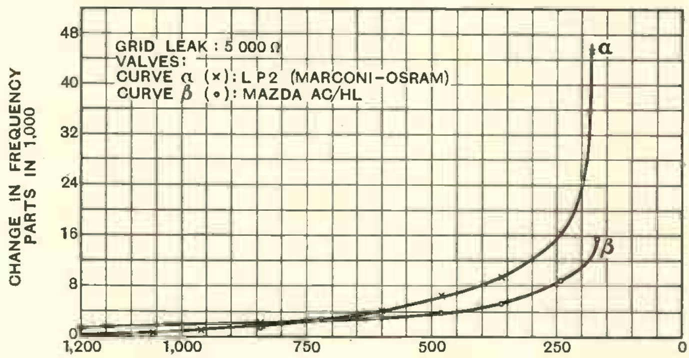
For the phase/frequency curve of a tuned circuit also becomes less steep as the frequency departs from resonance, so that it is undesirable to work at a large phase angle, even though it be a fixed one. An appreciable phase angle between anode current and voltage is also undesirable from the point of view of power supply.

It has been usual to regard the flow of grid current in the valve as equivalent to a pure resistance shunted across the grid and cathode terminals of the valve; the frequency has then been said to be a function of the grid-cathode resistance ρ_g of the *valve*, which resistance of course varies with the valve's operating voltages. In many practical cases, however, a grid-leak and condenser are used; it is to be expected that the impedance of the circuit will then be determined almost entirely by the grid leak, not by the valve. The use of a relatively low resistance grid leak should not, therefore, by pure resistance effect make the frequency of the valve more susceptible to valve-operating voltages; though in fact grid current does have this effect. As a check is unlikely to be changed by the valve, there is always the risk of change in the grid leak resistance due to heating; to avoid this danger, the reactance of the grid coupling condenser should be small compared with



(*Above*) Fig. 3.

(*Right*) Fig. 4.



on the constancy of input resistance with low values of grid leak resistance, a tuned-anode oscillator with inductive grid coupling was set up, and the anode voltage varied, resulting in a variation also of the amplitude of radio-frequency voltage developed across the tuned circuit. Graphs were plotted of rectified current in the grid leak against r.f. voltage applied to the grid coupling coil, and were found to be practically straight lines provided the input were not very small (Fig. 2). Although this gives no direct measure of the input resistance, it is fair to assume that the power consumed is some function of the rectified grid current, and that a constant ratio of rectified current to r.f. input implies a constant r.f. load. The grid leak had a resistance of 5,000 ohms, and two curves are given, for grid condensers of 10,000 $\mu\mu F$ and 250 $\mu\mu F$; the latter is important, since it shows that the constancy of input resistance is not dependent upon the time-constant of the grid leak and condenser being large compared with the period of the applied voltage. The input impedance of a valve employing a grid leak and condenser is therefore a function of the values of these components rather than of the valve itself, and "ρ_g" need not be considered further; for we have seen that the behaviour of the grid circuit is unaffected by large changes in the potentials applied to the valve.

If, however, the frequency depends on the input impedance, even though this impedance the input impedance. (It is clear from Fig. 3 that this is the condition for minimising the phase angle between V_0 and V_g; and any such phase angle in the grid coupling arrangements must, as explained above, result in a departure of the frequency from the resonant value.) The next step, therefore, was to determine experimentally the value of coupling capacity necessary at the frequencies employed (550 to 1,000 kc/s) and with a grid leak of 5,000 ohms. The curves of Fig. 4 show the change of frequency occurring when the value of grid condenser

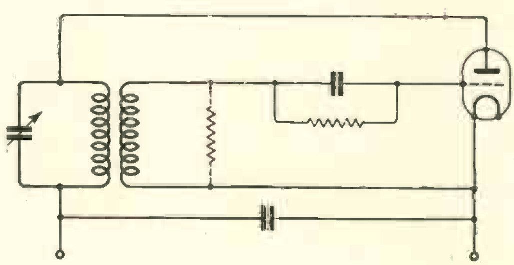


Fig. 5.

is reduced from a very large value to so small a value that oscillation ceases; the two curves are for two different valves, and the slight differences may be due to differences in the input capacities of the valves. In view of these results it was decided to employ a condenser having a capacity of 1,000 $\mu\mu F$.

Even so, change of grid leak resistance continued to cause a change of frequency; and that this was not due to pure resistive damping of the tuned circuit was clearly demonstrated by the following experiment. Using the same oscillator as before, the grid leak was first varied, and the resulting frequency changes plotted against resistance values; the grid leak resistance was then fixed at a high value, and loading resistances shunted across the coupling coil as indicated by the dotted lines in Fig. 5. The results are shown in Fig. 6, where it will be seen that these loading resistances, which must produce a damping effect similar to that of grid current, produce a much smaller change of frequency. It appeared possible that the frequency changes were due to the harmonics which must be produced in the grid voltage when the peak of the voltage wave is flattened by the flow of grid current.* A series acceptor circuit was accordingly connected directly between grid and cathode, and tuned to the second harmonic, making it impossible for any appreciable second harmonic voltage to exist between grid and cathode. Fig. 7 shows the changes of frequency with variation of grid leak and loading resistance, taken both with and without the second harmonic filter. It is evident that with this particular arrangement the grid current was influencing the frequency chiefly through the generation of harmonics; as explained in the Appendix, the fundamental component of a wave which has been distorted in this way has a slight difference of phase from the original wave, so that the effect of grid current is to introduce a phase-difference between the actual grid voltage and the voltage in the coupling coil, and hence a frequency change.

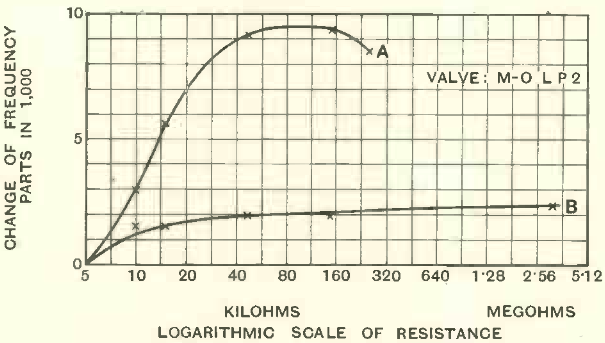


Fig. 6.—*Curve A, variation of grid leak. Curve B, variation of resistance shunted across grid coil. f ≑ 880 kc/s.*

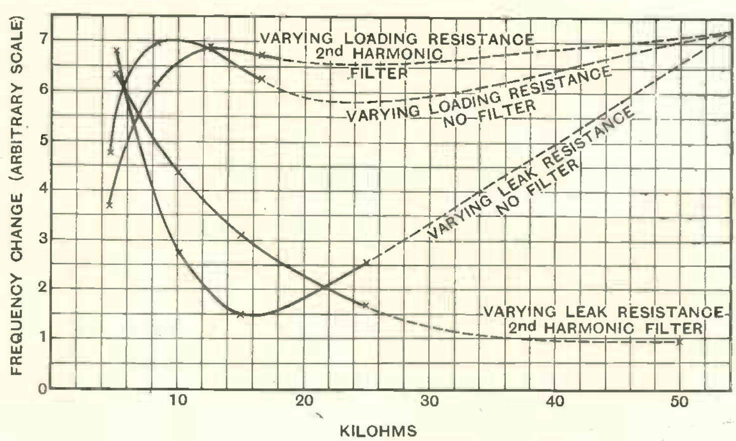


Fig. 7.—*Changes of frequency with grid leak and loading resistance variations.*

The next question to be considered was the closeness of coupling between anode and grid coils, particularly as other writers have suggested on various grounds that a small grid coil with tight coupling is desirable; in the above experiments the coupling was fairly loose. As examples of tight coupling the circuits of Fig. 8*a* and *b* were employed, in both of which the grid coil is a portion of the same winding which forms the main tuning inductance; the circuit of 8*a* gives the closest possible coupling between grid and anode inductances, since the two are here physically the same winding. (The coupling between anode and grid *circuits* cannot be freely varied, since it is necessary to keep the ratio of anode to grid voltage

* Divoire and Baudoux (reference 3) have reported an improvement in stability on tuning the grid circuit either to the fundamental frequency or to the second harmonic.

within limits.) With either of these two circuits the effect of grid current on frequency was very small. Using an L.S.5 valve with a grid leak of 50,000 ohms (found by trial to be the value giving the highest efficiency with this oscillator), it was possible to obtain a useful output of 1 watt across an external non-inductive resistance with an input of 2.4 watts, and a stability limited

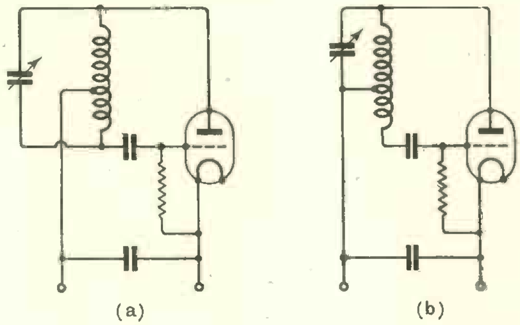


Fig. 8.

only by change of interelectrode capacity of the valve. The change of frequency for a drop of anode voltage from 220 to 100 was actually of the order of 1 in 10,000 but not more than 1 in 100,000 could be ascribed to grid current, the remainder being due to change of interelectrode capacity. The value of 40 per cent. for *overall* efficiency is very good, since there are appreciable losses both in the grid circuit and in the resistance of the tuned circuit.

It seems, then, that the harmonic effect from grid current is large in an oscillator with loosely coupled coils since the leakage reactance causes the harmonic currents, which are inevitable with grid current, to result in distortion of the voltage waveform also; but if leakage reactance is small, the voltage waveform on the grid is compelled to follow that across the tuned anode circuit, which latter is practically sinusoidal. Provided that one is prepared to tap the anode coil at the appropriate place, there should never be any need for coupling with large leakage reactance (it must be remembered that the use of a small grid coupling condenser introduces undesirable reactance just as much as the use of a large grid coil with small mutual inductance to the anode coil). The general conclusion is, provided that suitable coupling (of small leakage reactance) is employed, the presence of appreciable grid current need not cause noticeable loss of stability.

The experimental work described in this paper was carried out in the Engineering Laboratory, Oxford University, and the author wishes to thank Mr. E. B. Moullin for his many helpful suggestions and continued interest in this work.

Appendix: Non-Linear Conductors

The non-linear valve oscillator is a difficult problem on which many mathematical papers have been published. But Llewellyn (4) showed that as far as the fundamental frequency was concerned a non-linear conductor behaved as a combination of resistance and reactance, the magnitude of the reactance depending upon the impedance of the external circuits to the harmonics generated; and Moullin (5) has calculated for the dynatron the magnitude of the phase-difference introduced between the applied voltage and the fundamental component of the distorted current wave. As a good approximation therefore the analysis of the linear valve oscillator may be modified to allow for non-linearity by replacing the statement that "the lumped voltage must of necessity be in phase with the anode current" (p. 540) by "the total effective voltage of fundamental frequency must differ in phase from the fundamental component of the anode current by a small amount dependent upon the curvature of the valve characteristic and the nature of the external circuit." This implies a frequency change which in practice is additive to other effects.

References

(1) Abélès, "Détermination de la Condition d'Entretien et de la Période d'Oscillation des Oscillateurs à Triode." *Rév. Gén. de l'El.* Vol. 23, p. 696.

(2) Mallet, "Frequency Stabilisation of Valve Oscillators." *J.I.E.E.*, Vol. 68 (1930), p. 578.

(3) Divoire and Baudoux, "Sur la Stabilisation de la Fréquence dans les Oscillateurs à Triode." *Onde El.*, Feb. 1934, Vol. 13, p. 53.

(4) Llewellyn, "Constant Frequency Oscillators." *Proc. I.R.E.*, Vol. 19 (1931), p. 2063.

(5) Moullin, "The Influence of the Curvature of the Characteristic on the Frequency of the Dynatron Generator." *J.I.E.E.*, Vol. 73 (1933), p. 196.

New Measuring Instruments

RECENT additions to the series of measuring and testing instruments produced by the Instrument Department of E. K. Cole, Ltd., Southend-on-Sea, include two inductance bridges (one for the determination of very small inductances and the other for mass-production testing of inductance coils, 1-100 millihenries) and an electrolytic condenser bridge.

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

3661. EXISTENCE OF A SURFACE WAVE IN RADIO PROPAGATION.—C. R. Burrows. (*Nature*, 15th Aug. 1936, Vol. 138, p. 284.)

The writer points out that Rolf's evaluation of Sommerfeld's formula for radio propagation over a plane earth (1930 Abstracts, pp. 29, 388) differs from the formulae of Weyl & Norton (*see* 2538 of 1935) by exactly the "surface wave" component. This has been experimentally verified for the propagation of 2 m waves over deep fresh water. "A revision of the Sommerfeld-Rolf curves is required for propagation over all types of ground for which the dielectric constant cannot be neglected."

3662. DIRECT DETERMINATION OF THE ELECTRICAL CONSTANTS OF SOIL AT RADIO FREQUENCY [by Variable Reactance Method: Data for Various Values of Moisture Content and Frequency].—B. Sen Gupta and S. R. Khastgir. (*Phil. Mag.*, August, 1936, Series 7, Vol. 22, No. 146, pp. 265–273.) For method *see* Ratcliffe & White, 1931 Abstracts, p. 28.

3663. RESEARCHES ON THE ELECTRICAL CONDUCTIVITY OF STONES.—F. Bayard-Duclaux. (*Ann. de Physique*, July/Aug. 1936, Vol. 6, pp. 5–107.)

3664. NON-FADING NOISE-FREE BROADCASTING SERVICES [and the Wavelengths for Maximum Efficiency: etc.].—Green. (*See* 3934.)

3665. TRANSMISSION OF ELECTROMAGNETIC WAVES IN HOLLOW TUBES OF METAL [provided Frequency is Greater than Critical Value which is Inversely Proportional to Tube Radius and to Dielectric Coefficient to Tube Interior: Conditions for Minimum Attenuation: etc.].—W. L. Barrow. (*Proc. Inst. Rad. Eng.*, August, 1936, Vol. 24, No. 8, pp. 1053–1054: summary only.)

3666. ULTRA-HIGH-FREQUENCY TRANSMISSION BETWEEN THE RCA BUILDING AND THE EMPIRE STATE BUILDING, IN NEW YORK CITY [Preliminary Tests (176–182 Mc/s) for 177 Mc/s Link from RCA Television Studios to 50 Mc/s Transmitting Station in Empire State Building: Signals by Several Paths (Reflection from Ground and Buildings): Effects of Horizontal and Vertical Directivity and Change in Polarisation Angle: Theoretical Response Curve for Assumed Combination of Rays compared with Experimental Curves].—P. S. Carter and G. S. Wickizer. (*Proc. Inst. Rad. Eng.*, August, 1936, Vol. 24, No. 8, pp. 1082–1094.)

3667. THE 5-METRE TESTS OF THE F615 ON 14TH AND 16TH JULY, 1936 [Flight over North Holland and Texel].—H. Suyling and W. Metzelaar. (*Radio-Centrum*, 23rd July, 1936, Vol. 2, No. 30, pp. 419–420: in Dutch.)

3668. RECEPTION DIAGRAMS IN AUSTRALIA, AMERICA, AND ELSEWHERE OF ROTATING 14.82 m BEAM SIGNALS FROM ROME.—Pession. (*See* 3942.)

3669. EXPERIMENTAL RESEARCHES ON THE PROPAGATION OF SHORT ELECTRIC TELEVISION WAVES (WAVELENGTHS 41 AND 74 m).—Rivault. (*See* 3859.)

3670. SOME OBSERVATIONS ON THE C REGIONS OF THE IONOSPHERE.—H. Rakshit and J. N. Bhar: S. K. Mitra. (*Nature*, 15th Aug. 1936, Vol. 138, p. 283: pp. 283–284.)

The C regions are the ionised layers at heights of about 55 km, 20–35 km and 5–15 km (*see* 2539 of 1935, 2078 of June and 2508, 2509, 2510 of July) which the present writers propose to call C_1, C_2 and C_3 regions respectively. Observations on their general behaviour are here given; echoes from C_1 are much more frequent and of greater strength than those from C_2 and C_3; day-time echoes are weaker than night-time echoes; echoes have been observed at all times but are more frequent during the afternoon and usually too weak to be detected at noon. Typical curves are given for the variation of the square of the critical penetration frequency for region C_1; it is concluded that the ionisation is of solar origin. The average values of penetration frequency for C_2 and C_3 regions are of the same order as those for C_1 region. Mitra points out that it is not justifiable to take the critical frequency curves as proportional to the square root of the ionisation density, on account of the high and perhaps variable values of the collisional frequency at the levels in question.

3671. The Lower Regions of the Ionosphere [General Observations on C and D Regions].—R. C. Colwell, A. W. Friend, N. I. Hall and L. R. Hill. (*Nature*, 8th Aug. 1936, Vol. 138, p. 245.)

The general seasonal behaviour of C and D regions is noted, with the turbulence of C region during thunderstorms and strong winds. Fluctuation and lowness of C region coincided with a magnetic disturbance and absence of signals on the 20 m band. Signals from a balloon situated above C region were reflected into space from its upper boundary.

3672. Russian Eclipse Measurements on the Ionosphere [suggest that Ionisation of F_2 Region is due not only to Ultraviolet Light but also to Corpuscular Influences].—W. Kessenich & collaborators. (*Nature*, 1st Aug. 1936, Vol. 138, p. 195: short preliminary note.)

3673. The Ionosphere, Solar Eclipse [of June 19th, 1936], and Magnetic Storm [Abnormal Ionospheric Conditions associated with Magnetic Storm rather than with Eclipse: Effect of Magnetic Disturbance].—S. S. Kirby, T. R. Gilliland, N. Smith and S. E. Reymer. (*Phys. Review*, 1st Aug. 1936, Series 2, Vol. 50, No. 3, pp. 258–259.)

The principal results of ionospheric observations during this eclipse period are summarised; the abnormal conditions are considered to be associated with a simultaneous magnetic storm rather than with the eclipse. The writers' general conclusions as to the effect of a magnetic storm are that: "(1) Disturbed radio conditions correlate much better with disturbances of the Z than with disturbances of the H component. (2) A severe magnetic disturbance beginning during the day-time may show little correlation with radio data, while a severe magnetic disturbance before sunrise is accompanied by disturbed radio conditions during the whole of the following day. (3) The disturbed radio conditions include lowered critical frequencies, increased absorption, and increased virtual heights, indicating a diffusion of the ionosphere. (4) During a magnetic disturbance the higher part of the ionosphere is the most disturbed."

3674. On Abnormal Upper-Atmospheric Ionisation on 14th Feb. 1936.—G. Leithäuser. (*Funktech. Monatshefte*, July, 1936, No. 7, pp. 241–242.)

Between about 16.20 and 16.40 on 14th February, the German P.O. stations found that short-wave reception from directions west of Berlin was completely suspended, whereas eastward communication (*e.g.* with Japan) remained normal. This phenomenon has been correlated by Morgenroth with a special activity of the sunspot group on the central meridian of the sun's surface: in an appendix to his paper (in No. 6 of the *Mitteilungen des Deutschen Amateur-Sende- und Empfangdienstes*) this writer mentions that the National Physical Laboratory workers have reported, for the same time, a decrease in reflections at the upper-atmospheric layers. "In view of these reports," the present writer remarks, "it seems important to see whether the continuous recording of the ionosphere, carried out by the Institute for H.F. Research under the author's direction at Pieskow, gave indications of the disturbance": specimen records are here reproduced. Fig. 1 shows clearly the sudden disappearance of F-layer reflections at 16.25, lasting till about 16.45 (full strength regained at about 6.55): soon after 17.00 the appearance of multiple reflections from the F layer is visible, showing abnormally strong F-ionisation. Fig. 2, of the following morning, shows the continuous F-layer trace with an unbroken transition into the lower daylight height (sunrise at 7.09); whereas Fig. 3, for the preceding morning, after no abnormal electron invasion, shows no F layer from 6.00 until, shortly before 7.00, it makes a diffuse appearance which becomes definite at about 7.20 and gives multiple reflections.

The observed difference between west and east communication is explained by the fact that at the moment of electron invasion a state of highest day ionisation (10.00 local time in N. America) existed over the Atlantic Ocean, and the additional ionisation in these illuminated regions would raise the total ionisation to such a point that reflection could not occur (excessive absorption, or such a disturbed state that the incident energy was diffused). On the dark side, on the other hand, the regions were already attacked by recombination, and the additional ionisation caused by the electron invasion would improve, instead of spoiling, their reflecting powers.

The writer ends by stressing the importance of continuous ionosphere-height recording, and states that simultaneous consideration of the magnetic records shows that no auroral phenomena occurred to cause the observed results. He concludes, therefore, that the transit time of the electrons from the sun to the earth is two hours, giving the velocity, as estimated by Morgenroth, of 207 000 km/sec.

3675. Solar Eclipse and Radio Reception [Inconclusive Dutch Results on Short Waves: and Doubts on the 54-Day Periodicity of the "Dellinger Effect"].—J. H. C. Lisman. (*Radio-Centrum*, 30th July, 1936, Vol. 2, No. 31, pp. 425–426: in Dutch.) From the radio-laboratory of the State Telegraphs.

