A B.

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AND

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Editorial

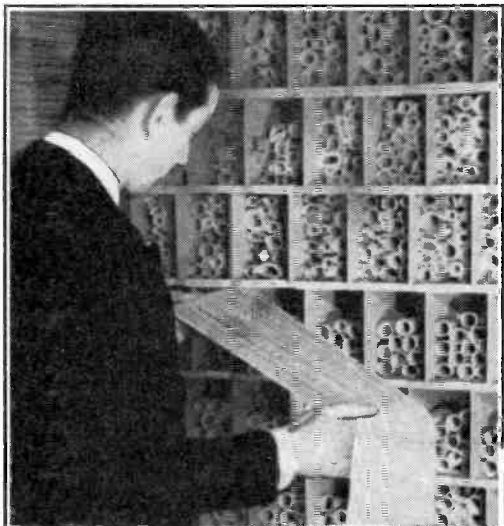
Electrically Maintained Tuning Forks

WHEN a tuning fork is used for its original purpose it is essential that it should communicate energy to its surroundings. When it is fixed to or held on a sounding board or resonant box its power of communicating its energy is increased. The vibration of the prongs causes small variations in the axial length of the fork, and therefore some parts of the fork must have an axial movement in addition to the more obvious transverse movement of the prongs. It is this axial movement of the stalk which communicates the energy to the sounding board. If suspended freely in space, some point of the prongs will have no axial movement, whilst the free ends of the prongs and the stalk will have axial oscillation. To allow this axial movement of the stalk to take place unhindered, and thus keep the damping down to a minimum, the Lorenz Company, in their tuning fork device for controlling the frequency of radio transmitters, suspend the fork on thin corrugated aluminium bands attached to the stalk. Care is taken that any natural frequencies of the supports are far removed from the fork frequency.

It may be doubted, however, whether such an unbalanced system is desirable when the need for communicating the vibrations produced by the want of balance to the surroundings no longer exists. If a very heavy mass were fastened to the stalk the point of zero axial movement would shift towards that end, and if one could go a step farther and assume the stalk to be rigidly fixed in some ideal manner to an infinitely rigid support, no energy could be transmitted from the fork to it. Now this ideal can be realised by arranging two exactly similar forks back to back, i.e., one at each end of a common stalk. If each fork is electrically maintained but with the coils connected in the anode and grid circuits of a common valve, any slight difference of natural mechanical frequency will be automatically corrected. The coils must be so connected that both forks move similarly, i.e., that both sets of prongs move apart simultaneously and together simultaneously. If they are identical they will exert equal and opposite forces on the stalk, which will have no tendency to move and the whole system can be mounted on a support clamping the system at the centre of the stalk. There would be no need for any elastic support since the support would be free from vibration, and the whole system would be balanced. This advantage is not obtained, however, without some counterbalancing disadvantage. The axial restraint sets up stresses in the steel and it is obvious that the stalk is subjected to rapid tension and compression. These alternating stresses will cause loss of energy and introduce a damping which was not present to the same extent in the single elastically supported fork. It may be that this increased damping, even when every precaution has been taken to reduce it to a minimum, will be so considerable as to outweigh the advantages of the balanced system.

It is questionable whether in such a balanced system there is any advantage in using forks of the usual classical pattern in preference to a simple arrangement of four vibrating reeds carried on a central support which could be a simple rectangular block.