3676. DX BY THE CALENDAR: PRACTICAL MONTH-TO-MONTH FORECASTS BASED ON THE 27-DAY SOLAR CYCLE.—C. D. Perrine. (*QST*, August, 1936, Vol. 20, No. 8, pp. 34–35.) For remarks on 10 m reception *see* pp. 8 and 68.

3677. THE TEMPERATURE AND CONSTITUENTS OF THE UPPER ATMOSPHERE.—Martyn and Pulley. (*Australian Rad. Res. Board*, Report No. 11, 31 pp.) *See* 2073 of June.

3678. OZONE AS A HEATING FACTOR IN THE ATMOSPHERE [Calculated Curves of Cooling and Heating Effect: Maximum Effects at Height of about 50 km, where the Heating is 10 Times the Cooling Effect: No Effect below 25 km].—R. Penndorf. (*Nature*, 8th Aug. 1936, Vol. 138, p. 247.)

3679. COMPARISON OF HUGGINS BANDS IN THE SPECTRUM OF THE BLUE SKY WITH THE TEMPERATURE OF ATMOSPHERIC OZONE.—J. Dufay. (*Comptes Rendus*, 3rd Aug. 1936, Vol. 203, No. 5, pp. 383–386.)

3680. THE ABSORPTION OF HERTZIAN WAVES BY AN ELECTRONIC GAS IN A MAGNETIC FIELD.—G. Todesco & De Pace. (*Alta Frequenza*, July, 1936, Vol. 5, No. 7, pp. 437–439.) Prompted by the letter referred to in 2913 of August.

3681. IONISATION OF GASES BY COLLISIONS OF THEIR OWN ACCELERATED ATOMS [Minimum Energies of Neutral Atoms needed for Ionisation of Noble Gases].—R. N. Varney. (*Phys. Review*, 15th July, 1936, Series 2, Vol. 50, No. 2, pp. 159–161.)

3682. THE TOTAL IONISATION OF NITROGEN BY ELECTRON COLLISIONS.—G. A. Anslow and M. D. Watson. (*Phys. Review*, 15th July, 1936, Series 2, Vol. 50, No. 2, pp. 162–169.)

3683. ON THE ENERGY LOSSES OF ELECTRONS IN MOLECULAR NITROGEN [Energy Spectra of Electrons of Various Incident Energies after Impact with Nitrogen Molecules: Corresponding Transitions between Energy Levels].—J. E. Roberts, R. Whiddington and E. G. Woodroofe. (*Proc. Roy. Soc.*, Series A, 17th Aug. 1936, Vol. 156, No. 888, pp. 270–283.)

3684. A CASE OF LINEAR PULSE DISTORTION OCCURRING IN IONOSPHERIC WORK [due to Inductance of Magnetic Deflecting Coils in "Kinescope" Type of Cathode-Ray Tube].—Baerwald. (*See* 3705.)

3685. TRANSMISSION OF HIGH-VOLTAGE IMPULSES AT CONTROLLABLE SPEED [Measurements of Propagation of Potential in Long Discharge Tubes: Use of Discharge Tube as Transmission Line with Controllable Velocity of Voltage Wave].—L. B. Snoddy, J. W. Beams, W. T. Ham and H. Trotter. (*Nature*, 25th July, 1936, Vol. 138, p. 167.)

3686. NOTE ON SURGES OF VOLTAGE AND CURRENT IN TRANSMISSION LINES [Correct Solution on Heaviside's Lines].—F. W. Carter. (*Proc. Roy. Soc.*, Series A, 1st Aug. 1936, Vol. 156, No. 887, pp. 1–5.)

3687. DISCUSSION ON "RESOLUTION OF SURGES INTO MULTI-VELOCITY COMPONENTS."—Bewley. (*Elec. Engineering*, August, 1936, Vol. 55, No. 8, p. 903.) *See* 44 of January.

3688. THE APPLICATION OF SIMPLE EQUATIONS TO A RIGIDLY CORRECT DESCRIPTION OF TRANSMISSION OF ALTERNATING CURRENT [along Leads and Cables: Vector Working Diagrams: Geometrical Treatment of Transmission Phenomena].—E. Wich. (*Arch. f. Elektrot.*, 17th June, 1936, Vol. 30, No. 6, pp. 386–397.)

3689. THE PROPAGATION OF ELECTROMAGNETIC PHENOMENA IN A MEDIUM OF CYLINDRICAL STRUCTURE.—F. Pollaczek. (*Rev. Gén. de l'Élec.*, 25th July and 1st August, 1936, Vol. 40, Nos. 4 and 5, pp. 103–112 and 131–147.)

From the editorial summary:—To calculate the electromagnetic fields which exist, in a periodic régime, in a medium of cylindrical structure to which certain initial values (sinusoidal in respect to time) of the tension are imposed, together with certain limiting conditions homogeneous with respect to the E and H components, the writer employs on the one hand a relation of "orthogonality" existing between any two free oscillations with different propagation constants, and, on the other hand, the properties of ideal electric or magnetic lines situated in such a medium. Since the free spatial oscillations and the propagation constants correspond to the free vibrations and to the natural frequencies of mechanics, and since the fields of the ideal lines are analogous to Green's functions, it follows that the results of this theory present a formal analogy to those of the classic theories. The writer particularly stresses the existence, in the most general case, of a "continuous spectrum"; that is to say, of one or of several continuous ranges of propagation constants—a phenomenon which has no analogy in elementary line theory. As an example, the classic case is treated of the propagation along a cylindrical wire, of infinite length, immersed in a dielectric and supplied with a sinusoidal tension in the plane $z = 0$: here it is found that, at a great distance from the source of tension, that part of the field which is due to the continuous spectrum preponderates over the remainder.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

3690. LIGHTNING AND ATMOSPHERICS [Flash heard on Receiver before being perceived Visually may be the Intermittent Discharge preceding the Main Flash].—Fyson. (*Nature*, 15th Aug. 1936, Vol. 138, p. 278: short note on observation by P. F. Fyson.)

3691. RADIO ATMOSPHERICS FROM A HIGH-TENSION TEST LINE.—H. Norinder. (*Wireless Engineer*, August, 1936, Vol. 13, No. 155, pp. 414–422.)

In a previous paper (449 of February) the writer showed that " short " disturbances were best dealt with by the E method and " long " by the dE/dt method. Difficulties arose in connection with a " medium " type of disturbance (300–1000 μsecs.) which was found to form about 10% of the total disturbances, and to which neither method really applied. The procedure now described, in which the previous horizontal aerial was replaced by a very long high-tension line with high insulation from earth, was designed so that the whole scale with regard to time variation could be dealt with. The observations covered the period Sept. 1935 to Feb. 1936.

3692. A Directional Recorder for Atmospherics [Narrow-Sector Instrument with Certain Modifications of the Radio Research Station (Slough) Design].—W. J. Wark, R. W. Boswell and H. C. Webster. (*Australian Radio Research Board*, Report No. 10, 1936, pp. 9–18.)

3693. Observations of Atmospherics with a Narrow-Sector Directional Recorder at Canberra [on 10 kc/s: Two Main Types of Source—Regular (Tropical Thunderstorm Areas from N. Queensland to Africa) and Irregular (of Lower Activity, chiefly " Frontal " Thunderstorms associated with Cold Fronts: Valuable for Weather Forecasting)].—G. H. Munro, W. J. Wark and A. J. Higgs. (*Australian Radio Research Board*, Report No. 10, 1936, pp. 19–30.)

Previous reports (Abstracts, 1933, p. 267, and 2935 of 1935) were based mainly on results with cathode-ray direction-finders, necessarily restricted to cover small parts of the day and night. The present report is on continuous records with the recorder dealt with in 3692, above: " On account of the poor intensity scale of the charts, they are not adequate to replace c.r.d.f. observations. They do however, give warning of the approach of relatively local disturbances, and hence indicate when detailed c.r.d.f. observations are likely to be worth while taking."

3694. Characteristics and Distribution of Sources of Atmospherics [" Irregular " Type: Geographical and Seasonal Distribution over Eastern Australia and Tasman Sea: Correlation with Thunderstorm Records].—Munro, Wark and Higgs. (*Australian Radio Research Board*, Report No. 10, 1936, pp. 31–41.) Combination of c.r.d.f. and directional-recorder results over 127 days, 1931/32.

3695. Sources of Atmospherics over the Tasman Sea [during September, 1932: Sources appear and disappear Earlier on Canberra Charts than in Auckland C.R.D.F. Records, indicating General Movement from West to East: Activity up to 10 Days].—R. W. Boswell. (*Australian Radio Research Board*, Report No. 10, 1936, pp. 42–46.) " The results show that automatic recorders may be used to trace atmospheric sources, and therefore thunderstorms, over distances of up to 1500 miles."

3696. Movements of Electrically Charged Cloud Particles [Observations of Motion past a Sphere: Conditions similar to those surrounding Falling Rain Drop in Thundercloud: Agreement with Wilson's Theory of Thundercloud Mechanism].—J. P. Gott. (*Proc. Camb. Phil. Soc.*, July, 1936, Vol. 32, Part 3, pp. 486–492.) *See* 45 of January and back references.

3697. Susceptibility to Lightning Strokes: Tests of the " Loire et Centre " Power Company on Air Conductivity.—T. Rich. (*Electrician*, 24th July, 1936, Vol. 117, pp. 115–116.) In a report on the Power Producer's Conference.

3698. The Protection afforded by " Distant " Lightning Conductors, and the Lightning Stroke Frequency in Certain German Cities.—B. Walter. (*E.T.Z.*, 20th Aug. 1936, Vol. 57, No. 34, pp. 981–982.) For the " distant " conductor *see* Walter, 1933 Abstracts, p. 268. The present report on a new paper contains references to criticisms (Toepler, Beenken) on Walter's model tests.

3699. Remarkable Lightning Bolt [Ribbon of Flame appearing to ignite Something high in Its Course, leaving Wisps of Flame persisting Momentarily and then Drifting away as if carried by Wind.].—H. A. Allard. (*Science*, 7th Aug. 1936, Vol. 84, pp. 136–137.)

3700. Discussion on " Lightning Investigations on a Distribution System."—Halperin and Grosser. (*Elec. Engineering*, August, 1936, Vol. 55, No. 8, pp. 903–906.) *See* 1367 of April.

3701. V.D.E. Survey of High-Voltage Technique in 1935 [including Lightning Research].—(*E.T.Z.*, 2nd July, 1936, Vol. 57, No. 27, pp. 772–773.) With numerous references to German literature.

3702. Papers on Transmission Phenomena of Surges, Impulses, etc.—(*See* 3684/3689 and 3705/3707.)

3703. An Arrangement for Recording Rapid Magnetic Disturbances.—H. Aschenbrenner and G. Goubau. (*Hochf:tech. u. Elek:akus.*, June, 1936, Vol. 47, No. 6, pp. 177–181.)

The apparatus here described is designed to measure variations of the earth's magnetic field of period between 10 min. and 1/20 sec. and of amplitude down to 0.3 γ. The principle is that a closed iron core E (Fig. 1) in the earth's field is magnetised by sinusoidal a.c. of period small compared with that of the magnetic disturbances to be measured. The current produces a large magnetic field in the iron, which goes beyond the linear part of the magnetisation curve. A coil S surrounds the whole of E; if there were no terrestrial magnetic field, no voltage would be induced in S. The premagnetisation of E due to the earth's field gives rise however to an alternating voltage U of frequency twice that of the magnetising current and of amplitude proportional to that of the earth's field. The variations of the latter can thus be measured by the amplitude variations of U. This is amplified and rectified, and an oscillogram is taken of the rectified current. The magnetisation phenomena in the iron are explained in § II; the magnetising system is shown in Fig. 3, the generator giving the magnetising a.c. in Fig. 4 and the amplifier in Fig. 5. The adjustment and tests of the system are described in detail in §§ IV and V, and typical records are reproduced (Figs. 6–10). The apparatus in its present form is not suitable for slow field variations.

3704. COSMIC RAYS AND THE HELIUM [Hypothesis that Helium in Upper Atmosphere is partially generated from Meteoric Dusts by Cosmic Radiation].—T. Takéuchi. (*Jap. Journ. of Physics*, March, 1936, Vol. 11, No. 1, Abstracts p. 22.)

PROPERTIES OF CIRCUITS

3705. A CASE OF LINEAR PULSE DISTORTION OCCURRING IN IONOSPHERIC WORK [when using a Cathode-Ray Tube with Magnetic Deflection ("Kinescope" Type): Reduction, without Loss of Sensitivity, by Shunt Condenser across Coils: Mathematical Analysis of Circuit, applicable to Many "Delaying and Integrating" Circuits].—H. Baerwald. (*Tech. Phys. of USSR*, No. 7, Vol. 3, 1936, pp. 604–632: in English.)

Such circuits are essential components of echo-eliminators; devices for automatic level control (Küpfmuller, Abstracts, 1929, p. 104), the spectrum analysis of static interference (Salinger, 1929, p. 637), and telemetering (Hudec, 1931, p. 511); etc. The writer calculates the pulse distortion by two methods, by the complex Fourier integral, yielding eqn. 23, and by means of the "weight function"—defined as the response to a pulse excitation of infinitely short duration and unit area—yielding eqn. 28. "Both 23 and 28 show the obvious fact that the distortion increases with λ [defined as ratio of system time-constant to duration of pulse]. Its cause, however, is interpreted in two ways. According to 23 it is due to the unequal transfer of the different frequency components, while by 28 it is due to the application of a kind of continuous mean-value process. Thus, when wanting to reduce distortion, it is necessary to level the transfer factor within the essential frequency range (2) or to reduce the 'width' of the weight function, respectively. Since, at the same time, deflectional sensitivity must not be impaired, it is not feasible to diminish λ for this purpose. It remains to consider the influence of the parameter a [related to the circuit decrement—see eqn. 21]. It is evident that the d.c. sensitivity does not depend on a. On the other hand, it will be seen that a proper choice of a leads to a marked reduction of distortion." Later on the writer says: "The reduction of distortion brought about by changing a from 0 to $\sqrt{2}$, while keeping λ constant, is obvious [from the curves of Fig. 7]; the pulse becomes sharper, less asymmetrical, and its peak lies closer to $\sigma = \lambda$, where it occurs if there is no distortion. . . . In order to fix an upper limit for λ and to design the deflection system accordingly, a suitable quantitative definition of pulse distortion is required which must be independent of the pulse shape. This will be given in the following" [pp. 620–622, leading to eqn. 44 defining the pulse-broadening distortion, and eqn. 45 defining the asymmetry effect]. The paper ends by considering whether the simple shunt-condenser circuit of Fig. 1 (adjusted according to eqn. 30a) leads to minimum distortion for a given deflectional sensitivity. It is found that the more complicated circuit of Fig. 10 gives no improvement.

3706. DIFFERENTIAL INDICIAL ADMITTANCES: CURRENTS PRODUCED BY UNIT DIFFERENTIAL PULSE VOLTAGE.—M. K. Ts'en. (*Chinese Journ. of Physics*, April, 1936, Vol. 2, No. 1, pp. 43–75: in English.)

Author's summary:—"The difference of two unit functions is used to represent a pulse voltage of abrupt rise and fall. By the principle of superposition, the currents produced by such a voltage on fifteen different circuits, covering twenty cases and thirty-six types, are analysed. Many interesting graphs are included. The main characteristics of the pulse currents are given by formulae with a system of notations." The circuits dealt with are elementary ("sometimes so simple as to be apt to hide mistakes"); series circuits (including R, L and C in series with critical and with logarithmic damping); coupled circuits; parallel and series-parallel circuits. "As the application of indicial admittance is not limited to electric circuits, but also to heat, air, hydraulic, mechanical circuits, etc., the results listed above may also be applied to them; for instance, the case (7) of resistance, inductance and capacitance in series brings out the principle of isochronism of a pendulum."

3707. TRANSIENTS OF A DISSIPATIVE LOW-PASS ELECTRIC WAVE FILTER WITH A TERMINATING RESISTANCE [Solution for T-Type Filter, with Oscillographic Confirmation].—W. Chu and C. K. Chang. (*Chinese Journ. of Physics*, April, 1936, Vol. 2, No. 1, pp. 76–105: in English.)

The non-dissipative case has been dealt with by Weber and Di Toro (2572 of 1935). "When the terminating resistance is gradually increased from zero, the damping constants of the sine terms begin to differ from each other, ranging in decreasing magnitude from the term of the lowest frequency to the last term of the cut-off frequency. Hence the transient is ultimately of the cut-off frequency. At cut-off frequency, this constant is near to but greater than $R/2L$. For each increase of a section, there is introduced an additional sine term with smaller damping constant. Therefore transients die out faster in filters of a smaller number of sections. Since transient amplitudes are of the same order of magnitude before and after cut-off, the filtering property only exists in the steady states."

3708. ELECTRIC NETWORK PARAMETRIC TRANSFORMS—EXAMPLES.—Y. W. Lee and S. H. Chang. (*Sci. Reports of Nat. Tsing Hua Univ.*, China, Series A, July, 1936, Vol. 3, No. 4/5, pp. 417–425: in English.)

"From equations (1) to (9) it is seen that with a proper change of variables (5) the parameters of an electric network may be expanded into Fourier cosine and sine series, the parameters being grouped in pairs, each pair consisting of a cosine and a sine series, both series having the same coefficients except for a constant. It is further seen that with the aid of an harmonic analyser, electric network parametric determination has been reduced to an easy routine."

3709. THE APPLICATION OF ELECTRIC FILTERS TO DELAY NETWORKS [for Sound Ranging in Air and Water].—Federici. (*See* 3849.)

3710. FUNDAMENTALS IN THE APPLICATION OF MATRICES TO ELECTRICAL NETWORKS: PART II [with Chart].—J. D. Pernice. (*Communication & Broadcast Eng.*, July, 1936, Vol. 3, No. 7, pp. 12–17.)

3711. GENERAL THEORY OF FORCED AND FREE OSCILLATIONS OF AN ELECTRIC OSCILLATORY CIRCUIT, AND OF THE RECEIVING OF RAPID UNPERIODIC ELECTROMAGNETIC RADIATION.—E. Hallén. (*Nova Acta Regiae Societatis Scientiarum Upsaliensis*, Series IV, No. 2, Vol. 10, 1936, pp. 3–40: in English.)

The writer has previously calculated (1934 Abstracts, p. 265) the free oscillation periods of a circuit consisting of a receiving coil or frame in series with a condenser and a resistance. The assumptions there made, that the length of the coil is small and the number of turns great, are here removed; the mathematical calculations involved in the consideration of a coil with a finite number of turns spaced along the coil and separated by a medium of known dielectric constant are given. The general formula for the effect of an external magnetic field is found and the effect of an ohmic resistance discussed. The formulae obtained are finally compared with experimental values.

3712. OSCILLATIONS IN SYSTEMS WITH NON-LINEAR REACTANCE [Theoretical Study of Circuit including Generator and a Condenser having One Plate elastically Supported to constitute a Mechanically Resonant System].—R. V. L. Hartley. (*Bell S. Tech. Journ.*, July, 1936, Vol. 15, No. 3, pp. 424–440.)

The possibility of such oscillations was originally discovered in a theoretical study of the possible use of a moving-plate condenser as a modulator in a carrier system. The present paper gives an analysis showing that sustained oscillations can be maintained by applying to the condenser an alternating electromotive force of a frequency higher than, and unrelated to, the resonant frequency of the movable plate, "provided that the impedance of the system at these two frequencies and their various combinations satisfy certain relations, and the applied e.m.f. exceeds a threshold value. When the oscillations are negligible at all frequencies except these two and their sum and difference, the most favourable condition, lowest threshold voltage, occurs when the plate vibrates at its resonant frequency, and the electric circuit is resonant at the applied frequency and at the difference frequency, and anti-resonant at the sum frequency." The oscillations "represent a special case of a class of similar oscillations, all of which depend on the presence of a non-linear reactance. Another special case is a molecular model capable of reproducing the main features of the Raman effect." For experimental confirmation *see* 3713, below.

3713. OSCILLATIONS IN AN ELECTRO-MECHANICAL SYSTEM [Experimental Results].—L. W. Hussey and L. R. Wrathall. (*Bell S. Tech. Journ.*, July, 1936, Vol. 15, No. 3, pp. 441–445.) *See* 3712, above.

3714. TWO COUPLED OSCILLATORS WITH "SOFT" SELF-EXCITATION.—V. I. Gaponov. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 6, 1936, pp. 801–811.)

The theoretical study by A. G. Mayer (1724 of May) is re-examined and a simplified method is proposed in which the oscillating system with two degrees of freedom is replaced by a system with one degree of freedom, acted on by an external asynchronous force. The operation of the system under various conditions is determined theoretically and a number of curves are plotted. This is followed by a report on an experimental investigation, which forms the main subject of the paper, and the experimental curves are shown side by side with those obtained theoretically. A comparison between the two sets of curves shows a very close agreement.

3715. ON A CASE OF AUTO-PARAMETRIC EXCITATION.—V. V. Migulin and Ya. L. Alpert. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 6, 1936, pp. 812–818.)

In the present paper the operation of an oscillating system with one degree of freedom is investigated when it is acted upon by two harmonic forces. It is shown experimentally as well as theoretically that when the natural frequency ω_0 of the system is approximately equal to $(\omega_1 \pm \omega_2)/2$, where ω_1 and ω_2 are the applied frequencies, oscillations of a frequency exactly equal to $(\omega_1 \pm \omega_2)/2$ may appear in the system and persist within a certain range of de-tuning. The phenomenon is investigated from the standpoint of auto-parametric excitation (*see* 3328 of September) and it is shown that in order to represent adequately the processes taking place in the system, the equation of the valve characteristic must be of at least the 5th degree.

3716. FREQUENCY DIVISION—A NEW CIRCUIT FOR THE GENERATION OF SUBHARMONIC FREQUENCIES [and Derivation of Formulae giving Highest Anode Output for Frequency "Splitter" (dividing Frequency into 2 Equal Parts): Extension to Frequency Division into *n* Parts: Experimental Confirmation giving Division by 3].—H. Sterky. (*Ericsson Technics*, No. 2, 1936, pp. 31–37: in English.)

3717. NEW TYPES OF TRIODE MULTIVIBRATORS.—A. Nicolich. (*Alta Frequenza*, July, 1936, Vol. 5, No. 7, pp. 430–436.)

"The dissymmetrical multivibrator already described by Vecchiacchi [1932 Abstracts, p. 355] can have modifications, distinctly advantageous in some ways, which lead to the two new circuits shown in Figs. 1 and 6." The circuit of Fig. 1 is a two-triode combination differing from the Vecchiacchi and the symmetrical Abraham-Bloch circuits in having only one inter-valve coupling possessing a time constant. Of the two couplings actually existing between the valves, one is of the direct type obtained by a resistance R_{12} in the common anode circuit, on the side of the two cathodes. The other coupling, whose time constant determines the frequency of oscillation, is effected by the combination of the resistance R and the capacity C: the second variable resistance, R', is sometimes kept at zero (curves of Fig. 4 and right-hand curves of Fig. 5) but is made of the same order as R if the two half-waves are required to be about equal or if a rectangular wave-form is desired (Fig. 5, left-hand curves). The advantages claimed for the new circuit are the elimination of complex oscillations; wide frequency range by varying the one and only capacity C or resistance R; the possibility of varying C, and hence the frequency, without altering the wave-form; and the possibility of obtaining practically rectangular waves with various ratios of the lengths of the half waves.

The second circuit, Fig. 6, uses only a single triode; the transformer T ensures the phase relation for the coupling between grid and plate necessary to start the oscillations. Here again the comparative lengths of the half waves can be varied by altering the ratio R/R'.

3718. RELAXATION OSCILLATIONS [Survey].—S. Gradstein. (*Philips Tech. Review*, February, 1936, Vol. 1, No. 2, pp. 39–45.)

3719. FEED-BACK AMPLIFIERS [and the Use of Negative Feed-Back for Radio Receivers and Transmitters, Carrier Telephony, etc.].—Black. (*Electronics*, July, 1936, Vol. 9, No. 7, pp. 30–31.)

3720. THEORY OF THE UNWANTED OSCILLATION IN BACK-COUPLED AUDION CIRCUITS WITH GRID-CIRCUIT TAPPING.—Kautter. (*See* 3750.)

TRANSMISSION

3721. THE OSCILLATIONS OF MAGNETIC-FIELD VALVES AND THEIR ELUCIDATION: PART I—EXPERIMENTAL.—F. Herriger and F. Hülster. (*Telefunken-Röhre*, July, 1936, No. 7, pp. 71–93.)

A quantitative investigation (measurements within about 5%) of magnetron behaviour, chiefly on two-segment and four-segment models with 5 mm anode radius and 20 mm anode length. Authors' summary:—" For all the oscillations of a magnetic-field valve the external oscillatory circuit has a frequency-determining influence. Only in the region of the shortest wavelengths attainable with the two-segment type do the working conditions also have a marked effect on the frequency: in all other cases they have practically no effect except on the efficiency. Oscillatory-circuit data and the emission can be so chosen that they need not be considered further during the determination of the oscillation regions. The efficiency is used to give a measure of the 'readiness to oscillate' [*see* p. 73: " preliminary tests showed that the two quantities characterising the optimum working conditions, namely the efficiency and the useful output power, do not always coincide in their maxima. As a measure of 'readiness to oscillate' the efficiency appears to us the more suitable, firstly because of its more general physical significance and secondly because the useful output power is so subject to subsidiary effects such as space charges and cathode back-heating "]. The treatment is generalised by introduction of the 'order' equation $n = \lambda . B/12\,300$ in place of λ and of B/B_{crit} in place of B. The efficiency η and the ratio B_{opt}/B_{crit} are thus found to be independent of anode potential and anode radius.

" The two-segment magnetron has two separate oscillation regions; one of the first order, while the second begins at the third order and has a flat efficiency-maximum between the 20th and 250th order. The four-segment magnetron has only one oscillation region with a first sharp maximum between the 10th and 25th order. The magnetic field B_{opt} increases almost linearly with λ in the second oscillation region of the two-segment magnetron and in the whole oscillation region of the four-segment type.

" Other things being equal, B_{opt} is proportional to p, the number of segment-pairs. The relation between the most important working values is given by the empirical formula $\lambda = 1100 . r_a^2 . B_{opt}/p . V_a$," where r_a is the anode radius in cm.

3722. DISCUSSION ON " THE ACTION OF A SPLIT-ANODE MAGNETRON."—Gill and Britton. (*Journ. I.E.E.*, August, 1936, Vol. 79, No. 476, pp. 224–226.)

See 2129 of June. Awender & Tombs quote results indicating oscillation intensity *not* related to anode cut-off point: Megaw maintains that " precession " theory, though on right lines, fails to account for conversion efficiencies in excess of ratio peak-voltage/mean-anode-voltage; derives theoretical formula for optimum wavelength, agreeing with experiment; etc. The authors reply.

3723. THE LIMITS OF OSCILLATION GENERATION [Survey of Micro-Wave Generation Methods: Present Limit for Undamped Waves given as 1 cm (Magnetron): at 25 cm a Four-Segment Magnetron gives 15 Watts with 40% Efficiency: at 10 cm a Two-Segment Magnetron gives 0.5 Watt at 5% Efficiency].—E. C. Metschl. (*Funktech. Monatshefte*, July, 1936, No. 7, pp. 251–256.) *See* also 3769.

3724. EXPERIMENTS ON THE TRANSITION FROM ELECTRIC WAVES TO DARK HEAT RAYS [Wavelengths down to 0.66 cm and 0.48 cm separated out of Spectrum of Hertz Oscillator of Fundamental 15.6–26 cm: Presence of Shorter Waves (down to 0.7 mm and Less) indicated, and confirmed by Action on Thermopile: Criticism of Early Results claimed by Nichols & Tear].—K. F. Lindman. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 17, 1936, pp. 269–275.) Using some of the apparatus dealt with in 2151 of 1935.

3725. 56-Mc CRYSTAL CONTROL WITH RESONANT-LINE COUPLING, *and* 100-WATT 56-Mc CRYSTAL-CONTROL OUTPUT WITH ONLY FOUR STAGES.—E. Sanders: B. Goodman. (*QST*, August, 1936, Vol. 20, No. 8, pp. 12–15: pp. 16–18.)

3726. An Investigation of the Frequency Stability of a Valve Oscillator Stabilised by the Kusunose Method.—A. A. Arkhangel'skaya, A. A. Kostrov and B. K. Schembel. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 6, 1936, pp. 819–826.)

For the work of Kusunose & Ishikawa see 1932 Abstracts, p. 342. The theory of the oscillator is given and the effect of various factors on its frequency stability is determined. This is followed by a detailed account of experiments which were carried out to check the theoretical conclusions reached, and a number of curves are given showing the frequency variations of the oscillator under various conditions. The experiments were conducted on medium wavelengths and the frequency stability obtained is much higher than that indicated by Kusunose & Ishikawa in their paper. The circuit is however not suitable for operation on wavelengths under 100 m.

3727. A New High-Efficiency Power Amplifier for Modulated Waves.—W. H. Doherty. (*Bell S. Tech. Journ.*, July, 1936, Vol. 15, No. 3, pp. 469–475.) For previous summaries *see* 2965 and 2966 of August.

3728. Discussions on "High-Power Audio Transformers."—Peters. (*Elec. Engineering*, August, 1936, Vol. 55, No. 8, pp. 889–890.) *See* 1402 of April.

3729. Transmitter Adjustments [for High-Fidelity, Optimum-Efficiency Broadcasting]. —J. G. Sperling. (*Electronics*, July, 1936, Vol. 9, No. 7, pp. 15–17 and 54.)

3730. The Behaviour of the Grid-Controlled Gaseous-Discharge Tube when employed as [Relaxation-] Oscillation Generator [and the Superiority of Hydrogen over Argon as Filling].—P. Drewell. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 17, 1936, pp. 249–262.)

Author's summary :—" The investigation of the condenser discharge through grid-controlled gaseous-discharge tubes with hot cathodes shows that such a tube in relaxation-oscillation working, where a condenser is periodically discharged through it, is quite abnormally loaded. The high current peaks occurring during the discharge can only be explained by very violent ionisation by collision in the gas and by the setting free of electrons by ionic bombardment, since only a small fraction of the current can be carried by the thermionic emission from the hot cathode. Consequently the grid of the tube also takes a distinct part in the current conduction of the condenser discharge.

" The extinction of the tube, after the condenser discharge, is due to the blocking action of the grid which comes into action for small discharge currents, reinforced by the fall of anode voltage (to below the static ignition voltage) consequent on the surplus of charge carriers produced by the condenser discharge. Investigations on argon-filled tubes show that the anode voltage of these tubes may fall right to zero even when the discharge current is still considerable. Further current conduction through the tube is then mainly carried out by electron diffusion out of the plasma.

" In tubes with hydrogen filling, on the other hand, de-ionisation takes place so rapidly that a charge-carrier surplus can hardly come into action. As a result of the greater mobility of the hydrogen ions, however, the grid is able to set free considerably larger currents than with an argon filling, so that the condenser charging current, and therefore the relaxation-oscillation frequency, can be considerably greater [100 kc/s compared with about 20 kc/s]. An additional advantage of the hydrogen filling is that hydrogen ions even of high velocity do not attack the hot cathode [condenser discharges at 700 volts are harmless] whereas the ions of all the inert gases rapidly destroy the cathode even at velocities corresponding to 50 volts " [*see* also Drewell, 1582 of April]. The measurements were made with a special " kippschwing " tube with long indirectly heated cathode and concentric grid with only a single slot.

RECEPTION

3731. Measurements and Investigations on Quartz Crystals for Receiver Control. —E. Roeschen. (*E.N.T.*, June, 1936, Vol. 13, No. 6, pp. 187–197.)

The difficulty in the use of quartz crystals for receiver control has hitherto been their low attenuation, which gives rise to a very narrow band width. The experiments here described determine the transmission constants of the crystal ; the writer succeeds in broadening the resonance curve by coupling two crystals and by attenuation due to a surrounding gas discharge, so that the quartz may be used as a control element in the intermediate frequency stage of heterodyne receivers without cutting off or distorting the modulation. The scheme of the arrangement is shown in Fig. 1 and the full circuit in Fig. 2 ; the quartz Q is connected as a quadripole element and receives h.f. voltage from a sender S which can be modulated. The voltage input and output to the quartz are measured by the valve voltmeters RV_1 and RV_2 respectively. The receiver E is also connected to a valve voltmeter RV_n. The sender is described ; its modulation was observed with a cathode-ray tube and the degree of modulation determined. A resonance circuit connected in front of the valve voltmeter made it independent of frequency ; the calibrating arrangement is shown in Fig. 3. The receiver first used consisted of a rectifier and l.f. amplifier ; later, a heterodyne receiver was used (Fig. 4) with the quartz in the intermediate frequency stage. The crystal was excited in longitudinal oscillations in the X-direction and coupled very loosely to the sender by a resonance circuit (Fig. 6). The equations of the circuits are worked out.

The quartz was supported on knife edges at the nodes of its first harmonic and clamped by needle points at nodes on the upper surface : Figs. 7 and 8 show the arrangement. Fig. 9 shows resonance curves with low attenuation for an unmodulated h.f. signal, with low input voltages. For higher voltages the crystal was held more securely ; the average ratio of input to output voltage was found to be 5.60 and was practically constant in the frequency range used. Fig. 10 illustrates the determination of the transmission ratio for various input voltages ; Fig. 11, the a.f. transmission spectrum of the quartz. Fig. 12 shows distortion in the resonance curve for modulation; the modulation note was changed. These effects were traced to the luminous discharge round the crystal and could be avoided by using very small voltages (which showed incidentally that only small energies are needed for receiver control). Artificial attenuation of the crystal vibrations was produced by altering the crystal shape (resonance curves Fig. 14) or by coupling two crystals (Figs. 15a, b); the band width thus attained was still not sufficient. It was found that artificial damping by means of a gaseous discharge was sufficiently effective (resonance curves for discharges in argon and helium, Figs. 16, 17, 17a). The gas pressure should not be too low; the sharp dips in the resonance curves of two coupled crystals are then no more marked than in an ordinary band filter and the sides of the curve are almost vertical. Two obliquely-cut crystals of exactly the same wavelength were found to give the best results (Figs. 18, 19). Fig. 20 shows the resonance curve for an unsuitable gaseous discharge. Damping by immersion of the crystal in oil was found to have many disadvantages compared with the methods adopted in this work.

3732. BAND-PASS FILTER CHARACTERISTICS [Chart relating Coupling Coefficient to Band-Width passed, in terms of Q Values].—H. W. Jaderholm. (*Electronics*, July, 1936, Vol. 9, No. 7, pp. 34 and 33.)

3733. A NEW DEVICE FOR INTERFERENCE ELIMINATION AT THE RECEIVER [Description, with Critical Comments, of the Lamb "Silencer"].—K. Tetzner: Lamb. (*Funktech. Monatshefte*, July, 1936, No. 7, pp. 266–268.) *See* 3361 of September and back references. The present article is based on a paper by Granger in *All-Wave Radio* of February.

3734. ANTI-NOISE CIRCUITS [and a Gap or Neon-Tube Limiter for Static and Other Noises].—R. H. Marriott. (*Electronics*, July, 1936, Vol. 9, No. 7, p. 52.) U.S. Patent 1 836 379.

3735. PROTECTION OF RADIOTELEGRAPHIC RECEPTION AGAINST INTERFERENCE DUE TO PARASITES [based on Asymmetry of Parasites and Symmetry of Side-Bands: Device functioning only when actuated by Two Currents of Same Frequency and Phase].—Aubert, Berton and others. (French Pat. 797 805, pub. 5.5.1936: *Rev. Gén. de l'Élec.*, 25th July, 1936, Vol. 40, No. 4, p.32 D.)

3736. SUPPRESSING MAINS INTERFERENCE [Steps to be taken at the Receiving End].—J. Neale. (*Wireless World*, 21st Aug. 1936, Vol. 38, pp. 180–181.)

3737. BACKGROUND NOISE MORE OBJECTIONABLE WHEN RECEPTION LEVEL IS HIGH THAN WHEN IT IS LOW: EXPLAINED BY DIFFERENCE-PERCEPTION CURVE OF EAR.—O. Burkard. (*World-Radio*, 31st July, 1936, Vol. 23, p. 12.)

3738. HIGH-FREQUENCY OSCILLATIONS IN SODIUM LAMPS [capable of causing Radio Interference: Type A due to Positive Ions, Type B to Electrons: Suppression Methods].—L. Blok. (*Philips Tech. Review*, March, 1936, Vol. 1, No. 3, pp. 87–90.)

3739. ELECTRICAL INTERFERENCE WITH BROADCASTING: REPORT OF I.E.E. COMMITTEE.—(*Journ. I.E.E.*, August, 1936, Vol. 79, No. 476, pp. 206–212.) For comments *see* 3363 of September.

3740. THE MEASUREMENT OF "ROTATION" NOISE [in Receivers, produced by Rotation of Variable Resistances and Potentiometers].—H. Sachse and M. Bidlingmaier. (*Funktech. Monatshefte*, July, 1936, No. 7, pp. 257–259.) From the Siemens & Halske Laboratories.

3741. THE PRACTICAL CONSTRUCTION OF AN EQUIPMENT WITH AUTOMATIC CONTRAST EXPANSION ["Dynamiksteigerung"]: A PUSH-PULL POWER AMPLIFIER WITH 5 WATTS OUTPUT.—H. Lamparter. (*Funktech. Monatshefte*, July, 1936, No. 7, pp. 274–275.) For a previous article on contrast expansion *see* 1417 of April. The present paper describes a power amplifier suitable for ordinary work but with the necessary properties for use with the "expander" unit, which will be described in the following issue.

3742. THE TIME CONSTANT IN "DYNAMIC REGULATION" [Automatic Contrast Expansion: the Question of the Necessity for a Time Lag].—T. Sturm. (*Funktech. Monatshefte*, July, 1936, No. 7, pp. 260–261.)

Whereas many workers consider that there should be no time lag, the writer concludes that to alter the amplification during the course of the first period would be equivalent to introducing non-linear distortion, particularly at low frequencies. A compromise must be made; the only *perfect* solution is for the contrast control at the transmitter to have the same time constant as that at the receiver.

3743. "QUALITY" CIRCUITS [Tuning and Other Refinements] FOR THE BROADCAST RECEIVER [Silent Tuning: "Silent Sharp" Tuning: Automatic Tuning Correction: Contrast Correction].—R. Schiffel. (*Tech. Vorträge ü. Rohrenprobleme* [Supp. to *Telefunken-Röhre*, July, 1936], pp. 88–100.)

3744. REMOTE TUNING OF ULTRA-HIGH-FREQUENCY RECEIVERS: A SIMPLE METHOD USING "CONDENSOMETER" FREQUENCY CONTROL [Rotor Element of Condenser coupled to Power-Type M.C. Galvanometer].—M. W. Rife. (*QST*, August, 1936, Vol. 20, No. 8, pp. 32–33 and 64, 66.)

3745. THE END OF THE L.F. PRE-OUTPUT STAGE? [in Modern Four-Stage Superheterodynes: Should the Extra Stage be a R.F. Pre-Amplifier, a Second I.F. Stage, or a L.F. Stage?] — H. J. Wilhelmy. (*Funktech. Monatshefte*, July, 1936, No. 7, pp. 261–265.)

The writer concludes that the l.f. pre-output stage is only desirable for certain home constructors, and that the extra stage should be r.f. when high quality medium- and long-wave reception is desired, or i.f. if high sensitivity on the short waves is to be included.

3746. Diode Coupling Transformers.—F. H. Scheer. (*Rad. Engineering*, July, 1936, Vol. 16, No. 7, p. 25 : summary only.)

3747. Improving Low-Frequency Response [with Particular Emphasis on Reduction of Cabinet Resonance Effects].—R. D. Rettenmeyer. (*Rad. Engineering*, June, 1936, Vol. 16, No. 6, pp. 14–15.)

3748. Protection of Electrolytic Smoothing Condensers against Over-Voltages, by Interposition of Resistance with Large Negative Temperature Coefficient: Method of Manufacture.—" OSA " Company. (French Pat. 797 373, pub. 25.4.1936: *Rev. Gén. de l'Élec.*, 25th July, 1936, Vol. 40, No. 4, pp. 31–32 D.)

The element described, made from a mixture of titanium and magnesium oxides, has a resistance of 300 000 ohms at ordinary temperatures and only 300 ohms at the working temperature of 300–400° C. " The invention allows the voltage which can be applied to the anodes of an amplifier to be almost doubled. Similarly, it is possible to increase considerably the load on the winding of the loudspeaker."

3749. The Voltage Strain on Condensers in Mains Units [with Particular Reference to the Permissible Strain on Electrolytic Condensers, and the Protection of These from Overstrain by the Use of " Urdox " Resistances].—O. Harr and W. Wehnert. (*Telefunken-Röhre*, July, 1936, No. 7, pp. 132–145.)

3750. Theory of the Unwanted Oscillation in Back-Coupled Audion Circuits with Grid-Circuit tapped off the Oscillating Inductance.—W. Kautter. (*Telefunken-Zeit.*, July, 1936, Vol. 17, No. 73, pp. 52–57.)

" In receivers with retroaction the smallest capacity changes in the audion [leaky-grid detector] circuit make themselves so objectionable, especially on the shorter waves, because the l.f. beat note changes audibly even when the capacity change is far too small to throw the circuit out of synchronism. For this reason attempts have been made to cut down to a minimum these frequency variations which occur, particularly, when valves are changed, and with this object in view the grid has been coupled not to the full oscillatory circuit but only to a tapping on the inductance. The effect of the valve in this case naturally diminishes as the square of the step-down. But with this arrangement disappointing results have been obtained, the circuit generally displaying no inclination to oscillate at the frequency controlled chiefly by the oscillatory circuit, but oscillating at a high frequency chiefly determined by the inductance of the grid branch circuit and the capacity between grid and cathode." By the use of an equivalent circuit in the form of a three-winding transformer (the three windings representing the whole oscillating-circuit inductance coil, the part of it tapped off to the grid, and the back-coupling coil) a simple theory of this phenomenon is evolved, and the conditions found in which the unwanted frequency can be prevented from appearing. The theory confirms the experimentally found fact that the coils should be specially arranged so that the back-coupling will act as little as possible on that portion of the coil which is contained in the grid circuit: other methods of avoiding the unwanted frequency, such as the introduction of resistances, are liable to fail if conditions are slightly changed. The paper ends with a description of the curious phenomena occurring if conditions are made equally favourable for the wanted and the unwanted waves.