G. W. O. H.

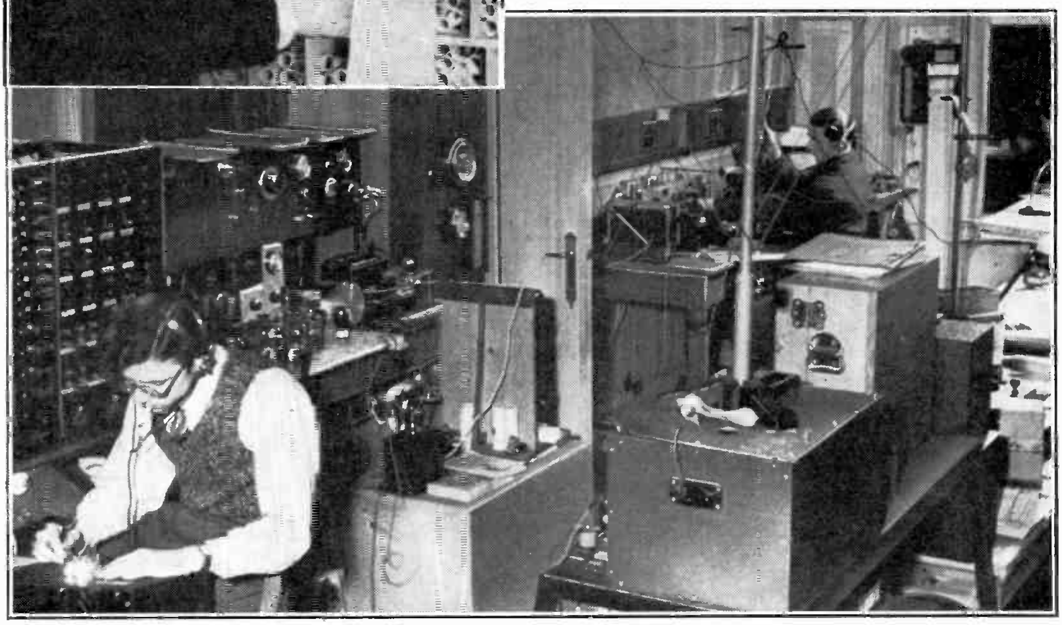


WAVELENGTH CHECKING IN BRUSSELS

LACK of space is proving a serious difficulty at the International Broadcast Checking Station, presided over by M. Raymond Braillard in Brussels. The left-hand picture shows the archives in which the monthly wavelength charts for each European station have been kept since 1930.

The lower picture, giving a general view of the interior of the checking station, is eloquent of the urgent need for more space.

In the left foreground is the frequency measuring gear; behind the engineer is the apparatus for measuring modulation. In the background is a field strength "explorer"—a modified superhet receiver with tuning controls driven by a special mechanical device providing a paper record of the reception field strength of all European stations receivable in Brussels.



The Mechanism of Electronic Oscillations*

By W. E. Benham

Marconi's Wireless Telegraph Co., Ltd.

THERE is at present a drift of opinion from the "swinging electron conception" of the oscillations produced in a retarded field triode towards an explanation depending mainly on the phase differences between electron current and voltage brought about by electron inertia.

The object of this note is to explain as simply as possible the view now gaining ground, and at the same time to arrange matters in such a way as to allow for the existence of a proportion of electrons which must, as universally agreed, swing to and fro on either side of the grid.

Referring to Fig. 1 in which *V* may be considered as representing a plane or cylindrical triode with cathode *C*, grid *G*, plate *P*, electrons accelerated by *G*, are caused to turn back before reaching *P* at *K*. It can be shown that, in cases where *P* is only slightly negative in potential with respect to *C*, *K* may be regarded as a virtual cathode, but it can also be shown† that the alternating current properties of *K* may be very different from those associated with the real cathode *C* in that large alternating potentials can exist at *K*, whereas the alternating potential at *C* can be made zero by earthing that electrode.

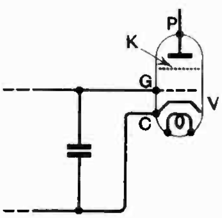


Fig. 1.

The question as to why the oscillations are maintained may be approached in the following manner.

Let us suppose a small oscillation to be already produced. If the electrons were entirely without inertia, they would respond immediately to changes in the electrode potentials and there would be zero phase difference between the electron current received by any electrode and the potential of that electrode. Because of electron inertia the electrons do not respond immediately to rapid changes in potential, and in consequence the electron current lags in phase behind the potential.