3751. A Novel Receiver for Phase- or Frequency-Modulated Signals [using Local Oscillator with Large " Flywheel " Effect, locking in with Received Carrier and producing a Species of Demodulation].—C. F. Wolcott. (*Proc. Inst. Rad. Eng.*, August, 1936, Vol. 24, No. 8, p. 1054: summary only.)

3752. Non-Radiating Super-Regenerative Detectors [eliminating Radiation and permitting Optimum Operating Conditions to be maintained, unaffected by Absorption of Energy by Aerial or R.F. Amplifier: Balanced-Bridge Principle].—W. E. Bonham. (*Rad. Engineering*, July, 1936, Vol. 16, No. 7, pp. 23–24 and 29.)

3753. Demonstration Model illustrating Superheterodyne Reception [at Brussels World Exhibition: Sand Figures on Slowly-Moving Belt: Cathode-Ray Oscillograph.]—H. J. J. Bouman: Wirix. (*Philips Tech. Review*, March, 1936, Vol. 1, No. 3, pp. 76–81.)

3754. Circuit Problems in the New Broadcast Receivers [Choice of Grid-Leak Values, governed by Four Effects causing Grid Current: Protecting Resistances for Output Valves (against Ultra-High-Frequency Parasitic Oscillations): Volume-Control Stages and Their Limitations: Screen-Grid Retroaction and Its Requirements, only partly Comprehended]. — F. Neulen. (*Tech. Vorträge ü. Röhrenprobleme* [Supp. to *Telefunken-Röhre*, July, 1936], pp. 80–87.)

3755. 1937 Radio Receivers [Victor " Magic Voice " (10–15 Pipes changing Phase of Sound from Rear of Cone): Fidelity Range to 6 000 c/s or over (7 200 c/s in High-Fidelity " Electrola "): Needle-Scratch Filters, and Needle Pressure reduced to 1¾ oz: Beam Power Valves: Automatic Frequency Correction: " Colorama " and " Target " Tuning: Spider's-Web All-Wave Aerial: etc.].—(*Electronics*, July, 1936, Vol. 9, No. 7, pp. 22–26.)

3756. All-Wave Super Seven [16–50 m and Ordinary Broadcast Bands: AVC and Variable Selectivity].—W. T. Cocking. (*Wireless World*, 7th, 14th and 21st Aug. 1936, Vol. 38, pp. 116–119, 141–146 and 187–188.)

3757. THE MENDE OCTODE-SUPER 278 [Four-Circuit Three-Valve Receiver designed to restore the 3-Valve Superheterodyne to Public Favour, recently Lost through Faulty Designs].—(*Funktech. Monatshefte*, July, 1936, No. 7, pp. 279–280.)

3758. THE TECHNIQUE OF THE GERMAN SUPERHETERODYNE "SUITCASE" PORTABLE RECEIVERS [Körting and Braun Models, of Widely Contrasting Design].—E. Schwandt. (*Funktech. Monatshefte*, July, 1936, No. 7, pp. 247–251). The "straight" sets were dealt with in a previous article (3008 of August).

3759. AN IMPROVED FORM OF RESPONSE-CURVE PROJECTION APPARATUS [Primarily for Loudspeakers, etc., but Applicable to Broadcast Receiver Over-All Response Measurement, by Addition of Second Stage of Heterodyning].—Reid. (*See* 3885.)

AERIALS AND AERIAL SYSTEMS

3760. THE HIGH-DIPOLE AERIAL OF THE MUNICH HIGH-POWER STATION.—R. M. Wundt. (*Lorenz Berichte*, May, 1936, No. 2, pp. 3–11.)

Comparison of the results given in a previous paper (3033 of 1935) with the vertical radiation characteristics given by the aeroplane tests dealt with in 2276 of 1935: potential and current distribution, and the efficiency of the high dipole (variation with characteristic impedance and mast height): economic influence of mast height.

3761. RADIATION DIAGRAMS OF AERIALS [Graphical Method of calculating Electric Field of an Aerial of Any Form with Any Current Distribution].—P. Benussi. (*Alta Frequenza*, August, 1936, Vol. 5, No. 8, pp. 504–511.) Even when the current distribution cannot be represented by analytical methods.

3762. "AERIAL TERMINAL CALCULATIONS: TECHNICAL PAPER No. 10" [Book Review].—Marconi Company. (*Electrician*, 14th Aug. 1936, Vol. 117, p. 193.)

3763. NEW CONCENTRIC-TUBE TRANSMISSION SYSTEM FOR BROADCAST TOWER LIGHTING, AVOIDING NEED OF FILTERS.—Bell Laboratories. (*Electronics*, July, 1936, Vol. 9, No. 7, p. 38.)

3764. LONG DISCHARGE TUBES AS TRANSMISSION LINES WITH CONTROLLABLE VELOCITY OF VOLTAGE WAVE.—Snoddy & others. (*See* 3685.)

VALVES AND THERMIONICS

3765. RECEIVING-VALVE NOISE IN THE REGION OF 150 kc/s TO 15 Mc/s.—H. Rothe and G. Plato. (*Telefunken-Röhre*, July, 1936, No. 7, pp. 94–108.)

"In the course of recent years a number of papers on valve noises have been published. Most of them have dealt with the noise in the a.f. region or with researches on isolated parts of the problem, such as the influence of space charge on the noise, the noise due to secondary emission, and so on. Up to the present, however, there have been no investigations on the h.f. noise of the new receiving valves, from which one could obtain the absolute values of the noise and the effect of the various working parameters (potentials, currents, frequencies and so on) for the types in most common use. In the following paper the results of such measurements on a large number of different valves are given. By a discussion of the experimental results an attempt is also made to elucidate the physical causes of the noise. A list of references to the most important papers already published is given at the end."

The following four possible causes of the total noise are dealt with:—shot effect, scintillation, insulation noises, and ion formation by residual-gas ionisation. The parts played by each of these are traced by systematic measurements of the total noise as a function first of the anode current, then of the anode and screen-grid voltages, of the heating voltage, and finally of the frequency. Scintillation effect is ruled out as a cause of h.f. noise because the former varies very markedly with frequency (it is actually only noticeable below about 5000 c/s) whereas no important frequency dependence is found for the latter anywhere in the three frequency ranges 150–300, 600–1500, and 6000–15 000 kc/s. Only in certain valves, *e.g.* a directly heated h.f. pentode, was there a slight increase in noise for frequencies above 2 Mc/s, amounting to 30–40% at 15 Mc/s: the cause of this is not yet fully understood. Ionisation noise and insulation noise are also excluded, since such effects would be bound to vary with the working voltages on grid and anode: no such voltage dependence of the noise was observed. This statement, however, must be qualified by the remark that the measurements were, throughout, made with the control grid short-circuited, so that any failure of control-grid insulation would be unable to make itself evident; insulation noise, therefore, is ruled out definitely only as regards anode and screen-grid insulation.

Shot effect is thus left as the greatly predominating cause of the noise. This conclusion is supported by the curves of noise-voltage variation with anode current and with heating current, and also by an auxiliary test (Fig. 9) on the noise-voltage of an indirectly heated h.f. pentode as a function of the time during which the cathode was heating up, in the first place when the heating current was switched on with the valve at room temperature and in the second place when it was switched on with the whole valve immersed in liquid air (−180°C). The two curves show the expected displacement in time, but no difference in shape, so that shot effect alone is seen to be the cause of the noise, since any insulation or ionisation effects would have been affected by the cooling.

The paper ends with a table showing the results (averaged over a number of samples) for different types of triode and pentode. Directly heated cathodes give better results than indirectly heated, and triodes rather better results than pentodes. The differences are generally small, and no definite reason for them is known. Possibly a static fluctuation of the current distribution may explain the increased noise in screen-grid valves. Secondary emission at the screen grid or the anode appears *not* to be the cause, according to Ziegler, 2190 of June (continued in 2618 of July). The writers point out that in actual receivers a number of other types of noise appear, such as those due to the presence of a carrier wave and the noise phenomena in mixing valves. "Theoretically no new problems are involved in these cases, but they will be dealt with in detail in a later paper."

The writers, at the end of their discussion of valve noise as a function of anode current (pp. 98–101), make use of an equivalent circuit for a thermionic valve which differs from the usual equivalent circuit in that the valve is represented as a generator delivering a constant *current* $S \cdot e_g$ to the parallel combination of R_a and R_i. This circuit is preferable when considering valve noise.

3766. Investigation of the Electron-Path Curves in the Magnetron [including Four-Segment and Eccentric-Cathode Types].—M. Grechowa. (*Tech. Phys. of USSR*, No. 7, Vol. 3, 1936, pp. 633–640: in German.)

Further development of the work with the fluorescent-spot model dealt with in 1786 of May (the author's footnote reference is untraceable). "Besides the electrons with simple path curves there are those which reach the anode after making more than one revolution round the cathode. For the investigation of these complicated paths the model already described was modified by an addition (Fig. 1). The existing rotatable, air-tight tapered plug B_1 carrying the cathode was supplemented by a second, similar plug B_2 carrying four screens—a_1, a_2, a_3 and a_4—consisting of glass frames strung over with fine glass threads coated with a fluorescent salt. By twisting the plug B_2 the electron-path curves were followed by means of the luminous spot on the screens. The observation is made easier if the axis is slightly inclined to the magnetic field, so that the path curves are no longer flat: a slight inclination has no marked effect on the number of revolutions.

"In the previous paper only the electrons with simple path curves, emerging from the cathode within the limiting angle a_3 (*loc. cit.*) were considered, and the characteristic curves made from the results were found to resemble the usual static characteristic of the split-anode magnetron. It is clear, however, that the amplitudes and available powers of magnetrons must depend also on the behaviour of the other electrons, emerging from the filament within the angle a_2 [*see* Figs. 5 and 12, and the previous paper]: to increase the amplitudes and available output it is necessary that the greater part of these electrons should arrive at the anode with as low a potential as possible. The model tests show that for certain values of magnetic field and anode voltage, more electrons with complicated paths do actually arrive with lowered potential at the anode, increasing the falling part of the characteristic and bringing the characteristic curve closer to the characteristic of an actual magnetron."

By suitable design of the electrodes the path lengths of the complicated-path electrons may be reduced. The various methods are (1) use of a four-segment anode, (2) eccentric displacement of the cathode parallel to the anode axis, (3) special shape of anode, and (4) anode "end-plates" (*see* Linder, 2611 of July). The writer gives the results of his investigations of four-segment and eccentric-cathode models. With the four-segment anode the complicated curves are simpler than those with the two-segment anode. All, or at any rate by far the majority, of the complicated-path electrons circle less than twice round the cathode, so that their paths are shorter (Fig. 7: Figs. 5 and 6 give the simple path curves only, for two values of magnetic field: Fig. 5 also shows the emergence angle of the complicated-path electrons). The $I_a = f(\Delta V)$ curves derived from the model tests resemble the static characteristic of an actual four-segment magnetron. Figs. 8 and 9 show the static characteristics of a four-segment magnetron (Fig. 8) and of the same magnetron with its segments connected so as to form a two-segment magnetron (Fig. 9): they show that the slope of the two-segment tube is steeper than that of the four-segment type.

The remaining figures illustrate the results with an eccentric cathode: the investigation was carried out with a model provided with a corrugated glass extension which was sufficiently flexible to allow the cathode to be displaced from its coaxial position. The complicated curves of the eccentric type of magnetron are simpler than those of the symmetrical type, and the electrons reach the anode after a shorter journey. Only for high magnetic fields (four times the critical value) do multi-revolution curves occur such as that shown in Figs. 15 and 16. Such a shortening of path should help towards the very desirable practical end of decreasing the necessary working voltages.

3767. Discussion on "The Action of a Split-Anode Magnetron."—Gill and Britton. (*See* 3722.)

3768. Magnetron Oscillators for the Generation of Frequencies between 300 and 600 Megacycles [Negative-Resistance Type: including a 50 Watts Output Design (at 550 Mc/s) with Heavy Copper Oscillating Circuit (Carbonised to increase Heat Radiation) included in Bulb and Inductively Coupled to Outside Transmission Line: and a Similar Water-Cooled Design for 100 Watts Output at 600 Mc/s, Conductively Coupled: Efficiencies: Limitations].—G. R. Kilgore. (*Proc. Inst. Rad. Eng.*, August, 1936, Vol. 24, No. 8, pp. 1140–1157.) The full paper, a summary of which was referred to in 2964 of 1935.

3769. Smallest Tube [Retarding-Field Valve with 0.5 and 0.2 mm Inside Diameters of Electrodes: Wavelength 1 cm].—Chao-Ying Meng. (*Electronics*, July, 1936, Vol. 9, No. 7, p. 42: photograph and caption only.)

3770. Input and Output-Resistance of Thermionic Valves at High Frequencies [Transit-Time Effects above 1 Mc/s].—H. Rothe. (*Tech. Vorträge ü. Röhrenprobleme* [Supp. to *Telefunken-Röhre*, July, 1936], pp. 101–103.) As regards mutual conductance, its magnitude is independent of frequency up to at least 100–300 Mc/s, but at high frequencies it is a complex quantity, since the anode a.c. has a phase lag behind the grid a.c. potential which at 30 Mc/s already amounts to some 10°–20°.

3771. Some General Relations of Vacuum Tube Electronics [Transit-Time Effects], illustrated by Current Distributions in Tubes with Plane Electrodes.—W. E. Benham. (*Wireless Engineer*, August, 1936, Vol. 13, No. 155, pp. 406–413.)

Introduction (including the part played by electron inertia in the passage of light through thin metallic films, in the dispersion of electromagnetic waves in a refractive medium, and in valves): an impedance theory applicable to valves and condensers: application to vacuum tubes. For the papers referred to in the text *see* Abstracts, 1928, pp. 224 and 288 (Benham); 1449 and 1450 of April (Ferris: North); 1931, p. 143 (Hartree); 1390 and 3374 of 1935 (Bakker & de Vries); 552 of February (Llewellyn); also (in footnote to p. 407) Abstracts, 1931, p. 212 (Benham) and 1933, p. 568 (Protze).

3772. The Space-Charge Equation for Electrons possessing Initial Velocity [Integration of Poisson's Equation: Calculation of Potential and Current Distribution: These show Sudden Changes when the Total Current is Varied: Bearing on Calculation of Characteristics of Multiple-Grid Valves].—G. Plato, W. Kleen and H. Rothe. (*Zeitschr. f. Physik*, No. 7/8, Vol. 101, 1936, pp. 509–520.)

3773. The Development of Large Radio Transmitting Valves [including the C.A.T.15, Water-Cooled, for Max. Input of 3.75 kW at 3 m and 2 kW at 2 m: Air-Cooled-Anode Valves: Dull-Emitter Cathodes: Binocular-Anode Rectifiers].—R. Le Rossignol and E. W. Hall. (*G.E.C. Journal*, August, 1936, Vol. 7, No. 3, pp. 176–190.)

3774. The Amplifying Properties of the High-Frequency Pentode.—W. Kleen and H. Rothe. (*Telefunken-Röhre*, July, 1936, No. 7, pp. 109–131.)

Previous papers (147 of January and 2630 of July), on the calculation of S, R_i and μ for triodes and pentodes, have shown how the two types differ fundamentally as regards these values. This difference must, of course, show itself in the behaviour of the valves as amplifiers. After recapitulating the previous results, the writers examine the amplifying properties of the h.f. pentode, beginning with the case of the "fully coupled circuit without regard to selectivity" (flywheel circuit, of resonance resistance R_p directly across anode and cathode, as load resistance), continuing with the tapped-down anode circuit, again without regard to selectivity. In each section the equivalent case for the triode is compared. The writers then point out that for the triode as h.f. amplifier it is generally undesirable, for reasons of selectivity, to use the classic matching condition $R_i = \ddot{u}^2 R_p$ giving maximum amplification (where $\ddot{u}$ is the percentage of coupling): a weaker coupling has to be employed, with consequent loss of amplification. Although, theoretically, the same matching condition gives maximum amplification for the pentode also, this maximum can never be reached in practice, since for sufficiently small currents R_i is always greater than R_p, and $\ddot{u}$ can never exceed unity. The maximum amplification for a h.f. pentode is given when $\ddot{u} = 1$ (no tapping-down) and $R_i = 2\,R_p$ (eqn. 5). This, however, is without regard to selectivity, and the writers now consider whether, for reasons of selectivity, this condition must be departed from on lines similar to those for the triode. It is obvious that consideration of the selectivity-diminishing effect of the internal resistance of a pentode is only necessary when this resistance is of the same order as, or smaller than, the resonance resistance of the flywheel circuit. This is not the case in the average mains-driven receiver; but in battery receivers using directly heated h.f. pentodes with quite low anode voltages, and in many other cases, the point is of considerable importance. The analysis on pp. 120–123 leads to the general conclusion that no tapping-down is desirable for h.f. pentodes.

Regarding their results on the behaviour of the pentode as h.f. amplifiers, the writers remark that they appear at first sight somewhat surprising. "The physical cause of these effects is the independence of slope and internal resistance in multi-grid valves, dealt with in [2630 of July], which in the pentode has the result that not only the amplification factor μ but also the [Barkhausen] 'figure of merit' $S \,.\, \mu$ increases with decreasing current and constant anode voltage (see Figs. 2 and 3). Actually this rule holds good only within definite limits, but these are widely spaced."

A short section (B) deals with aperiodic amplification with ohmic external resistances; here also the pentode differs from the triode in optimum working conditions. The treatment really applies only to l.f. amplification, since with amplification of very wide frequency bands the external resistances must be kept so small that the calculation does not hold good. The problem considered is the determination of the anode current for maximum amplification, for an external resistance limited by the permissible frequency-variation of amplification and for a given available d.c. voltage. The final section (C) considers the application of pentodes to that scheme of d.c. voltage amplification which makes fullest use of the valve amplification factor by employing a valve as external resistance. The single stage shown in Fig. 15 gives an amplification of 8000—"the highest ever reached in one stage"; and although a still greater amplification could be obtained by making the two h.f. pentodes into two ordinary stages, the circuit has the distinct advantage of being remarkably economical in batteries. It is also of interest as indicating the maximum μ of a pentode (in this case an AF7 at 125 volts): $\mu_{max} = 16\,000$.

3775. The Recent Improvements in Vacuum Tubes.—Decaux. (*Ann. des Postes, T. et T.*, July, 1936, Vol. 25, No. 7, pp. 665–684.) *See* 3062 of 1935.

3776. Remarks on the Valve Programme of the Year 1936/37.—K. Steimel. (*Tech. Vorträge ü. Röhrenprobleme* [Supp. to *Telefunken-Röhre*, July, 1936], pp. 1–5.)

3777. "Critical Distance" Tubes [Corrections and Additions].—J. O. Harries. (*Electronics*, July, 1936, Vol. 9, No. 7, p. 48.) *See* 3025 of August.

3778. THE NEW HIGH-POWER OUTPUT VALVES AD1, AL4 AND CL4 [Anode Dissipations 15, 9 and 9 Watts: Triode (4-Volt), Pentode (4-Volt) and Pentode (33-Volt), respectively].—Th. Tillmann. (*Tech. Vorträge ü. Röhrenprobleme* [Supp. to *Telefunken-Röhre*, July, 1936, pp. 37–68.)

3779. NEW OUTPUT VALVES WITH STEEPER SLOPE [AD1 Triode and AL4 & CL4 Pentodes].—E. Schwandt. (*Funktech. Monatshefte*, July, 1936, No. 7, pp. 243–246.)

3780. OUTPUT VALVE PROBLEMS [Survey].—W. Kleen. (*Tech. Vorträge ü. Röhrenprobleme* [Supp. to *Telefunken-Röhre*, July, 1936], pp. 6–36.)

3781. THE BATTERY-DRIVEN OUTPUT STAGE WITH KC3 [Triode Driver] AND KDD1 VALVES [Push-Pull Two-Triode Valve with Paralleled Cathodes and Separately Led-Out Grids and Plates].—J. E. Scheel. (*Tech. Vorträge ü. Röhrenprobleme* [Supp. to *Telefunken-Röhre*, July, 1936], pp. 69–79.)

3782. METAL TUBES [Résumé of Type Numbers and Purposes, with References to Data].—(*QST*, August, 1936, Vol. 20, No. 8, pp. 18 and 70.)

3783. THE METAL VALVES AND OTHER NEW VALVE DEVELOPMENTS [Hurried Development of American All-Metal Valve and its Consequent "Infantile Ailments": Remarks on Electron Multipliers and on the Renode of Schleimann-Jensen].—K. Steimel. (*Tech. Vorträge ü. Röhrenprobleme* [Supp. to *Telefunken-Röhre*, July, 1936], pp. 104–109.)

3784. MIXING-TUBE AMBIGUITY.—Wilhelm. (*Electronics*, July, 1936, Vol. 9, No. 7, pp. 50 and 52.) Long illustrated abstract of the German paper dealt with in 2579 of July.

3785. THE "KIPPSCHWING" VALVE [Special Hydrogen-Filled Tube with Long Indirectly Heated Cathode and Coaxial Grid with One Slot only].—Drewell. (*See* 3730.)

3786. THE POLAROID STRAIN DETECTOR [Internal Strains in Valve Bulbs, etc., detected by Polaroid Glass].—E. H. Land. (*Rad. Engineering*, June, 1936, Vol. 16, No. 6, pp. 23–24.)

3787. INDIRECTLY HEATED CATHODES [and the Technique of Manufacture].—G. D. O'Neill. (*Rad. Engineering*, June, 1936, Vol. 16, No. 6, pp. 8–11.) From the Hygrade Sylvania Corporation.

3788. THE EMISSION IMAGES OF THORIATED TUNGSTEN AND THORIATED MOLYBDENUM. PART III.—COMPARISON OF THE FUNDAMENTAL PHENOMENA OF THORIATED TUNGSTEN AND THORIATED MOLYBDENUM.—Brüche and Mahl. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 17, 1936, pp. 262–266.)

For Parts I and II *see* 1804 of May. The present work deals in a similar way with thoriated molybdenum and shows that the previous conclusions as to the behaviour of the thorium are not limited to thoriated tungsten but apply equally well when that carrier metal is replaced by another metal with a similar high melting point. The spreading of the thorium from its "emission points" takes place with a velocity which depends on the carrier material (it is higher with molybdenum than with tungsten) and increases quickly with the temperature. The activated surface is deactivated by bombardment with positive ions or (in the case of tungsten) by incandescence.

3789. THE EFFECT OF TEMPERATURE, DEGREE OF THORIATION AND BREAKDOWN ON FIELD CURRENTS FROM TUNGSTEN AND THORIATED TUNGSTEN.—A. J. Ahearn. (*Phys. Review*, 1st Aug. 1936, Series 2, Vol. 52, No. 3, pp. 238–253.)

"Electron field currents from thoriated tungsten, with different degrees of thoriation, were found to be independent of temperature. The characteristic field current curve was found to be independent of the degree of thoriation." An electrical breakdown with sudden enormous increases of current was found to occur with thoriated tungsten and pure tungsten cathodes. Investigation of this breakdown under various conditions favoured the conclusion that "the electric field applied to the cathode rather than the applied voltage is the more important factor in producing breakdown. The anode has no effect on the breakdown. When the shielding of glass surfaces is adequate, the breakdown is determined primarily by conditions at the cathode." "The suggestion is made that breakdown involves a rupturing of the cathode surface under the action of local heating and mechanical strain associated with the electric field."

3790. ERRATUM: HEAT CONDUCTIVITY OF TUNGSTEN AND THE COOLING EFFECTS OF LEADS UPON FILAMENTS AT LOW TEMPERATURES [Correct Form of Equation].—Langmuir and Taylor. (*Phys. Review*, 15th July, 1936, Series 2, Vol. 50, No. 2, p. 190.) *See* 3413 of September.

3791. THE THERMAL CONDUCTIVITY OF TUNGSTEN [measured by applying Theory of Heat Losses from Electrically Heated Wire supported by Springs].—W. C. Michels and Martha Cox. (*Physics*, April, 1936, Vol. 7, No. 4, pp. 153–155.)

3792. INELASTIC SCATTERING OF ELECTRONS FROM SOLIDS [such as Films of Ba or BaO on Ag: Measurements of Energy Distribution of Scattered Electrons provide Sensitive Tool for Study of Surfaces], *and* THEORY OF INELASTIC SCATTERING OF ELECTRONS FROM SOLIDS.—E. Rudberg: E. Rudberg and J. C. Slater. (*Phys. Review*, 15th July, 1936 Series 2, Vol. 50, No. 2, pp. 138–150: pp. 150–158.)

3793. THE DETERMINATION OF THE COEFFICIENT OF [Thermal] ACCOMMODATION FROM ASPECTS OF THE TEMPERATURE-DROP EFFECT [between Heated Wire and Adjacent Gas].—H. S. Gregory. (*Phil. Mag.*, August, 1936, Series 7, Vol. 22, No. 146, pp. 257–265.)

3794. THE ENERGY DISTRIBUTION OF SECONDARY ELECTRONS FROM COLUMBIUM.—L. J. Haworth. (*Phys. Review*, 1st Aug. 1936, Series 2, Vol. 50, No. 3, pp. 216–219.)

3795. THE RESISTANCE AND THERMOELECTRIC PROPERTIES OF THE TRANSITION METALS [Pd, Pt: Alloys with Au, Ag: Ferromagnetics: Explanations in Terms of Quantum Theory].—N. F. Mott. (*Proc. Roy. Soc.*, Series A, 17th Aug. 1936, Vol. 156, No. 888, pp. 368–382.)

DIRECTIONAL WIRELESS

3796. THE NAVIGATION BY RADIO OF THE AIRSHIPS GRAF ZEPPELIN (LZ 127) AND HINDENBURG (LZ 129).—Wittemann and Pruss. (*Telefunken-Zeit.*, July, 1936, Vol. 17, No. 73, pp. 47–52.)

Owing to the present impossibility of using Adcock aerials on aircraft, the long-wave transmitters of the airships have been provided with pulse equipment to eliminate errors due to night effect: "It is therefore most necessary that ground stations on their route should be provided with the pulse d.f. equipment [with cathode-ray tube] which proved so successful in tests at certain German ground d.f. stations. . . ." The Telefunken target-flight direction finders are discussed, and the writers then deal with the three types of error in d.f. reception on board—quandrantal error (reduced by electrical compensation from 20° to 0.5°); "dipole" error (arising when the airship is not horizontal and is therefore excited by the field of the station whose bearing is being taken, and re-radiates on to the loop aerials: it is worst on the natural wavelength of the airship—around 500/600 m—and until a satisfactory method of compensation has been found it will be necessary to keep the airship horizontal while taking a bearing); and night effect. This last is not so serious for d.f. on board as it is for land stations taking the bearing of the airship, for (particularly over sea) the ground wave at the travelling height of the airship is stronger in comparison with the troublesome space wave. It does, however, come seriously into question when over land near a coast, or along valleys, and it is worst for c.w. reception and in the east-west direction. Its elimination needs further research. The paper ends with a description of fog-landing arrangements. For other wireless equipment of the Hindenburg *see* 3944, below.

3797. OPTICO-ELECTRIC "DETECTING TRIANGLE" AND SOUNDING APPARATUS [for Aircraft: Vertical Beam (of Visible or Invisible Rays) directed towards Earth, producing Spot which is detected by Photocell].—Schlesinger and Haefner. (French Pat. 796 674, publ. 11.4.1936: *Rev. Gén. de l'Élec.*, 25th July, 1936, Vol. 40, No. 4, p. 29 D.)

3798. SONIC MARKER BEACON FOR FOG AVIATION *and* THE SONIC LOCATOR: AN AID TO FOG NAVIGATION.—C. W. Rice. (*Journ. Acous. Soc. Am.*, July, 1936, Vol. 8, No. 1, pp. 26–29 and 30–33.) Working on frequencies between 2000 and 4000 c/s.

3799. PAPERS ON THE DIRECTION FINDING OF SOURCES OF ATMOSPHERICS.—(*See* under "Atmospherics and Atmospheric Electricity.")

ACOUSTICS AND AUDIO-FREQUENCIES

3800. ON THE FREE VIBRATIONS OF A CIRCULAR PLATE SUPPORTED AT THE EDGES WITH FRICTION.—G. Ostroumov. (*Tech. Phys. of USSR*, No. 7, Vol. 3, 1936, pp. 583–598: in German.)

"But all these investigations [Goldhammer, etc.] are of only slight importance for the acoustic development of musical instruments with a flat sound board, because measurements made on such instruments [by Ugolnikov, at present unpublished] give the following results:—(1) Along a dry board the extinction of the flexural wave is vanishingly small; (2) the radiation damping of a whole sounding board is very small compared with its actual damping; (3) an actual sounding board vibrates as a plate which is not clamped at the edges but only supported (at any rate for medium and low frequencies); and (4) at this supported edge a large amount of vibrational energy is consumed. An actual sounding board therefore vibrates like a plate which is not free at the edges but is supported there with friction, and which is acted on by vanishingly small surface and extinction forces. The friction must be regarded as a moment which opposes, at the edges, the tiltings of the plate." It is these edge forces, hitherto neglected, which are particularly investigated in the present analysis of the simplest case (that of a circular plate); two new quantities, the "torsional impedance" (Drehimpedanz) of the edge attachment (page 585) and the "flexural-wave impedance" (p. 586). The paper ends with a discussion of the mathematical results from a physical standpoint. For a previous paper *see* 1483 of April.

3801. THE CALCULATION OF THE VIBRATION FORMS OF A CIRCULAR PLATE WHICH IS SUPPORTED AT THE EDGE WITH FRICTION AND IS EXCITED AT ITS CENTRE.—G. Ostroumov. (*Tech. Phys. of USSR*, No. 7, Vol. 3, 1936, pp. 599–603: in German.)

Prompted by remarks in Schünemann's paper (592 of February) as to limitations of theoretical treatment and the necessity for experimental data, the writer deals mathematically with the problem given in the title—"an example of greater importance in the design of musical instruments than the centre-fixed plate" considered by Schünemann. The method is similar to that described in the preceding paper (3800, above). It is seen that a sudden phase-change can only occur when Z_1, the "torsional impedance" of the edge attachment, is wholly imaginary: *i.e.*, when energy losses are absent.

3802. A COMPOUND HORN LOUDSPEAKER [Smooth Uniform Response from 50 to 9000 c/s by Single Mechanism coupled to Straight-Axis High-Frequency Horn and Folded Low-Frequency Horn: Efficiency around 50% over Large Part of This Range].—H. F. Olson and F. Massa. (*Journ. Acous. Soc. Am.*, July, 1936, Vol. 8, No. 1, pp. 48–52.)

3803. Investigations on the Elastic Vibration of Piezo-Crystals of Rochelle Salt.—Michailov. (*See* 3895.)

3804. Theory of the Loudspeaker and of Mechanical Oscillatory Systems: Part I.—H. Roder. (*Rad. Engineering*, July, 1936, Vol. 16, No. 7, pp. 10–12 and 22.)

3805. Note on the Functioning of Electro-dynamic Loudspeakers.—N. Mezey. (*L'Onde Élec.*, August, 1936, Vol. 15, No. 176, pp. 487–497.)

"A m.c. loudspeaker fed by a multi-electrode valve and a coupling transformer constitutes a combination of which certain physical properties are not generally known. By a simple calculation we shall give a general notion of the mode of action of the diaphragm and of the effect of its electro-mechanical properties. We shall show that the load which it constitutes varies with the frequency, and that these variations are important in the neighbourhood of mechanical resonance. We shall also show that the difference of phase between the voltage applied to the valve grid and the oscillations of the membrane [measured by J, the axial displacement] presents also important variations as a function of frequency. We shall establish simple formulae permitting the design of the transformer." The practical conclusion is that the resonant frequency of the diaphragm should be below the limit of audibility. "This end is reached by the construction of membranes of large mass (large diameter) with very supple suspensions. The mass of the diaphragm being limited by other conditions, it is the suspension which must be very carefully studied. The use of divided and multiple diaphragms also diminishes the effect of resonance. The employment of an absorption circuit, tuned to the mechanical resonance of the diaphragm and connected in the grid circuit of the valve, may also be recommended; this, however will not avoid the phase displacement between different frequencies."

3806. Loudspeaker Measurements.—F. Massa. (*Electronics*, July, 1936, Vol. 9, No. 7, pp. 18–21 and 56.) Power-handling capacity (mechanical strength, temperature rise, harmonic distortion, sub-harmonics): efficiency (integrated acoustic output method, reverberation chamber method, motional impedance method): response/frequency characteristics (reflection errors, close-up errors, indoor response curve errors due to reflection, outdoor response curves): references.

3807. An Improved Form of Response-Curve Projection Apparatus [Applicable to Loudspeaker Testing and Analysis of Complex Wave-Forms].—Reid. (*See* 3885.)

3808. On the Subject of Acoustic Relief [Stereophonic Reproduction at Brussels Exhibition].—Besson: Divoire. (*L'Onde Élec.*, August, 1936, Vol. 15, No. 176, pp. 485–486.)

For Besson's editorial on stereophonic broadcasting *see* 2214 of June. He has now received, from Divoire, details of the Brussels demonstrations in which three microphones facing the orchestra in a studio were connected by separate lines to three loudspeakers on the stage of the great "Auditorium de l'Alberteum." "The perspective effect was so good that part of the audience, not in the secret, were deceived up to the moment when the curtain in front of the stage was raised." Among the various conclusions the following are quoted:—(a) The sensation of distance, or depth, depends above all on the sensation of intensity noted by the memory. Not at all marked for impressions which succeed each other, the effect is notable for *simultaneous* impressions. (b) The angular sensation depends naturally on the difference of phase of the sounds reaching the two ears, but much more still on their difference in *intensity*. (c) It is necessary to reduce the sound intensity transmitted by the central channel (it was regulated to about 10 db below the right and left channels). (d) It is of advantage to space the loudspeakers more widely than the microphones (this naturally increases the effect of relief). (e) It is essential that each channel should have characteristics as perfect as possible, and in any case strictly identical. Any defect in one channel leads to the attention being concentrated on the others, with consequent loss of perspective effect.

3809. Loudspeakers at the Olympic Games [Berlin].—(*Wireless World*, 7th Aug. 1936, Vol. 38, pp. 120–121.)

3810. The Electro-Acoustic Installation of the Berlin Olympic Stadium.—U. Brusaferro. (*Alta Frequenza*, August, 1936, Vol. 5, No. 8, pp. 525–534.)

3811. Individual Loudspeakers quieten "Drive-In" Theatres [Cars parked with Radiators almost touching Loudspeaker Cone, Sound transmitted through Dashboard].—(*Sci. News Letter*, 1st Aug. 1936, Vol. 30, p. 76.)

3812. Public Address Equipment Type V 35 [as used at the Winter Olympic Games at Garmisch-Partenkirchen].—K. Hallen. (*Lorenz Berichte*, May, 1936, No. 2, pp. 13–18.)

3813. New Method of Modulating an Electrical Current, specially applicable to Sound-Reproducing Apparatus [Resistance-Variation of Film of Conducting Liquid between Foot of Glass Tube and Nearly-Touching Glass Plate].—L. and P. Nogier. (French Pat. 797 593, pub. 29.4.1936: *Rev. Gén. de l'Élec.*, 25th July, 1936, Vol. 40, No. 4, p. 32 D.)

3814. On Distortion in Sound Reproduction from Films.—M. V. Laufer. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 6, 1936, pp. 1064–1070.) A further analysis of the distortion (*see* 2672 of July) due to uneven illumination of the scanning slit. Certain conclusions following from these two papers are stated.

3815. The Effect of the Slanting Position of the Slit in the Intensity System [of Sound-on-Film Recording or Reproduction: Simple Derivation of Formula].—P. Schrott. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 17, 1936, pp. 275–276.) The formula given by Fischer & Lichte in their book "is correct but rather complicated and not very illuminating, since the influence of the slit width, which is here of no importance, is included." For Narath's work on the distortion due to the slant of the reproducing slit, for various recording systems, *see* 1934 Abstracts, pp. 565–566.

3816. The "Double-Note" Method of Distortion Measurement and Its Application to Sound Films [including a Survey of the Various Types of Distortion in the Photographic Processes of Sound-on-Film Work].—A. Narath. (*Telefunken-Zeit.*, July, 1936, Vol. 17, No. 73, pp. 57–68.)

Author's summary:—What is called the "double-note" method of distortion measurement is the process of investigating non-linear distortion by measuring the combination-tone strengths of two primary tones of different frequencies which are fed into the distorting system. . . . Formulae are derived for the calculation of overtones and combination tones for any shape of characteristic curve, and various possible definitions are critically examined [such as the "combination-tone factor" and "distortion factor" suggested by Graffunder, Kleen & Wehnert, 1051 of March, and the "difference-tone factor" of von Braunmühl, 456 of 1935]. In the practical carrying out of the double-note method the final working-out can be done either by an electrical or by a photometric procedure, provided that the double notes are recorded on some carrier [*e.g.* on film: when only an amplifier or a microphone is to be tested, no such record would probably be made and the measurement would be carried out by the procedure developed by von Braunmühl]. For photographic investigations the photometric method is greatly to be preferred, since it gives absolute values.

3817. New Possibilities of Sound-on-Film Recording by the Multi-Band Reproducer [with from Two to Ten Component Sound-Film Records delivering to Mixing Desk and thence to Sound Camera].—(*Funktech. Monatshefte*, July, 1936, No. 7, Supp. pp. 51–53.)

3818. Filtration of Elastic Waves in Solid Rods with Membranes as Side Branches.—Lindsay and Barnes. (*Journ. Acous. Soc. Am.*, July, 1936, Vol. 8, No. 1, pp. 42–47.) The full paper, a summary of which was dealt with in 3462 of September.

3819. Mechanical Vibrations at Radio-Frequencies [Chladni Figures up to 80 kc/s by Magnetostrictively Driven Plates].—R. C. Colwell and L. R. Hill. (*Journ. Acous. Soc. Am.*, July, 1936, Vol. 8, No. 1, pp. 60–61.) *See* also 1855 of May and back references.

3820. Musical Instruments and Acoustical Science [New Electronic Instruments should wait for Composers to write for Them and for Players to master Their Technical Peculiarities].—W. B. White. (*Journ. Acous. Soc. Am.*, July, 1936, Vol. 8, No. 1, pp. 62–63.)

"A violin is not a violin in its effects if it cannot give us, not only the Fourier harmonics proper to its strings, but the non-harmonic partials that arise out of the bowing, the way of applying the pressure upon the string, and so on. These 'noise elements' (as in fact they are) certainly detract from the pure acoustical value of the violin; but they are part of its musical 'atmosphere' which the human ear has come to expect . . ."

3821. The Hammond Organ [using Series of E.M.Fs corresponding to Overtones of Any Note with Intensities regulated by Resistances, thus imitating Any Musical Instrument: Short Note on Tonal Qualities and Mechanism].—J. Barrett. (*Nature*, 15th Aug. 1936, Vol. 138, p. 297.)

3822. Systematic Investigations on Tubes excited to Resonance, with the Help of a New Method of Measurement [Fine Hole in Closed End forms Air Jet impinging on Thermocouple].—V. Hardung. (*Helvetica Phys. Acta*, Fasc. 5, Vol. 9, 1936, pp. 341–366: in German.)

3823. Psychophysiological Acoustics: Pitch and Loudness.—S. S. Stevens and H. Davis. (*Journ. Acous. Soc. Am.*, July, 1936, Vol. 8, No. 1, pp. 1–11.) With an appendix on electrical relations within the cochlea, pp. 12–13.

3824. Change of Pitch with Loudness at Low Frequencies [Experimental Data on 9 Observers: Conclusions: Equipment and Technique].—W. B. Snow. (*Journ. Acous. Soc. Am.*, July, 1936, Vol. 8, No. 1, pp. 14–19.)

3825. The Influence of Intensity on the Pitch of Violin and 'Cello Tones.—D. Lewis and M. Cowan. (*Journ. Acous. Soc. Am.*, July, 1936, Vol. 8, No. 1, pp. 20–22.)

3826. Certain Subjective Phenomena accompanying a Frequency Vibrato.—W. E. Kock. (*Journ. Acous. Soc. Am.*, July, 1936, Vol. 8, No. 1, pp. 23–25.)

3827. Sound Waves and the Auditory Sensation [Wave Forms not the Same: Auditory Sensation builds up during about 10 Waves, and decays (after Cessation of Sound) taking about 0.3 Second: etc.].—R. Taguti. (*Jap. Journ. of Physics*, March, 1936, Vol. 11, No. 1, Abstracts p. 12.)

3828. Rearranging Speech Spectra for Tactile Recognition, *and* Studies of the Vibro-Tactile Senses as Means for Determining Direction.—L. D. Goodfellow: R. H. Gault. (*Journ. Acous. Soc. Am.*, July, 1936, Vol. 8, No. 1, p. 65: summaries only.)

3829. A NON-DIRECTIONAL MICROPHONE [Moving-Coil Spherical Design with Screen].—R. N. Marshall and F. F. Romanow. (*Bell S. Tech. Journ.*, July, 1936, Vol. 15, No. 3, pp. 405–423.) A short note on this microphone was dealt with in 200 of January. The present paper includes an appendix on the theory of the moving-coil microphone and its equivalent circuit.

3830. MATHEMATICAL CONTRIBUTION TO THE EXPLANATION OF SPONTANEOUS MICROPHONE VARIATIONS.—G. Kretschmer. (*E.N.T.*, June, 1936, Vol. 13, No. 6, pp. 198–205.)

Waetzmann & Kretschmer have already put forward an explanation of spontaneous periodic microphone variations (3448 of September); here a mathematical treatment is attempted, which, however, discusses only the effect of the temperature conditions on the variations. Calculations of the variation period agree on the whole with experimental results.

3831. MICROPHONE TESTING [Recommendations of the American Standards Association].—(*E.N.T.*, June, 1936, Vol. 13, No. 6, pp. 216–218.) *See* 2675 of July.