In order to give mathematical expression to the above, we might start as follows. Consider the alternating potential

$$e = E_1 \epsilon^{jpt}$$

to exist between the pair of electrodes, *C* and *G* (Fig. 1). Only two electrodes are necessary to produce electron oscillations; the effect of the third electrode *P* may be regarded as subsidiary only in considering the mechanism at work. The resulting alternating component of electron current between *C* and *G* may be written:

$$i = I_1 e^{j(pt - \eta)}$$

where η is the phase difference introduced by electron inertia. Then the impedance of the electron path between *C* and *G* may be represented by

$$z = \frac{e}{i} = \frac{E_1}{I_1} \epsilon^{j\eta} = Z_1 \epsilon^{j\eta}$$

The real part of *z* may be represented by *R* and is given by

$$R = Z_1, \cos \eta$$

It is seen that the value of *R* lies somewhere in the range $-Z_1$ to $+Z_1$. The range of η corresponding to negative values of *R* is clearly given by

$$\frac{\pi}{2} < \eta < \frac{3\pi}{2} \qquad \ldots \quad \ldots \quad (1)$$

The above simple analysis was given by Hershberger (Ref. 3), but does not fully represent the effects of electron inertia. It is to be noted here that displacement current is not referred to. The importance of the latter will be evident from Fig. 2, which shows the large value of admittance

* MS. accepted by the Editor, November, 1934.

† The alternating current properties of a virtual cathode have been studied in detail, in a paper entitled "Electronic Theory and the Magnetron Oscillator," which is due to appear shortly in "The Proceedings of the Physical Society."

at high frequencies. Condition (1) would be quite in order were it not for a phase difference differing from $\frac{\pi}{2}$ between the calculated values of displacement current and voltage, suggesting a form of loss in the elec-

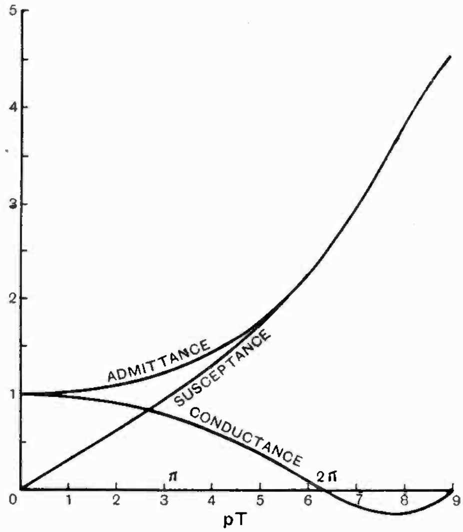


Fig. 2.

tron atmosphere. This " loss " could only be measured at the electrodes of the valve, so that we cannot say that there is a *real* loss in the dielectric constituted by the electrons. This aspect is nevertheless convenient for present purposes, but will be discarded later. If space charge is negligible negative damping cannot arise (except possibly with the assistance of an applied magnetic field), so that it is absolutely essential to include the effect of space charge.

In the case of a plane diode limited by space charge (Ref. 1), to which Fig. 2 refers, it can be shown that the range of values of η which corresponds to negative damping is actually

$$\pi < \eta < 2\pi \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

We may explain the difference between conditions (1) and (2) on the basis of the " dielectric loss " referred to above. The " dielectric loss " over the range

$$\frac{\pi}{2} < \eta < \pi$$

is such as to prevent the negative resistance effect from showing itself. Conversely, the " dielectric loss " over the range

$$\frac{3\pi}{2} < \eta < 2\pi$$

is negative, so that the overall effect of a negative resistance is obtained, despite the positive value of R.

Referring to Fig. 3, also reproduced from Reference (1), $\frac{r}{R_0}$ represents the " dielectric loss " and $\frac{R}{R_0}$ the main valve resistance in terms of the zero frequency value R_0. The ranges of pT for which r is positive and negative respectively correspond to the ranges of η discussed above.