3832. MIDGET MICROPHONE-PREAMPLIFIER [$4\frac{3}{4} \times 3\frac{3}{4} \times 2\frac{1}{2}$ Inches, Net Gain 90 db, Linear Response 20–20 000 c/s: using Acorn Valves].—Poppele. (*Communication & Broadcasting Eng.*, July, 1936, Vol. 3, No. 7, p. 23.)

3833. ON THE STUDY OF THE TELEPHONE RECEIVER [Mathematical Analysis by Separation into Two Series of Equations, for Mean Values (corresponding to D.C.) and Alternating Values].—T. A. Tanasesco. (*Bull. de Math. et de Phys. de l'École Polytech. Roi Carol II*, Bucarest, 1933/34, Fasc. 14/15, pp. 127–132: in French.)

3834. DISCUSSIONS ON "HIGH-POWER AUDIO TRANSFORMERS."—Peters. (*See* 3728.)

3835. THE TELEPHONE TRANSFORMER: PART II [Extension to General Case where Terminal Impedances are not necessarily Equal: Calculation of Attenuation Coefficient, and Basis of Practical Design: Analytical and Graphical Treatment].—C. Calosi. (*Alta Frequenza*, July, 1936, Vol. 5, No. 7, pp. 421–429.) For Part I *see* 3068 of August.

3836. ACOUSTIC STUDIES OF SOME NON-TRANSFORMING AND TRANSFORMING SPECIAL STEELS AT LOW TEMPERATURES [Method for Determination of Persistence of Vibration and Vibration Frequency of Transversely Vibrating Bars at Different Temperatures: Examination of Special Steels during Transformation].—Mary D. Waller. (*Proc. Roy. Soc.*, Series A, 17th Aug. 1936, Vol. 156, No. 888, pp. 383–393.)

3837. A NEW TYPE OF UNDERGROUND TELEPHONE WIRE [Rubber-Compound-Insulated, Parallel-Twin Construction, ploughed into Ground: Provision for Loading: Attenuation for Non-Loaded Wire about 1.1 db/mile and 0.49 db/mile for Loaded: Nominal Cut-off Frequency of Loaded Circuit 3 600 c/s.]—D. A. Quarles. (*Bell S. Tech. Journ.*, July, 1936, Vol. 15, No. 3, pp. 446–454.)

3838. AUDIO COMPENSATING SYSTEMS [and the "Queer" Results often found, due to Resonant Circuits with Less than Critical Damping: a Circuit for Radio, P.A., or Gramophone].—A. W. Barber. (*Rad. Engineering*, June, 1936, Vol. 16, No. 6, pp. 5–7.)

3839. POWER AMPLIFIER DESIGN.—P. Adorjan. (*Rad. Engineering*, June, 1936, Vol. 16, No. 6, pp. 12–13.) From Rediffusion, Ltd., London.

3840. BEAT-FREQUENCY OSCILLATORS [Points on Design: Avoidance of Spurious Frequencies and Reduction of Temperature Effects].—A. W. Barber. (*Rad. Engineering*, July, 1936, Vol. 16, No. 7, pp. 13–16.)

3841. "AN A.C.-OPERATED BEAT OSCILLATOR": CORRECTIONS.—Haefner and Hamlin. (*Electronics*, July, 1936, Vol. 9, No. 7, p. 52.) *See* 3076 of August.

3842. ABSOLUTE SOUND-PRESSURE MEASUREMENTS [Raleigh Disc and Condenser-Microphone Methods: Less than 7% Difference over Range up to 8000 c/s].—J. de Boer. (*Philips Tech. Review*, March, 1936, Vol. 1, No. 3, pp. 82–86.)

3843. OPTICAL MODEL EXPERIMENTS FOR STUDYING THE ACOUSTICS OF THEATRES [and Application to Improvement of the Philips Theatre: including the Use of the "Ripple Tank" with small Artificial Water Waves].—R. Vermeulen and J. de Boer. (*Philips Tech. Review*, February, 1936, Vol. 1, No. 2, pp. 46–52.)

3844. APPARATUS AND TECHNIQUE FOR REVERBERATION MEASUREMENTS [Semi-Automatic Timer with Novel Features].—F. V. Hunt. (*Journ. Acous. Soc. Am.*, July, 1936, Vol. 8, No. 1, pp. 34–41.) For the writer's direct-reading frequency meter *see* 1566 of 1935.

3845. APPARATUS FOR THE MEASUREMENT OF REVERBERATION TIME [with a Short-Wave Regenerative Triode Circuit as Electronic Relay, selected in preference to Mechanical or Neon-Tube Relays].—A. Gigli and G. Sacerdote. (*Alta Frequenza*, August, 1936, Vol. 5, No. 8, pp. 516–524.)

3846. ELECTRO-ACOUSTIC INVESTIGATIONS IN RESOUNDING CHAMBERS [including Effect of Partitions].—H. Frei. (*Naturwiss.*, 14th Aug. 1936, Vol. 24, No. 33, pp. 524–525: book review.) *See* also 3460 of September.

3847. THE THEORY OF SOUND ABSORPTION OF POROUS MATERIALS, FLEXIBLE AND NON-FLEXIBLE.—M. Rettinger. (*Journ. Acous. Soc. Am.*, July, 1936, Vol. 8, No. 1, pp. 53–59.) For previous work *see* 1507 of 1935.

3848. A SPECIAL ASPECT OF THE FIGHT AGAINST NOISE: THE "SILENCING" OF AEROPLANES.—A. Métral. (*Génie Civil*, 25th July, 1936, Vol. 109, No. 4, pp. 79–82: to be continued.)

3849. The Application of Electric Filters to Delay Networks [for Sound Ranging in Air and Water].—M. Federici. (*Alta Frequenza*, July, 1936, Vol. 5, No. 7, pp. 395–420.)

Author's summary :—" The application of delay networks to equipment for the determination of the direction of sounds in air and in water is examined. The properties of the most commonly employed delay network (prototype the low-pass filter) are set out, and the conditions to be observed in order to obtain uniform delay, independent of frequency, are found. The two principal types of circuit used in such equipment are discussed [microphones in a line or circle] and formulae for their calculation are given." In particular, the effect of the coil resistances, and of accidental variations of the characteristic impedance of the line, on the uniformity of delay is examined.

3850. Sonic Instruments for Fog Aviation.—Rice. (*See* 3798.)

3851. Supersonic Surface Waves [Use of Complex Propagation Vectors in Theoretical Determination of Form/Frequency Surface: Determination of Electrical Constants of Solid Bodies]. — H. Ludloff. (*Physik. Zeitschr.*, 15th July, 1936, Vol. 37, No. 14, p. 524.)

3852. Diffraction of Light by Ultra-Sonic Waves [is most accurately described by Raman and Nath's Theory].—F. H. Sanders. (*Nature*, 15th Aug. 1936, Vol. 138, p. 285.) *See* also 2254 of June and 3082/3 of August.

3853. On the Diffraction of Light by Supersonic Waves in Air [Experiments: First and Second Order Spectra visible: Calculations from Observed Results, using Raman-Nagendra-Nath Theory and Lorentz-Lorenz Equation].—R. Bär. (*Helvetica Phys. Acta*, Fasc. 5, Vol. 9, 1936, pp. 367–371.)

PHOTOTELEGRAPHY AND TELEVISION

3854. Television Transmission over Telephone Lines.—F. Ring. (*Funktech. Monatshefte*, July, 1936, No. 7, Supp. pp. 49–51.)

Since the writer's previous paper (2290 of June) the German P.O. has carried out a number of tests (using the 180-line Witzleben transmissions) which all lead to the conclusion that distances of 3–4 km can be covered over the ordinary subscriber's line without the use of repeaters: single-sideband carrier-current transmission was employed, with a carrier frequency of about 1.3 Mc/s, and the Telefunken television receiver FE III was found very suitable, its i.f. amplifier being designed for this carrier frequency. The range is limited by the general noise level. An over-all attenuation of 6–7 nepers, corresponding to a 4 km, 0.8 mm line, is found to be permissible. " Such lines can above all be employed in combination with the existing television cables, to which they will act as distributing lines. Since suitable telephone wires are always available, it will be possible to join up lines from practically every part of Berlin for television transmissions of special events from theatres, etc. In this connection must be considered also the laying of special lines (1.4 mm), or cheap television cables with a thin concentric conductor in a lead sheath which acts as return conductor, to various main centre offices in Berlin. These lines could then be from 7 to 10 km long without repeaters."

3855. Large-Picture Television [Survey with Possible Future Developments].—F. Schröter. (*Telefunken-Zeit.*, July, 1936, Vol. 17, No. 73, pp. 5–26.)

Expense of intermediate-film process: multi-lamp screen systems—distribution simplified by rectifiers in series with each lamp or by giving rectifying properties to each: Thun's data on image merit for various conditions of moving-picture projection: possibility of reducing band width by reducing framing frequency to stroboscopic minimum (17–20 per sec.) and multiplying at receiver: such multiplication unnecessary if intermediate photographic or electrographic recording (Selényi, 1869 of May) is used, for flicker can then be avoided by special (Mechau) projector or otherwise: discussion of two possible types of television, the " decay " type where each luminous element returns to blackness before changing to its new value, and the " überblendung " type where it is merely adjusted to its new value: multi-channel working and the cathode-ray rapid commutator: various Schröter patents: wide-band cable transmission: possibilities of u.s.w. beam or light-ray television: etc.

3856. An Analysis of Theatre and Screen Illumination Data.—S. K. Wolf. (*Bell S. Tech. Journ.*, July, 1936, Vol. 15, No. 3, p. 479: summary only.) From the *Journ. of Soc. of Motion Picture Engineers.*

3857. Progress in Stereoscopic Cinematograph Projection [including the Use of the Kodak Polarising Filters and the similar Zeiss-Ikon " Herotar " Filters, and a Special Mosaic Screen of Rolled Aluminium (von Ardenne) avoiding Diffusion and Consequent Loss of Polarisation].—P. Hatschek. (*Funktech. Monatshefte*, July, 1936, No. 7, Supp. pp. 53–54.) *See* also *Wireless World*, 28th Aug. 1936, p. 204.

3858. Ultra-High-Frequency Transmission between the RCA Building and the Empire State Building, in New York City.—Carter and Wickizer. (*See* 3666.)

3859. Experimental Researches on the Propagation of Short Electric Television Waves (Wavelengths 41 and 74 m).—R. Rivault. (*Comptes Rendus*, 3rd Aug. 1936, Vol. 203, No. 5, pp. 363–365.)

For transmission, reception and photographic apparatus *see* Bodroux & Rivault, 1934 Abstracts, p. 623. A simple black and white design was transmitted and its televised image photographed at the receiver. The reference image due to direct waves was observed to be accompanied by images formed by waves which had followed more complex paths, in particular that of reflection from a height of from 100 to 700 km. The diurnal variations of this height for the two wavelengths used are described and given as curves which indicate phenomena of multiple reflection and splitting. Periodic inversion of the image was also noted.

3860. Report of the RMA Television Committee.—(*Rad. Engineering*, July, 1936, Vol. 16, No. 7, pp. 19–20.)

3861. Eiffel Tower Television Station Changes [10 kW instead of 1 kW in Aerial: Studio Lights reduced from 25 000 to 10 000 Lux/cm², compensated for by Additional Electron Multiplier, etc.].—(*Communication & Broadcast Eng.*, July, 1936, Vol. 3, No. 7, p. 22: paragraph only.)

3862. "Television Reception" [Book Review].—M. von Ardenne. (*Electrician*, 7th Aug. 1936, Vol. 117, p. 171.) Translation, by Bedford & Puckle, of the book referred to in 3150 of 1935.

3863. Cathode-Ray-Spot Scanner for Televising Film.—von Ardenne. (*Electronics*, July, 1936, Vol. 9, No. 7, p. 46.) Based on the papers dealt with in 1947 of 1935 and 1866 of May.

3864. Electron-Optical Problems in High-Vacuum Television Receiving Tubes.—K. Diels and G. Wendt. (*Telefunken-Zeit.*, July, 1936, Vol. 17, No. 73, pp. 26–44.)

(1) Laws of optics and of electron-optics: analogies and differences. (2) Lenses of electron-optics: the double-layer lens and its combinations: the disc-aperture lens and its combinations: the tubular lens and its variations: the multiple-ring lens with external or enclosed potential-divider, and the "resistance" lens in which the multiple rings are replaced by a spiral high-resistance film (equivalent to a series of rings with linearly varying potentials) or in certain cases by a cylindrical resistance-layer (it is probably possible to imitate a non-linearly varying series of rings, by varying the width and spacing of the spiral, or the thickness of the cylindrical layer; but "resistance lenses are little used, on account of difficulties in manufacture"): and finally magnetic lenses and their combination to give the same 180° rotation as optical and electrostatic lenses. (3) The errors of electron lenses: five for the electrostatic type and an extra three for the magnetic (due to its "twisting" property): for the mathematical treatment of both types the reader is referred to Glaser's paper (303 of January): in the present paper all the various errors are examined and illustrated separately.

3865. Control of the Beam Intensity in Cathode-Ray Tubes [Short Survey of Aperture and Space-Charge Methods: Philips Television Tubes 3951 and 3952].—G. P. Ittmann. (*Philips Tech. Review*, March, 1936, Vol. 1, No. 3, pp. 91–94.)

3866. The Production of Sharp Fluorescent Spots in Cathode-Ray Tubes.—G. P. Ittmann. (*Philips Tech. Review*, February, 1936, Vol. 1, No. 2, pp. 33–38.)

3867. Cathode-Ray Screens for Large Amounts of Energy, giving Extremely Brilliant White Light [Velvet impregnated with (*e.g.*) Thorium with Trace of Uranium and then Burnt, yielding Close-Meshed Oxide Surface growing White-Hot under Bombardment: Stretched Tantalum Foil, giving Similar Effect].—Farnsworth Company. (French Pats. 796 715 and 796 716, pub. 14.4.1936: *Rev. Gén. de l'Élec.*, 25th July, 1936, Vol. 40, No. 4, pp. 29–30 D.) *Cf.* 3483 of September.

3868. Italian Tube projects Television Images [working on 7000 Volts: Ceramic Envelope with Metal Base and Hard Glass Screen: Interchangeable Cathode (Active Material on Nickel Disc): Direct Image 5 × 5 cm: Projected Image 30 × 30 cm].—(*Rad. Engineering*, July, 1936, Vol. 16, No. 7, p. 26.)

3869. Screening Cathode-Ray Tubes [and the Use of High-Permeability Alloys].—G. A. V. Sowter. (*Wireless World*, 14th Aug. 1936, Vol. 38, pp. 138–140.)

3870. The Crystal Photo-Effect and Rectifying Action in the Bulk of the Crystal [are related in Intensity].—G. Groetzinger and J. Lichtschein. (*Nature*, 25th July, 1936, Vol. 138, pp. 163–164.)

3871. A Formula for the Birefringence of Vibrating Media [Theory permitting Quantitative Analysis of Vibrations of Piezoelectric Crystals: Equation predicting Intensity of Light passing through Okolicsanyi Cell].—J. W. Cookson and H. Osterberg. (*Physics*, April, 1936, Vol. 7, No. 4, p. 166.) For papers on the cell named *see* 1876 of May, and for previous work by the present writers on the interference method *see* 683 of February.

3872. Composite, Transparent Photocathodes [Transparent Films of Cs Alloys possess Long-Wave Maximum which can be Displaced by Suitable Sensitisation Methods].—P. Görlich. (*Zeitschr. f. Physik*, No. 5/6, Vol. 101, 1936, pp. 335–342.)

Transparent cathodes are those which do not absorb completely either the incident light or any electrons set free in the middle of the cathode. To obtain the greatest possible sensitivity in the visible and infra-red spectral regions, various alloys of Cs with other metals, in particular Bi, were used for the cathodes, and spectral intensity-distribution curves are given for compact (opaque) and transparent cathodes. Displacement of the long-wave maximum and limit towards the red end of the spectrum was produced by sensitisation with oxygen. The long-wave maxima for light incident on and transmitted through the cathodes were not found always to occur at the same wavelength. The photoelectric yield was larger when metals of low conductivity (*e.g.* Bi and Sb) were used as the second component of the alloy.

3873. FATIGUE OF OXYGEN-CAESIUM PHOTO-CATHODES.—P. W. Timofeev and N. S. Kondorskaja. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 9, 1936, pp. 683–691: in German.)

Tests on the fatigue of these cathodes at room temperatures and at the temperature of liquid nitrogen lead to the following conclusions:—The curve of the very rapid fatigue of oxygen-caesium cathodes (containing some silver oxide left unreduced when the oxidised silver surface was treated with caesium vapour) cannot be represented by simple exponential formulae such as were shown by Suhrmann & Dempster to apply to potassium/naphthalene and potassium-hydride surfaces (2740 of 1935). "According to the theory of de Boer & Teves the fatigue processes of complex cathodes may be considered to be as follows:—the caesium (for example) atoms present in caesium oxide behave as energy centres; they lose their valency electrons and become positive ions, which in the electrical field are driven into the cathode. This produces a decrease in sensitivity. According to the assumption made, a lowering of the cathode temperature would produce an increase of the fatigue. Naturally the resistance of the semi-conducting under-layer is thereby increased, and the number of electrons emerging from the cathode decreases correspondingly, while the recombination of the alkali metal on the surface of the cathode, due to photoionisation, diminishes simultaneously. Obviously, for one and the same photoionisation, the number of ions leaving the surface will be the greater, the less they recombine and the stronger the electrical field which acts on them. The [experimental] curves, represented in Fig. 7, confirm this. The fact that these curves do not agree with those corresponding to the exponential law is explained by the fact that the thickness of the caesium-oxide film, which acts as carrier for the caesium film, is not equal all over the cathode, so that the recombination probability of the caesium atoms differs from point to point of the cathode surface. The fatigue curve of the oxygen-caesium cathode can therefore be expressed by a sum of exponential functions [formulae on p. 689]. The correctness of the above representation is confirmed by the varying sensitivity-losses of these cathodes under continued exposure to lights of various strengths: the greater the light intensity falling on the cathode surface, the greater is the loss of sensitivity."

The irreversible fatigue of these cathodes at room temperatures, on the other hand, is due to a decrease of free caesium on the cathode, from a reaction between the caesium ions diffusing into the interior of the cathode and the residual silver oxide: at the temperature of liquid nitrogen this reaction cannot take place, consequently there is no irreversible fatigue at this temperature.

3874. THE EXTERNAL PHOTOELECTRIC EFFECT WITH ALKALI HALIDES COLOURED BY CATHODE RAYS.—E. Asmus. (*Ann. der Physik*, Series 5, No. 8, Vol. 26, 1936, pp. 723–739.)

Experiments are described in which powdered alkali chlorides and bromides are coloured by cathode-ray bombardment; "the external photoelectric effect connected with the colouring is investigated with visible light. It is found that the photoelectrons do not arise directly from the colour centres but from a new excited state which is formed from the colour centres under the influence of the light absorbed in their absorption band. This photocurrent is proportional to the number of 'excited colour centres' when the wavelength is kept fixed."

3875. "TELEPHOTOGRAPHS": SYSTEM FOR TRANSMITTING PHOTOS BY ORDINARY WIRE TELEPHONE CIRCUITS, USING INDUCTIVE COUPLING.—W. G. H. Finch. (*Electronics*, July, 1936, Vol. 9, No. 7, p. 32.) Editorial note on a demonstration.

3876. PORTABLE PHOTOTELEGRAPH TRANSMITTERS [developed in conjunction with German P.O. and used at Olympic Games].—W. Keller. (*E.T.Z.*, 6th Aug. 1936, Vol. 57, No. 32, pp. 905–907.)

MEASUREMENTS AND STANDARDS

3877. THE THEORY AND DESIGN OF HOT-WIRE AMMETERS FOR FREQUENCIES OF 25 TO 100 MEGACYCLES [Improvements on 1930 Design of Screened Instrument].—C. L. Fortescue. (*Journ. I.E.E.*, August, 1936, Vol. 79, No. 476, pp. 179–193: Discussion p. 200–205.)

For the earlier design *see* 1930 Abstracts, p. 461. The improvements are both mechanical and electrical, leading to more compact instruments of lower impedance; they have arisen from a more careful consideration of the temperature distribution in the hot wire, the behaviour of the magnifying system, and the corrections at high frequencies. In his reply to the Discussion the writer defends the mechanical magnification method adopted against the claims of thermoelectric and photometric methods of indicating the temperature of the hot wire.

3878. DISCUSSION ON "THERMIONIC PEAK VOLTMETERS FOR USE AT VERY HIGH FREQUENCIES."—Fortescue. (*Journ. I.E.E.*, August, 1936, Vol. 79, No. 476, pp. 200–205.) *See* 3999 of 1935.

3879. "COMPENSATION" CIRCUIT [Positive Resistance in Series with Negative] USED AS VOLTMETER FOR VERY SMALL D.C. POTENTIALS, AS PEAK VOLTMETER, AND AS MULTIVIBRATOR.—N. Carrara. (*Alta Frequenza*, August, 1936, Vol. 5, No. 8, pp. 480–503.)

The theoretical circuit is seen in Fig. 1, where E represents a very small e.m.f. (such as that of a thermo-junction) to be measured. The negative resistance R_n may be furnished by a secondary-emission tetrode (Figs. 3 and 4) or by the two-triode arrangement (Fig. 5) due to Denina (1933 Abstracts, p. 97): concerning this latter circuit it is remarked that it may seem to resemble the Turner "kallirotron" but is really different: reference is also made to circuits of the same class studied by Latmiral (3117 of August).

For measuring very small d.c. voltages the circuit of Fig. 5 is so adjusted that R_p is larger, but only very slightly, than $|R_n|$; the more closely these approach each other the more sensitive does the circuit become and the more unstable and slow, so that its use is limited to voltages of not less than 10^{-4} volt or, in exceptional cases, 10^{-5} volt.

As a peak voltmeter the circuit possesses a very high impedance and can be used for very small amplitudes and extremely high frequencies. In addition to acting as a relaxation oscillator (battery E_0 omitted, and a condenser inserted between M and N) the circuit can be used as an electronic trip relay. The paper ends with a discussion of the stability conditions and time constants.

3880. A GENERAL PURPOSE VALVE VOLTMETER WITH RAY-TUBE [6E5] INDICATOR.—F. T. Griffin. (*QST*, August, 1936, Vol. 20, No. 8, pp. 19–20 and 64.)

3881. THEORY [and Experimental Confirmation] OF THE IMPULSE METER WORKING WITH DRY-PLATE RECTIFIERS AS USED IN COMMUNICATION ENGINEERING.—R. Bauer and E. Spenke. (*E.T.Z.*, 13th Aug. 1936, Vol. 57, No. 33, p. 940: summary only.)

3882. USE OF A VALVE AS A PHASE-ANGLE MEASURING DEVICE.—J. Kilga. (*E.N.T.*, June, 1936, Vol. 13, No. 6, pp. 185–186.)

The circuit used is shown in Fig. 1; it is based on the fact that the emission current depends on the phase angle between anode and grid voltages, being greatest when these are co-phasal and least when their phases are in opposition. The theory of the measurement is worked out. Fig. 2 shows the circuit for determining the loss-angle of an iron-cored transformer; Fig. 3, that for measuring the hysteresis angle of the iron in the core.

3883. THE MEASUREMENT OF THE THERMAL RESISTANCE OF INSULATING MATERIALS.—Batsch and Meissner. (*Zeitschr. f. tech. Phys.* No. 8, Vol. 17, 1936, pp. 283–285.)

The paper begins by quoting a remark of Vieweg to the effect that "electro-technique is to-day paying more and more attention to the thermal resistance of insulating materials. Things are difficult in this respect since the measurement of such resistance is by no means a simple matter." The object of the work here described was to eliminate these difficulties, so that the measurement may be made with sufficient accuracy and, above all, quickly. The defects of the usual method (by which a complete measurement took from 3–8 hours) are pointed out, and a new apparatus is described with which a measurement can be made in half an hour or (for high thermal resistances) in 1½ hours. Distinctive features are:—the heater plate and the plate under measurement are in a vacuum (less than 2×10^{-2} mm Hg); the usual clamping arrangement is abolished, the iron heater and the plate under test being pressed against the aluminium base (kept at a constant temperature around 14° by water cooling) by the attraction of an electro-magnet; the heat flow is measured by the electrical power put into the heater; and the contact surfaces between metal and insulating material are rubbed with oil. The only correction to be made is for the heat radiation from the heater plate. An accuracy within 5% is claimed. Some specimen curves are included.

3884. THE MEASUREMENT OF THE SELF-INDUCTANCE OF VARIABLE AIR CONDENSERS [Three Methods compared: Some Results—Self-Inductance undesirably High and varies with Setting: Possible Reduction by Use of Concentric Cylinders and by simplifying Connection to Moving System, perhaps by Series-Gap Idea].—W. H. Ward. (*Journ. Scient. Instr.*, August, 1936, Vol. 13, No. 8, pp. 251–260.)

3885. AN IMPROVED FORM OF RESPONSE-CURVE PROJECTION APPARATUS [Frequency Range 100 c/s to 500 kc/s: Beat-Frequency Oscillator with Electrically-Produced Frequency Sweep: Cathode-Ray Oscillograph with Crystal-Controlled Frequency Base, so that Calibration is unaffected by Mains-Voltage Changes, etc.].—D. G. Reid. (*Journ. I.E.E.*, August, 1936, Vol. 79, No. 476, pp. 194–200: Discussion pp. 201–205.) For another electrically-produced frequency sweep *see* 3515 of September.

3886. THE DIELECTRIC CONSTANT OF AIR AT RADIO-FREQUENCIES [determined by Beat-Frequency Method: Demodulated Broadcast Signals used as Sources of Constant-Frequency A.C.: Result agrees with L.F. and Static Value].—L. G. Hector and H. L. Schultz. (*Physics*, April, 1936, Vol. 7, No. 4, pp. 133–136.) *See* also 1903 of May.

3887. THE DIELECTRIC CONSTANTS OF ELECTROLYTIC SOLUTIONS [Measurements on Acids: Discussion of Existence of Saturation Effect].—E. Fischer. (*Ann. der Physik*, Series 5, No. 8, Vol. 26, 1936, pp. 697–704.)

Extension of work referred to in 4089 of 1935. Here the results of measurements on dilute solutions of strong acids are given, and the writer's method of measurement by a high-frequency bridge is found to be free from objection. The results of G. Fischer & Schaffeld (1904 of May) are discussed; the question as to the existence of a saturation effect cannot, in the writer's opinion, be settled without further evidence as to ionic values.

3888. DIRECT DETERMINATION OF THE ELECTRICAL CONSTANTS OF SOIL AT RADIO FREQUENCY.—Sen Gupta and Khastgir. (See 3662.)

3889. THE DYE QUARTZ RING OSCILLATOR AS A STANDARD OF FREQUENCY AND TIME.—L. Essen. (*Proc. Roy. Soc.*, Series A, 1st July, 1936, Vol. 155, No. 886, pp. 498–519.)

This type of quartz oscillator consists of "a cylindrical ring cut in a plane perpendicular to the optic axis and vibrating radially at a frequency of 20 000 c/s in its fundamental longitudinal mode." Details of the mounting, the enclosure and associated electrical circuits of the ring are given. "The results are given of . . . experiments designed to measure the frequency variations of the oscillator with the variations of the associated electrical and mechanical conditions." The determination of the rate and frequency of the standard is described and stability results are given. "The results also furnish some information concerning the accuracy of astronomical time signals."

3890. The Piezoelectric Resonator and the Effect of Electrode Spacing upon Frequency.—W. G. Cady. (*Physics*, July, 1936, Vol. 7, No. 7, pp. 237–259.)

" A new formulation of piezo-resonator theory, . . . the '*mechanical theory*,' is developed for a crystal resonator with gap between crystal and electrodes, involving the increase in effective stiffness caused by space or surface charge, and explaining the increase in resonance frequency with increasing gap." Various special crystal cuts are discussed in detail and a graphical treatment of the resonator, based on a resonance circle diagram, is given. " The mechanical theory is compared with the customary '*electrical theory*' . . . the mechanical theory, unlike the electrical theory, describes correctly the performance of a vibrating crystal bar that is not metallically coated." The relative increase in frequency caused by the gap is calculated. Observations made with various crystals are described. " A large increase in frequency with gap may be taken as a criterion of a good resonator . . . the effect of gap upon frequency can be utilised in determining approximately the piezoelectric constant of a crystal. The theory of the dependence of frequency upon gap for *overtone* vibrations is briefly discussed."

3891. Oscillating Plates of Piezoelectric Quartz without Variation of Frequency with Temperature.—Koga. (*L'Onde Élec.*, August, 1936, Vol. 15, No. 176, pp. 498–507.) Concluded from 3535 of September.

3892. Photoelastic Investigations of the Piezoelectrically Excited Flexural Oscillations of Quartz Bars.—K. Eichhorn. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 17, 1936, pp. 276–279.)

Author's summary :—" With the help of a stroboscopic Kerr-cell illumination in synchrony with the oscillation, two quartz bars were examined. These were set in flexural vibration in the *z*-direction, at the fundamental frequency of the shorter bar and the first harmonic of the other [17 kc/s and 23.42 kc/s respectively]. A phase changer [in the Kerr-cell modulating circuit], in conjunction with an electromagnetic rotating field, enabled every phase of oscillation of the bar to be observed. The course of the phase relation between exciting and excited frequencies could be followed. The shapes of the isochromatic curves for fundamental and first overtone are shown [Figs. 4 and 5]. The values of the edge strains and their variation along the length of the bar are also shown [Fig. 6], as is also the linear variation of the longitudinal strain with the distance from the neutral layer."

3893. The Production of Piezoelectricity by Torsion [Observations on Charges produced by Static Torsion : Torsional Oscillations in Hollow and Solid Quartz Cylinders].—R. E. Gibbs and L. C. Tsien. (*Phil. Mag.*, August, 1936, Series 7, Vol. 22, No. 146, pp. 311–322.) *See* also 2325 of June and back references.

3894. Measurements and Investigations on Quartz Crystals for Receiver Control.—Roeschen. (*See* 3731.)

3895. Investigations of the Elastic Vibration in a Piezo-Crystal of Rochelle Salt [Dependence of Frequency on Dimensions and Orientation to Crystallographic Axes : Calculation of Elastic Moduli from Experimental Results : etc.].—G. Michailov. (*Tech. Phys. of USSR*, No. 7, Vol. 3, 1936, pp. 652–661 : in English.) For the writer's investigation of the temperature effect *see* 3542 of September.

3896. Relation between Longitudinal Natural Frequency and Geometrical Form of a Magnetostrictive Nichrome Rod [Theory and Experimental Confirmation].—Torikai, Hayashi and Kasuno. (*Jap. Journ. of Eng., Abstracts*, 1936, Vol. 14, p. 107.)

3897. Mechanical Vibrations at Radio Frequencies [obtained by Magnetostrictive Oscillator].—Colwell and Hill. (*See* 3819.)

3898. The Magnetostriction of a Circularly Magnetised Bar, and Its Mechanical Applications.—S. Mori. (*Jap. Journ. of Physics*, March, 1936, Vol. 11, No. 1, Abstracts p. 35.) Apparently covering the same ground as the paper dealt with in 1933 Abstracts, p. 50.

3899. Frequency Stability of R.F. Oscillators using Multi-Electrode Tubes [and a new Beat-Frequency Oscillator giving Constancy within a Few Cycles in 1780 Kilocycles].—R. T. Gabler. (*Proc. Inst. Rad. Eng.*, August, 1936, Vol. 24, No. 8, pp. 1057–1058 : summary only.)

One frequency is crystal controlled ; the variable frequency is generated by a valve such as the 6A7, 6D6 or 6C6 and is stabilised by the proper selection of inductances and capacitances and by " a special compensating variable condenser operating by the deflection of a bimetallic structure."

3900. Direct-Reading Frequency-Meter for a Wide Range.—T. Fecker. (*E.N.T.*, June, 1936, Vol. 13, No. 6, pp. 205–216.)

The instrument here described is stated to have the advantages of a wide measuring range, direct and accurate reading on a scale with equal divisions, independence of the magnitude and harmonic content of the measuring voltage, very small power consumption and simple maintenance. It can be used both for direct observation and automatic recording. The complete circuit diagram is given in Fig. 14 ; the quantity measured is the charging current of a condenser (*see* Fig. 1, showing the circuit principle). This is charged by a constant direct voltage from a stabiliser, working off the mains, through two triodes in step with the frequency to be measured. Eqn. 1 shows that this current is directly proportional to the frequency, so that the ammeter in the charging circuit can be directly calibrated in c/s. The process of charging the condenser is analysed, to show the possible sources of error, and illustrated by Figs. 3, 4. The lines which the development of the apparatus must follow are deduced from this analysis : the charging process and its reversal must be accelerated and the charging current tend rapidly to zero ; the grid voltages during charging and reversal must be independent of the magnitude and form of the measuring voltage; possibilities of error, such as variation of filament voltage and change of valve characteristics, must be eliminated.

The charging process is discussed on the basis of the current/voltage characteristic, with both constant and variable grid voltage (circuit for the latter, Fig. 5); the reversal process requires a more complicated circuit, with an additional, reversed valve (Fig. 6) or a multiple-grid valve (Fig. 7). Fig. 8 summarises the results obtained with these circuits. Fig. 9 shows the circuit controlling the charging processes. The combined effect of these circuits is illustrated by Figs. 10 and 11, which show the potentiometer effect for positive and negative measuring voltage. An analysis of the action for high and low voltages is given. The production of the required direct voltage by the stabiliser is described; Fig. 13 gives the circuit for eliminating the influence of variations of the mains and temperature. The large and small models of the instrument (Fig. 15) have six and three ranges respectively; their accuracy and power consumption are discussed. Fig. 16 shows the amount of variation of the reading from its true value over a period of 8000 hours.

3901. New Types of Triode Multivibrators.—Nicolich. (*See* 3717.)

3902. Frequency Division—a New Circuit for the Generation of Subharmonic Frequencies.—Sterky. (*See* 3716.)

3903. "Elektrische Messungen" [Book Review].—W. Skirl. (*Electrician*, 21st August, 1936, Vol. 117, p. 224.) A Siemens Handbook.

SUBSIDIARY APPARATUS AND MATERIALS

3904. Electron-Optical System of Two Cylinders as applied to Cathode-Ray Tubes.—Epstein. (*Proc. Inst. Rad. Eng.*, August, 1936, Vol. 24, No. 8, pp. 1095–1139.)

Throughout the paper, the results are applied to the second lens of a cathode-ray tube: for an analysis of the first lens ("electron gun") *see* Maloff & Epstein, 2384 of 1935. Part I deals with the electron-optics of axially symmetrical electrostatic fields, including a first approximation of the focusing action of an electrostatic field by consideration only of paraxial electrons, the determination and use of the cardinal points, and a discussion of "thick" and "thin" lenses. Part II deals with the optics of two overlapping coaxial cylinders, the classification of the defects of an electron focusing system, and a detailed examination of the spherical aberration of the electrostatic field due to two cylinders.

3905. Contribution to Knowledge of the Electron-Optical Immersion Lens. II.—Behne. (*Zeitschr. f. Physik*, No. 7/8, Vol. 101, 1936, pp. 521–526.)

For I *see* 854 of 1935: for papers on the immersion objective *see* 3546 of September; *also* Johannson, 296 and 852 of 1935. Here, the experiments of I are extended with the arrangement shown in Fig. 2; the effect on the ray paths of varying the distance from the object N to the immersion lens L_2 was investigated. Plane and funnel-shaped stops (T in Fig. 2) were used for L_2. Fig. 3 shows the variation with object distance of the voltage ratio required for good definition of the image and the magnification obtained. The quality of the image is discussed on the basis of the reproductions in Figs. 4a, b; the funnel-shaped stops possessed the better optical qualities. The effect of altering the width of the stops was also investigated.

3906. A Regenerative Timing-Axis Oscillator for Cathode-Ray Tubes [Direct-Coupled Regenerative Amplifier, with Feed-Back Attenuation adjusted to equal Gain of Amplifier alone, gives Voltage across Output Resistance Linear with respect to Time].—Morton. (*Proc. Inst. Rad. Eng.*, August, 1936, Vol. 24, No. 8, p. 1055: summary only.)

3907. Direction of Motion of a Cathode-Ray Oscilloscope Spot.—Haynes. (*Rad. Engineering*, July, 1936, Vol. 16, No. 7, pp. 21–22.) *See* 2361 of June: the present paper is "somewhat revised by its author to include some specific radio applications"—*e.g.* to the study of phase conditions in multi-stage amplifiers and (more especially) feed-back circuits.

3908. Applications of Cathode-Ray Oscillographs [and an Oscillograph with High-Frequency Response increased by Inductance in Output Circuit of Amplifier, resonant with Deflector-Plate Capacity just above Upper Frequency Limit].—Schrader. (*Electronics*, June, 1936, Vol. 9, No. 6, pp. 38 and 65: *Rad. Engineering*, July, 1936, Vol. 16, No. 7, p. 25: summary only.) Applications discussed are to the measurement of vibrations, torsions, strains, engine pressures, etc.

3909. A New System of Deflection along the Time Axis applied to the Cathode-Ray Oscillograph [for Comparatively Slow Processes (Some Milliseconds): Triangular Wave Form obtained by Combination of Two Series of Half-Waves from Dry-Plate-Rectifier Bridge Circuits supplied with Sinusoidal Current: Advantages and Specimen Results].—Angelini. (*L'Elettrotec.*, 10th July, 1936, Vol. 23, No. 13, pp. 399–403.)

3910. The Simultaneous Observation of Current and Voltage Curves on the Cathode-Ray Oscillograph at Commercial Frequencies [by an Auxiliary Unit consisting of Rotating Commutator, with Synchronous-Motor Drive, and Special Single-Stage (REN914) Amplifier].—Schäfer. (*Zeitschr. f. tech. Phys.*, No. 8, Vol. 17, 1936, pp. 266–269.)

3911. "Cathode-Ray Oscillography."—G.W.O.H: MacGregor-Morris and Henley. (*Wireless Engineer*, August, 1936, Vol. 13, No. 155, pp. 403–405.) A critical editorial on the book referred to in 3554 of September.

3912. Second-Order Focusing for the Mass Spectrograph [Calculations for Motion of Charged Particles through Electric and Magnetic Fields when Electric Field is produced by Coaxial Cylindrical Plates: Conditions for Real Focus].—Sawyer. (*Proc. Camb. Phil. Soc.*, July, 1936, Vol. 32, Part 3, pp. 453–460.)

3913. Electrical After-Effects in Dielectrics Solidified in a High-Voltage Field [Dependence of Permanent Charges on Strength of Formative Field, Electrode Material, Cooling Conditions: Theoretical Discussion based on Space-Charge Measurements].—Thiessen, Winkel and Herrmann. (*Physik. Zeitschr.*, 15th July, 1936, Vol. 37, No. 14, pp. 511–520.)

3914. Tikond—a Solid Dielectric having a High Dielectric Constant.—N. Bogoroditski and N. Titov. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 6, 1936, pp. 792–800.)

A new type of dielectric known as Tikond has been produced in the U.S.S.R. by melting TiO_2 with glass or baking it with various substances such as PbO, SiO_2, B_2O_3 and MgO. Samples were produced by these two methods having dielectric constants of 50 and 100 respectively, at a frequency of 3×10^6 c/s. The angle of loss of the dielectric is of the order of 3 to 7 minutes.

The processes involved in the manufacture of this dielectric are described and its mechanical and electrical properties are shown in a number of tables. Curves are also given showing the effect of temperature on the angle of loss, specific resistance, and specific capacity. It is suggested in conclusion that the new dielectric is eminently suitable for use in radio apparatus.

3915. On the Effect of Temperature on the Electric Properties of Certain Dielectrics.—M. Mikhaylov and G. Soya. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 6, 1936, pp. 786–790.)

A report on experiments carried out with glass, marble, resin, shellac and other dielectrics at low temperatures (down to $-200°C$). The methods employed are described and curves are given showing the effect of temperature on the angle of loss and specific resistance of the dielectrics. Special attention was paid in these experiments to the presence of water in the dielectrics, and curves were therefore taken for samples at various degrees of humidity. On the basis of the curves obtained the effect of humidity on the properties of the dielectrics is discussed in detail.

3916. The Electro-Kinetic Processes in Dielectrics: the Colloidal Theory of Dielectric Losses.—B. M. Tareev. (*Journ. of Tech. Phys.* [in Russian], No. 5, Vol. 6, 1936, pp. 783–785.)

A theoretical investigation of processes taking place in a dielectric system when a voltage is applied across it. The system is assumed to consist of globular particles of dielectric uniformly suspended in another dielectric. The fundamental equation (1) is given of the movement of a particle in a viscous medium under the influence of a sinusoidal electric field, and formulae are derived determining the velocity and displacement of the particle, the power consumed per unit volume of the system, and the current flowing through the system. It is pointed out in conclusion that the colloidal theory affords a better explanation of losses in a dielectric than could be obtained with the aid of the theories expounded by Wagner and Debye.

3917. V.D.E. Survey of Insulating Materials in 1935.—(*E.T.Z.*, 2nd July, 1936, Vol. 57, No. 27, pp. 773–774.) For V.D.E. work on specifications *see* pp. 793–794.

3918. Special Properties of Artificial Rubber [including Electrical Properties and Resistance to Action of Ozone].—Koch. (*Zeitschr. V.D.I.*, 8th Aug. 1936, Vol. 80, No. 32, pp. 963–968.)

3919. Determination of Elasto-Optical Constants from Diffraction Experiments [Method and Results for Glass: Theory].—Bergmann: Fues. (*Naturwiss.*, 31st July, 1936, Vol. 24, No. 31, p. 492: p. 492.)

3920. The Measurement of the Thermal Resistance of Insulating Materials.—Batsch and Meissner. (*See* 3883.)

3921. The Voltage Strain on Condensers in Mains Units.—Harr and Wehnert. (*See* 3749.)

3922. Protection of Electrolytic Smoothing Condensers against Over-Voltages, by Resistance with Negative Temperature Coefficient.—"OSA" Company. (*See* 3748.)