As might be expected, the value of η corresponding to maximum negative damping is close to the middle of the range given by (2), *e.g.*,

$$\eta \doteq \frac{3\pi}{2} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

It is important to note that i and η refer to the *electron current* between the electrodes. *There are no means of measuring this current* at high frequencies by apparatus external

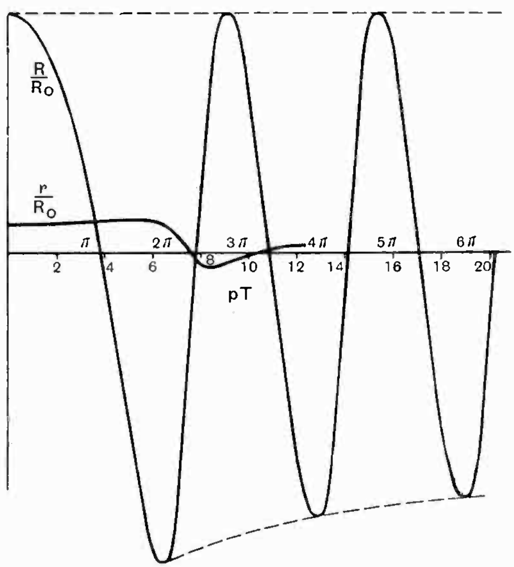


Fig. 3.

to the valve. Hence the importance of the *total* current, which can be measured and therefore has a real significance. The calculation of η is nevertheless of interest in that it expresses the electron lag, whereas the phase angle of the total current is modified by the presence of a large proportion of displacement current. Actually, the total current *leads* the potential in phase. In reference (1) the total current is *assumed* and the angle of lag of the potential, etc., *evaluated*. This method obviates the necessity of a "dielectric loss," which may therefore be regarded as fictitious. Thus part of the electrostatic potential at points in between the electrodes is set up by the electrons themselves, so that electron inertia influences the phase of the potential at intermediate points. The fact that the phase difference between displacement current and potential differs from $\pi/2$ is not due to dielectric loss, but merely to electron inertia.

The next step is to determine the value of η in terms of the electron transit time T. The latter is known in terms of the electrode potentials, geometry and space charge. Negative damping is only effective when *both* resistances of Fig. 3 are negative. The condition of maximum negative damping is also one of maximum negative conductance. From Fig. 2 this is seen to occur when

$$pT \doteqdot \frac{5}{2}\pi \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

If by some artifice the loss introduced by the large proportion of current which is associated with the resistance r of Fig. 3 could be removed, electron oscillations would be much easier to obtain. It is probable that such an artifice has already been adopted, the split anode magnetron being a case in point. From (3) and (4)

$$\eta \doteqdot \frac{3}{5}pT \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

which means that the time delay between *electron current* and *voltage* under the conditions for which maximum negative damping occurs is approximately three-fifths of the electron transit time. At very low frequencies the time delay between electron current and voltage is only $\frac{11}{30}$ of the transit time, as may be seen by inspection of Table II of Reference 1. The result that the electron lag, as expressed by η/p, is less than T would be expected from the fact that at the instant of applying the a.c. potential electrons quite near the positive electrode have only a small transit to perform.

Condition (4) corresponds to

$$T_0 = 0.82\,T \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

where T_0 is the time period of the oscillation.* The relation (6) was given in Ref. 1 from the data presented therein. What follows has not, however, to my knowledge been published in detail.

Now while it is true that equation (6) was derived by treatment of a plane "solid anode" construction, it is reasonable to expect that with suitable conventions we may extend this result so as to cover the case where the anode is perforated (grid). In this case the transit time to be considered is not the time of a direct transit of electrons from filament to grid, but is more nearly the time of transit from C to K and back again to G. If we consider a plane triode for simplicity, the transit time from C to G being T, the transit time of electrons which pass through G, reach K and return to alight on G will be very nearly $3T$. The value of the phase angle η corresponding to these electrons will be given by

$$\eta = \frac{9}{5}pT$$

and if these were the only electrons responsible for oscillations the latter would be of time period :

$$T_0 = 3 \times 0.82\,T = 2.46\,T$$

Electrons which miss the grid on the return journey from K and pass again into the grid-cathode space before alighting on the grid may also be involved in the mechanism of oscillation. In order to take into account all possible groups of electrons which miss the grid once, twice, three times, and so on, before being collected, let us denote by N_1 the number of electrons which miss the grid on the first outward journey