3923. The High Self-Inductance of Variable Air Condensers, and Its Possible Reduction.—Ward. (*See* 3884.)

3924. The Measurement of Receiver Noise due to Rotation of Variable Resistances and Potentiometers.—Sachse and Bidlingmaier. (*See* 3740.)

3925. The Polaroid Strain Detector.—Land. (*See* 3786.)

3926. D.C. Voltage Amplification with Pentodes [Single Stage giving Amplification of 8000].—Kleen and Rothe. (*See* 3774.)

3927. The Crystal Photo-Effect and Rectifying Action in the Bulk of the Crystal.—Groetzinger and Lichtschein. (*See* 3870.)

3928. Transmission of High-Voltage Impulses at Controllable Speed [and the Use of Long Discharge Tubes as Transmission Lines].—Snoddy & others. (*See* 3685.)

3929. The Behaviour of the Grid-Controlled Gaseous-Discharge Tube when employed as [Relaxation-] Oscillation Generator.—Drewell. (*See* 3730.)

3930. On the General Theory of the Exploring-Electrode Currents in the Gaseous Discharge [and the Failure of the Langmuir-Mott-Smith Theory except in Special Cases: Separation into Electron and Ion Components by Hypothesis of Axially-Symmetrical Magnetic Field: leading to Thorough Investigation of Ion Motion in the Plasma: Relation to Conditions in a Hull Magnetron].—Spiwak and Reichrudel. (*Physik. Zeitschr. der Sowjetunion*, No. 6, Vol. 9, 1936, pp. 655–682: in German.)

3931. Compressed Iron-Powder Cores in High-Frequency Technique for Long and Short Waves [including Transmitters].—Lämmchen. (*Lorenz Berichte*, May, 1936, No. 2, pp. 28–44.)

History: the electrical figure of merit of a coil: the various losses in an iron-cored coil: iron-powder cores and the choice of their permeability (and the question of air-gap *versus* more binding material): forms of iron-cored coils for long, medium and short waves (down to 20 m): trimming the self-inductance: effect of screening, temperature ("Celofer" unchanged after several days' run at 120° in a transmitter) and magnetic bias: h.f. iron cores in transmitters: summary: literature references.

3932. Magnetic Properties of Certain Natural Magnetites.—A. Z. Golik. (*Journ. of Tech. Phys.* [in Russian], No. 6, Vol. 6, 1936, pp. 1082–1083.)

3933. Continuous Magnetic Spectrum of the Transformer Sheet at Audio Frequencies [Prediction and Calculation of Decrease of Permeability of Material from "After-Effect" Constant depending on Magnetic Viscosity].—Arkadiew. (*Zeitschr. f. Physik.*, No. 7/8, Vol. 101, 1936, pp. 527–532.)

STATIONS, DESIGN AND OPERATION

3934. Non-Fading Noise-Free Broadcasting Services [Analysis of Data from Europe, U.S.A. and Australia on Ground- and Sky-Wave Intensities at Broadcasting Distances and Frequencies: Tolerable Fading, Distortion, and Noise: Calculation of Power required: Low Frequencies the Most Efficient].—Green. (*Journ. Inst. Engineers Australia*, June, 1936, Vol. 8, No. 6, pp. 203–215).

The following conclusions are reached:—"A satisfactory non-fading noise-free service is found to be (a) a signal intensity for city reception equivalent, with respect to noise interference, to 10 mv/m at a frequency of 750 kc/s; (b) for rural reception a signal intensity equivalent to 1 mv/m at 750 kc/s; (c) on account of the known variation of noise interference with respect to frequency being an inverse linear law, the standards of minimum acceptable service at frequencies other than 750 kc/s are inversely proportional to the frequency to which the listener's receiver is tuned; (d) a non-fading service obtains when the quasi-maximum night intensity of the combined ground and sky rays is not more than 50% greater than the day intensity." Calculations of the powers required to produce conditions equivalent to the 750 kc/s conditions given in (a) and (b), for city and country services respectively, furnished the curves of Figs. 5 and 6: these show that the maximum efficiency for a 40 mile radius would be given in both cases by a 500 kc/s wave, while for a country service beyond 50 miles the optimum frequency would be still lower.

3935. Problems of Broadcasting in India [Plea for Collaboration in gathering Statistics on Atmospherics on Various Wavelengths].—(*Current Science*, Bangalore, July, 1936, Vol. 5, No. 1, pp. 48–49.)

3936. NAB Allocation Report: Excerpts from Dr. C. B. Aiken's Testimony [including Recommendation of High-Power Broadcasting on Waves around 200 kc/s].—Aiken. (*Communication & Broadcast Eng.*, July, 1936, Vol. 3, No. 7, pp. 5–8 and 17, 25.) For Editorial *see* p. 2.

3937. FCC plans Future of Ultra-High-Frequency Region: Conflicting Needs of Various Services: New Standards for Television, "Apex" [above 30 Mc/s] Broadcasting and Facsimile proposed: Request regarding Frequency Modulation.—(*Electronics*, July, 1936, Vol. 9, No. 7, pp. 7–10.) For a note on "apex" stations *see* p. 36.

3938. Broadcast Station Modulation Monitors [Some Commercial Types conforming to FCC Requirements].—Taylor. (*Rad. Engineering*, July, 1936, Vol. 3, No. 7, pp. 18–21.)

3939. Design and Equipment of a Fifty-Kilowatt Broadcast Station for WOR [for High-Fidelity Operation: First Application to Broadcasting of Stabilised Feed-Back Principle: Special Directional Aerial: etc.]—Poppele, Cunningham and Kishpaugh. (*Proc. Inst. Rad. Eng.*, August, 1936, Vol. 24, No. 8, pp. 1063–1081.) *See* also 3211 of August.

3940. The Lyon-Tramoyes Broadcasting Station [Full Account: Buildings, Aerials, Power Plant, Transmitter, Modulation System, etc: Results].—Barroux. (*Ann. des Postes, T. et T.*, July, 1936, Vol. 25, No. 7, pp. 613–664.) *See* also 2971 of August.

3941. The Short-Wave Broadcasting Installation in Zeesen near Königswusterhausen [Recent Extensions to cope with Olympic Games Broadcasting].—Semm. (*E.T.Z.*, 6th Aug. 1936, Vol. 57, No. 32, pp. 907–908.)

3942. The Experimental Radioelectric Centre of the National Research Council [at Torre Chiaruccia, near Rome: 14.82 m Beam Aerial rotated to give Series of Signals (1 kW in Aerial) in Different Directions: Examples of Reception Diagrams in England, Australia, America, and elsewhere].—Pession. (*Alta Frequenza*, August, 1936, Vol. 5, No. 8, pp. 467–479.)

3943. Ultra-High-Frequency Multi-Channel Circuit [New York/Philadelphia].—(*Communication & Broadcast Eng.*, June, 1936, Vol. 3, No. 6, pp. 14–15.) *Cf.* 3627 of September.

3944. The Wireless Equipment of the Airship "Hindenburg" (LZ 129).—Behner. (*Telefunken-Zeit.*, July, 1936, Vol. 17, No. 73, pp. 44–47.) For the direction-finding equipment *see* 3796, above.

3945. "Wired Wireless" in Switzerland [Particulars of the Telediffusion Service run by Swiss Government].—(*World-Radio*, 14th Aug. 1936, Vol. 23, p. 5.)

3946. WTMJ Road-Safety Broadcasts [from Cruising Car visiting Busy Corners, etc.].—(*Communication & Broadcast Eng.*, July, 1936, Vol. 3, No. 7, p. 22.) *See* also *Electronics*, July, 1936, p. 42.

GENERAL PHYSICAL ARTICLES

3947. A New Process of Negative Ion Formation [Extraction of Two Electrons from Negatively Charged Electrode by Positive Ions: Measurements of Probability of Conversion of Positive into Negative Ions for Various Gases].—Arnot. (*Nature*, 25th July, 1936, Vol. 138, p. 162.)

3948. On the New Field Theory [Dynamical Conditions governing Motion of Point Charges derived from Variation Equation].—Pryce. (*Proc. Roy. Soc.*, Series A, 1st July, 1936, Vol. 155, No. 886, pp. 597–613.)

3949. Quasi-Holonomic Dynamical Systems [Use of Non-Holonomic Reference Frame correlates Maxwell's Field Equations with Lagrange's Dynamical Equations: Application to Rotating Electrical Machinery].—Kron. (*Physics*, April, 1936, Vol. 7, No. 4, pp. 143–152.)

MISCELLANEOUS

3950. A Laplacian Expansion for Hermitian-Laplace Functions of High Order [in Theory of Probability].—Molina. (*Bell S. Tech. Journ.*, July, 1936, Vol. 15, No. 3, pp. 355–362.)

3951. Researches on the Electrical Conductivity of Stones.—Bayard-Duclaux. (*Ann. de Physique*, July/August, 1936, Vol. 6, pp. 5–107.)

3952. An Interesting Case of Submultiple Resonance [in Airplane Vibrations: Beats formed by Interchange of Energy between Wing and Tail].—Tuckerman and Ramberg. (*Phys. Review*, 1st June, 1936, Series 2, Vol. 49, No. 11, p. 862: abstract only.)

3953. A Plea for Rational Radio Terms.—Hallows. (*World-Radio*, 10th July, 1936, Vol. 22, p. 3.)

3954. "Slownictwo elektrotechniczne polskie, Zeszyt I" [Polish Electrotechnical Vocabulary, Vol. I: Book Review].—(*Rev. Gén. de l'Élec.*, 11th July, 1936, Vol. 40, No. 2, p. 34.)

3955. Japanese Electrotechnical Committee. Electrical Terms—Section 110: Radio Communication.—(*Journ. I.E.E. Japan*, February, 1936, Vol. 56 [No. 2], No. 571, pp. 171–178: list in Japanese and English.)

3956. Microphotographic Duplication in the Service of Science [" Science Service" Documentation Division].—Watson Davis. (*Science*, 1st May, 1936, Vol. 83, pp. 402–404.) *See* also 2054 of May.

3957. Radio Manufacturers Association, Inc. —Information on U.S. Radio Patents and Suits [New York, 1926/32].—(At Patent Office Library, London: Cat. No. 76 146.)

3958. "Radio" [Broadcasting as a Means of Expression: Relation of Broadcasting to Film Industry, etc: Book Review].—Arnheim. (*World-Radio*, 22nd May, 1936, Vol. 22, p. 9: translated from the German.)

3959. "Reports on Progress in Physics: Vol. II" [Book Review].—Physical Society. (*Wireless Engineer*, June, 1936, Vol. 13, No. 153, p. 316.)

3960. "Radioeléctricité générale" [Vol. II, First Part: Functioning of Valves, Amplification, Modulation: Book Review].—Mesny. (*L'Onde Élec.*, June, 1936, Vol. 15, No. 174, pp. 32–33 A.) For review of Vol. I *see* 3273 of 1935.

3961. On the Discussion of the Project of the OST: Frequency and Wavelength Scale of the Electromagnetic Oscillations.—(*Journ. of Tech. Phys.* [in Russian], No. 4, Vol. 6, 1936, pp. 757–764: with chart.)

3962. Experiments on the Transition from Electric Waves to Dark Heat Rays.—Lindman. (*See* 3724.)

3963. The Training of Industrial Physicists [Note on Institute of Physics Discussion].—Crowther. (*Journ. Scient. Instr.*, May, 1936, Vol. 13, No. 5, pp. 141–143.)

3964. "The Radio Engineering Handbook" [Book Review].—Henney. (*Proc. Inst. Rad. Eng.*, April, 1936, Vol. 24, No. 4, p. 663.)

3965. The Task of the Chemist in the Construction of Electrical Machines.—Boller. (*Bull. Assoc. suisse des Élec.*, No. 11, Vol. 27, 1936, pp. 281–294.)

3966. The New German Patent Law of 5 May 1936.—Kuhlemann: Kahle. (*Zeitschr V.D.I.*, 30th May, 1936, Vol. 80, No. 22 pp. 685–686: *E.T.Z.*, 18th June, 1936 Vol. 57, No. 25, pp. 715–717.)

3967. Cathode-Ray Tube Applications.—Schrader. (*See* 3908.)

Some Recent Patents

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each. A selection of abstracts from patents issued in the U.S.A. is also included, and these bear a seven-figure serial number.

AERIALS AND AERIAL SYSTEMS

2 017 047.—Two horizontal aerials mounted one above the other, and energized out of phase so as to produce two distinct and diverging beams of radiation.

C. W. Hansell (assignor to Radio Corporation of America).

2 018 342.—Three-dimensional aerial "array" in which directional effects are produced by energizing each individual surface in-phase, whilst successive surfaces are energized in phase opposition.

R. Bechmann (assignor to the Telefunken Co.).

TRANSMISSION CIRCUITS AND APPARATUS

444 886.—Method of increasing the amplitude of the oscillations generated by a back-coupled valve without altering their frequency.

Marconi's W.T. Co.; G. M. Wright; and N. M. Rust. Application date 30th August, 1934.

445 084.—Magnetron oscillation-generators having the anode split into an even number of segments, which are connected together in pairs at each end.

Telefunken Co. Convention date (Germany) 21st August, 1934.

445 313.—Balanced push-pull valve circuit for generating ultra short waves of the order 50 to 80 megacycles.

G. W. White and Baird Television Ltd. Application date, 24th December, 1934.

445 431.—Method of broadcast transmission in which the normal distribution of the radiated side-band frequencies is varied, with the object of improving quality at the receiving end.

P. P. Eckersley. Application date 17th October, 1934, and 17th October, 1935.

447 280.—Back-coupled valve-oscillator arranged to maintain a constant frequency in spite of fluctuations of the supply voltage.

Marconi's W.T. Co. and G. M. Wright. Application date 14th November, 1934.

2 013 773.—Barkhausen-Kurz oscillator to which modulation is applied by varying the strength or direction of a magnetic field traversing the valve.

W. Weihe (assignor to Telefunken Co.).

RECEPTION CIRCUITS AND APPARATUS

444 094.—Method of facilitating aural tuning in a receiver fitted with automatic volume control.

Murphy Radio and L. A. Moxon. Application date 2nd July, 1934.

444 178.—Wireless receiver with feed-back coupling between two valves designed to give maximum "selectivity" with maximum "gain," and *vice versa.*

Marconi's W.T. Co., and N. M. Rust. Application date 15th August, 1934.

444 179.—Tuning indicator which serves to indicate both the presence of a relatively weak signal and also the comparative strength of a stronger one.

F. T. Lett. Application date 16th August, 1934.

444 608.—High-frequency coupling system, for all-wave receivers, designed to reduce the production of "parastic" currents.

Hazeltine Corporation (assignees of J. K. Johnson). Convention date (U.S.A.) 27th February, 1934.

444 826.—Superhet receiver in which A.V.C. is effected by controlling the anode voltage of the local-oscillator valve directly from the output of the second detector.

British Tungsram Radio Works and J. A. Szabadi. Application date 15th October, 1934.

445 030.—Receiver with two systems of A.V.C., one of which controls the input valve by voltages derived from a point in the circuit where the selectivity is comparatively low.

Marconi's W.T. Co. (assignees of K. A. Chittick). Convention date (U.S.A.) 30th September, 1933.

445 033.—All-wave receiver in which an extra H.F. valve is automatically inserted between the aerial and the input on the short-wave setting of the wave-band switch.

Marconi's W.T. Co. (assignees of W. La V. Carlson and V. D. Landon). Convention date (U.S.A.) 30th September, 1933.

445 350.—Method of automatically correcting for the initial mistuning of a wireless receiver.

E. K. Cole and G. Bradfield. Application date, 5th October, 1934.

445 543.—Automatically correcting for the initial mistuning of a wireless receiver by making use of the Miller effect in a valve shunted across the circuit to be corrected.

Marconi's W.T. Co. and N. M. Rust. Application date 14th September, 1934.

448 147.—Diversity-reception system designed to overcome the effects of fading.

Marconi's W.T. Co. (assignees of M. G. Crosby). Convention date (U.S.A.), 28th May, 1934.

448 268.—Tuning dial in which the station received is identified by the lighting-up of a corresponding point on a translucent map of Europe.

G. B. Kemp; L. A. Armstrong; and J. W. Courtman). Application date 5th December, 1934.

449 163.—Two-wave tuning circuit for wireless receivers employing iron-cored inductance coils.

W. J. Polydorff and V. Dumert. Application date 17th December, 1934.

2 013 650.—Selective input coupling for a wireless receiver in which the usual increase of effective resistance with increase of signal frequency is minimized.

W. F. Curtis.

2 020 409.—Method of frequency selection suitable for receiving one only of the two side-bands of a normally-modulated carrier-wave.

E. I. Green (assignor to American Telephone and Telegraph Co.).

VALVES AND THERMIONICS

444 567.—Construction of short-wave valves of the so-called acorn type.

Marconi's W.T. Co. (assignees of G. McN. Rose, Jr.). Convention date (U.S.A.) 24th June, 1933.

444 633.—Conical electrode assembly for a cathode ray tube, designed to facilitate accurate centering during assembly.

Radio Akt. D. S. Loewe and B. Wienecke. Convention date (Germany) 23rd September, 1933.

444 775.—Coating the deflecting-electrodes of a cathode-ray tube with a layer of alkaline-metal oxide or other highly emissive substance.

F. J. G. van den Bosch. Application date 13th February, 1935.

444 844.—Indirectly-heated cathode in which the emissive surface is formed by two intersecting convex surfaces, each forming part of a cylinder.

Telefunken Co. Convention date (Germany), 1st March, 1934.

445 285.—Electrode mounting for high-powered valves generating wavelengths of the order of 10 metres.

Telefunken Co. Convention date (Germany) 7th October, 1933.

445 507.—Cathode-ray tube with adjustable electrode, movable from outside the tube, to focus or adjust the electron stream.

F. J. G. van den Bosch. Application date 10th July, 1935.

449 127.—Method of "gettering" used in valve manufacture.

British Thomson-Houston Co. Convention date (U.S.A.) 13th September, 1934.

DIRECTIONAL WIRELESS

444 393.—Wireless system for automatically steering an aeroplane or other moving craft.

Siemens and Halske Akt. Convention date (Germany), 16th August, 1933.

444 850.—Combined short-wave radio and light-projecting beacon station for aircraft navigation.

Marconi's W.T. Co. (communicated by the Telefunken Co.). Application date 27th March, 1935.

TELEVISION AND PHOTOTELEGRAPHY

444 133.—Single-valve time-base circuit for generating both the line and frame scanning voltages required for television.

D. M. Johnstone and Baird Television. Application date 24th December, 1934.

444 151.—Method of projecting the object to be televised on to the photo-electric screen of a cathode-ray tube of the Iconoscope type.

Telefunken Co. Convention date 14th July, 1934.

444 774.—Circuit designed to receive television and sound signals simultaneously.

L. R. Merdler and Baird. Television. Application date 8th February, 1935.

445 068.—Method of preparing a permanent record of a television programme for subsequent use in a television receiver.

E. W. C. Russell. Application date 13th April, 1935.

445 372.—Cathode-ray tube with "cellular" anode and photo-sensitive electrodes for transmitting or receiving television.

A. B. Shorney. Application date 30th, November, 1934.

445 485.—Preventing the rapid deterioration of the photo-electric mosaic-cell electrode in a cathode ray tube of the Iconoscope type.

J. D. McGee and G. S. P. Freeman. Application date 24th October, 1934.

445 894.—Arrangement for reducing "flicker" in television by scanning alternately in two different directions.

Marconi's W. T. Co.; H. M. Dowsett and L. E. Q. Walker. Application date 19th October, 1934.

446 664.—Cathode-ray tube fitted with a mosaic-cell photo-sensitive electrode on which the picture to be televised is focused.

J. D. McGee. Application date 20th September, 1934.

448 238.—Optical system for multiplying the line-frequency in a scanning system of the rotating-mirror type.

E. Traub. Application date 3rd December, 1934.

2 017 136.—Film television system in which provision is made to quench the scanning arc-lamp should the transmission be interrupted, in order to avoid warping of the film by heat.

M. A. Trainer (assignor to Radio Corporation of America).

2 017 659.—Method of superposing the different light values in a system of coloured television.

H. E. Ives (assignor to Bell Telephone Labs. Inc.).

SUBSIDIARY APPARATUS AND MATERIALS

444 201.—Suppressing radiation from the ignition system of a motor car fitted with a wireless receiver.

Marconi's W.T. Co. and A. A. Linsell. Application date 15th September, 1934.

445 498.—Light valve of the Kerr-cell type designed to minimise the overall size and to give higher efficiency.

E. Traub. Application date 4th December, 1934.

445 970.—Design of suppressor units used for preventing radiation interference with broadcast reception.

Belling and Lee and A. G. Haslam. Application date 30th January, 1935.

448 189.—Loudspeaker in which the magnetic system is of conoidal shape and is mounted inside the throat of the horn where it serves as a phase-equaliser.

E. K. Cole and A. E. Falkus. Application date 15th December, 1934.

MISCELLANEOUS

444 316.—Circuit for synchronising clocks by wireless control from a distant transmitter.

J. E. Purser. Application date 18th Aug, 1934.

2 013 594.—Photo-electric cell used as a drift-indicator for an aeroplane.

V. K. Zworykin (assignor to Radio Corporation of America).

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