* J. Müller (reference 4) has recently been successful in confirming the existence of electronic oscillations in a diode with planar indirectly heated cathode and a pair of parallel anodes between which a tuned circuit is connected. The wavelength range was in accordance with theory, T_0 being given roughly by equation (6). As predicted in reference (1), the oscillations were found to be extremely weak, despite the careful elimination of losses.

from the cathode. We need not consider the electrons which are collected by the grid on the first outward journey as these are known not to contribute to the negative damping and the current which they provide may usually be reckoned as a dead loss. Thus if the grid were replaced by a cylindrical tube the diode thus formed cannot be made to oscillate (Reference 2, p. 320).

So far we have not considered the influence of the plate P. Apart from the effect of the potential of P on the position of K, the transit time will not be affected for small amplitudes of oscillation. In the mathematics which follows the possibility that P and C may capture electrons as they swing about the grid is included, and it is clear that for large amplitudes of oscillation the effective transit time is reduced ($\alpha < 1$, $\beta < 1$). No attempt is made to calculate the extent of the reduction, but this could doubtless be done.

Following the course of electrons which miss the grid on the outward journey, the majority of these will reverse their direction in the neighbourhood of the virtual cathode K and make their way back towards the grid G. A few will be collected by the plate P when oscillations are present. Let N_2 be the number of electrons returning from K, and let a fraction ϕ of these be collected by the grid. Then the number of electrons which have the transit time $3T$ is

$$N_2 \times \phi \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

Of the N_2 $(1 - \phi)$ electrons which again enter the cathode-grid space, a certain number may re-enter the cathode when oscillations are present, but the great majority will be reversed in direction just in front of the cathode and proceed again towards the grid. Let this number be αN_2 $(1 - \phi)$, where α is very nearly unity. Of this number a fraction ϕ will again be collected by the grid, so that the number of electrons which have the transit time $5T$ is

$$\alpha N_2(1 - \phi) \times \phi \quad \ldots \quad \ldots \quad (8)$$

Of the αN_2 $(1 - \phi)^2$ electrons which again enter the grid anode space a certain number will be collected by the plate P but the great majority, say a fraction, β where $\beta \doteq 1$ will pass back towards G. The number of electrons which have the transit time $7T$ is then

$$\beta\alpha N_2(1 - \phi)^2 \times \phi \quad \ldots \quad \ldots \quad (9)$$

We may thus define the effective average transit time T^1 in the following way :—

$$N_2 \,.\, T^1 = 3T \,.\, N_2\phi + 5T \,.\, \alpha N_2(1 - \phi)\phi + 7T\alpha\beta N_2(1 - \phi)^2\phi + \ldots \quad \ldots \quad (10)$$

The above may be divided throughout by N_2, giving the effective average transit time of an electron which misses the grid at least once. On re-arrangement we obtain :—

$$T^1 = T\phi[3 + 5\alpha(1 - \phi) + 7\alpha\beta(1 - \phi)^2 + \ldots] \quad (11)$$

The upper limit to T^1 for a given value of ϕ is obtained by giving both α and β the approximate value unity. We then obtain

$$T^1 = T\phi \sum_{n=0}^{n=\infty} (3 + 2n)(1 - \phi)^n \quad \ldots \quad (12)$$

The series can be shown to be absolutely convergent for all positive values of $1 - \phi$ less than unity, and to have the sum

$$\frac{3}{\phi} + \frac{2(1 - \phi)}{\phi^2} \quad \ldots \quad \ldots \quad (13)$$

We thus have

$$T^1 = 3T + \frac{2T(1 - \phi)}{\phi} \quad \ldots \quad \ldots \quad (14)$$

The influence of the grid pitch on the effective transit time T^1 will be seen from Table I.

TABLE I

Grid Capture Fraction ϕ	$\frac{T^1}{T}$	$\frac{T_0}{T}$
0	∞	—
$\frac{1}{4}$	9	7.38
$\frac{1}{2}$	5	4.10
$\frac{3}{4}$	3.6	3.01
1	3	2.46

The value $\phi = 0$ corresponds to no grid at all ; $\phi = \frac{1}{4}$ to a grid of very open type such as the Marconi LS5A. The values of $\frac{T^1}{T}$ will be on the high side, especially if the oscillations are strong, in which case it is very doubtful whether the approximation $\alpha = \beta = 1$ is justified. The last column gives the ratio $\frac{T_0}{T}$ using the relation $\frac{T_0}{T} = \frac{.82T^1}{T}$, and represents the ratio of the time period of oscillation to the time of transit (filament to grid). The values of $\frac{T_0}{T}$ are likewise on the high side, for reasons given above, but the error is not likely to be great for values of ϕ between $\frac{1}{2}$ and 1. It must also be remembered that in the case of cylindrical valves the transit time (cathode to grid) is almost invariably shorter than the transit time (grid to virtual cathode), and it is thus evident that a cylindrical geometry requires a separate treatment along similar lines. It is, however, likely that Table I applies with fair accuracy to cylindrical triodes if T is taken as $\frac{1}{2}(T_{C\rightarrow G} + T_{G\rightarrow K})$.

On the Barkhausen-Kurz conception oscillations were supposed to be produced by electrons proceeding from F to K and back again to F, the time period being given by

$$T_0 = 4T \quad \ldots \quad \ldots \quad \ldots \quad (15)$$

The fact that experimental results have on the whole shown fair agreement with equation (15) has been a factor which has largely influenced the acceptance of the so-called "swinging electron" hypothesis. From the present note, however, we see that the ratio $T_0/T = 4$ predicted by (15) would also correspond to $\phi = \frac{1}{2}$ nearly (Table 1) and it is significant that values on either side of 4 have been observed experimentally. In particular, fairly definite confirmation is available in the case of valves with closely wound grids, such as correspond to a value of ϕ in the neighbourhood of $\frac{3}{4}$. In Marchese Marconi's Microwave equipment the oscillations are of such a frequency that T_0/T works out to about 2.8 : 1 which is quite close to the value 3.01 given in Table 1. It is, however, not the purpose of the present note to dwell too much on the question of experimental agreement, if only for the reason that for the reasons already given the calculations are necessarily somewhat approximate. If from the description presented the new point of view becomes better understood the object of this note will have been served.

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The Physical Society's Exhibition

THE Twenty-fifth Annual Exhibition of Scientific Instruments and Apparatus, arranged by the Physical Society, will be held on January 1st, 2nd and 3rd, 1935, at the Imperial College of Science and Technology, Imperial Institute Road, South Kensington, London, S.W.7. The Sessions will be as follows :—

Tuesday, January 1st, 1935 (admission by ticket only), 3 p.m. to 6 p.m. and 7 p.m. to 10 p.m.

Wednesday, January 2nd, 1935, 2 p.m. to 4 p.m. (session for members only, admission by members' tickets only). 4 p.m. to 6 p.m. and 7 p.m. to 10 p.m. (admission by ticket only).

Thursday, January 3rd, 1935 (admission without ticket), 3 p.m. to 6 p.m. and 7 p.m. to 10 p.m.

The leading manufacturers of scientific instruments will be exhibiting their latest products in the Trade Section. The Research and Experimental Section will contain contributions from most of the important research laboratories in Great Britain, and there will be a special sub-section devoted to experiments of educational interest. In addition, the work submitted for the Craftsmanship Competition by apprentices and learners will be on view.

Discourses will be delivered each day at 8 p.m. as follows :—

January 1st.—B. Wheeler Robinson, M.A., Ph.D., "The Architecture of Molecules."

January 2nd.—C. V. Drysdale, C.B., O.B.E., D.Sc., M.I.E.E., F.Inst.P., "The Problem of Ether Drift."

January 3rd.—H. Spencer Jones, M.A., Sc.D., F.R.A.S., F.R.S., "Giant Telescopes."

Members of Institutions and Scientific Societies may obtain tickets from their Secretaries; tickets may also be obtained direct from the Exhibition Secretary, 1, Lowther Gardens, Exhibition Road, London, S.W.7.

Thermionic Emission.

By ARNOLD L. REIMANN, B.Sc., Ph. D., F.Inst.P. A member of the Research Staff of the General Electric Co., Ltd., and of the M.O. Valve Co., Ltd., Wembley.

This book deals very comprehensively with the whole subject of thermionic emission and is intended for the serious student. Pp. 324 + xi, with 64 graphs. Published by Messrs. Chapman and Hall, 11, Henrietta Street, Covent Garden, London, W.C.2. Price 21s. net.

Incremental Permeability and Inductance*

The Rôle of Waveform in Measurement

By L. G. A. Sims, Ph.D., M.I.E.E.

Introduction

IN the measurement of the incremental permeability or inductance of ferromagnetic materials complications arise due to the necessity for having a steady current present in the exciting winding during the measurement as well as an alternating component. This combination makes the familiar types of A.C. indicating instruments (such as, for example, the dynamometer or the moving iron or hot wire instrument) unsuitable because they are unable to discriminate between the alternating and steady quantities, of which only the former may be directly required in the measurement. Frequently the D.C. quantity is the greater, in which case the calculation of the alternating component, though theoretically possible, becomes inaccurate. For this reason, also because the currents involved are sometimes very small, methods of measurement have been used which do not follow the classic methods employed for testing iron under simple alternating or simple steady excitation.

The present contribution, in dealing with a number of such special methods, attempts to clarify certain aspects of their theory, particularly the part played by waveform.

In Fig. 1 are shown waveforms of exciting current of a simple alternating nature, flowing into a winding upon a closed iron core. The oscillograms were taken for different amplitudes of sinusoidal voltage at the terminals of the winding. The current waveform is seen to be far from sinusoidal even at low inductions, but the positive and negative half waves are mirror images of one another and only odd harmonics are present. This is typical of simple alternating excitation.

* MS. accepted by the Editor, May, 1934.

In Fig. 2 an exciting current wave is shown for the case when the same core and winding are subjected to combined D.C. and A.C. excitation, the D.C. component being fairly large. It will be seen that positive and negative half waves are no longer similar. Both odd and even harmonics are present.

This results, of course, from the fact that the hysteresis loop is displaced. If the point P on the magnetisation curve OA of Fig. 3 represents a state of steady magnetisation, then, if cyclic magnetisation of sequence $+\frac{\Delta H}{2} - \frac{\Delta H}{2}$ be superimposed, the path $PCDC$ will be traced. The path will differ to

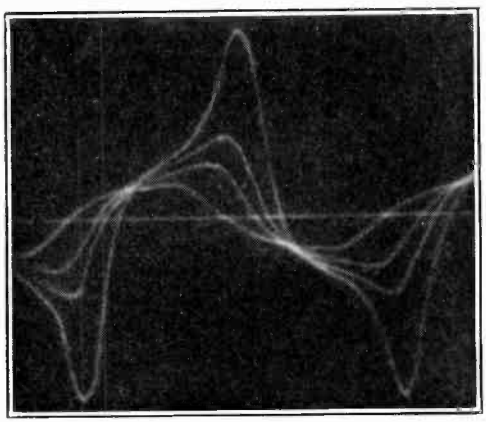


Fig. 1.

some extent if the negative half of the cycle be superimposed first. It is known that the slope of the cyclic figure is not stable until a number of cycles has been completed. It cannot be quite symmetrical even in its final form, though this has not always been recognised by experimenters. A loop which is symmetrical about the origin of axes is itself of symmetrical form and therefore can produce only odd harmonics of current or flux. But the displaced loop must also produce even harmonics.

If from an oscillogram the minor or displaced loop of large amplitude be reconstructed, it is found to approximate very

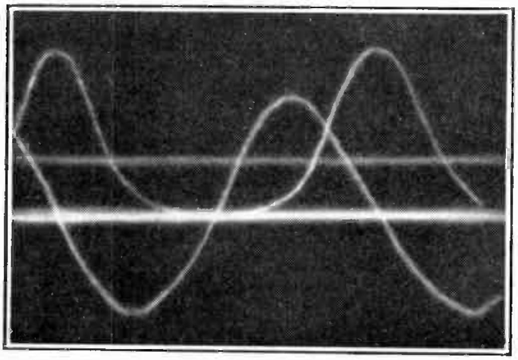


Fig. 2.

roughly to a bent ellipse. The diagram of Fig. 3 illustrates the general shape.

The presence of even harmonics in the flux cycle associated with such a loop can be most readily demonstrated by forcing sinusoidal current through the exciting winding, when the flux harmonics appear in exaggerated form in the induced voltage wave. This is demonstrated by the oscillogram of Fig. 3*a*. The sinusoidal waveform is that

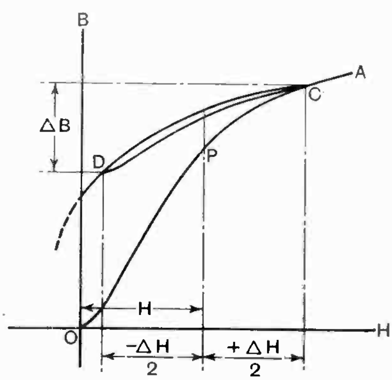


Fig. 3.

of the exciting current, superimposed upon a direct current. The amplitude of the A.C. was such that the resultant current did not reverse in sign. Under these conditions the induced voltage wave was of the irregular form shown, the presence of even harmonics being clearly evident in this voltage wave and therefore, by inference, in the flux wave.

It is very helpful to have in mind certain of the properties of periodic complex waveforms in order that the simple properties of the wave containing only odd harmonics (characteristic of pure A.C. excitation) may not obscure the complex considerations which arise when incremental magnetisation is concerned.

We may write a Fourier series in the form

$$f(t) = a_1 \sin\theta + a_2 \sin(2\theta - \alpha_2) + a_3 \sin(3\theta - \alpha_3) + \ldots\ldots + a_p \sin(p\theta - \alpha_p)$$

then, for a flux wave, an ordinate at angle θ will be given by

$$\phi_\theta = \phi_1 \sin\theta + \phi_2 \sin\overline{2\theta - \alpha_2} + \phi_3 \sin\overline{3\theta - \alpha_3} + \ldots\ldots + \phi_p \sin(p\theta - \alpha_p)$$

As we shall not be concerned with the formal proof of Fourier's theorem, but only with applications in which a statement of all terms of the series is not necessary, we may simplify the expression for ϕ to the form

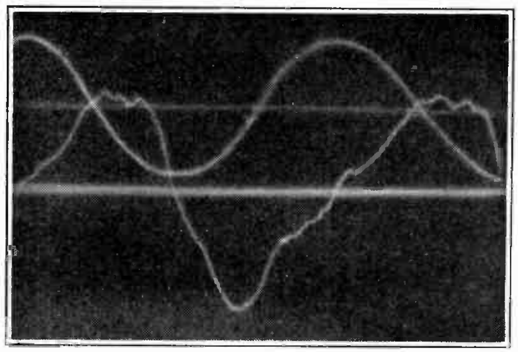


Fig. 3a.

$$f(t) = \phi_\theta = \phi_1 \sin\theta + \phi_n \sin\overline{n\theta - \alpha_n} \quad .. \quad (1)$$

where n may be any positive integer. That is, in equation (1) we take a component of fundamental frequency and a typical harmonic. It will be straightforward to interpret results obtained from this compact form as though they had been obtained from the full Fourier series.

Case I.—The function must be symmetrical in respect of a period 2π for all integral values of n. That is,

$$f(t) = f(2\pi + t) \quad \ldots \quad \ldots \quad (2)$$

At angle $(2\pi + \theta)$,

$$\phi_{(2\pi+\theta)} = \phi_1 \sin(2\pi + \theta) + \phi_n \sin[n(2\pi + \theta) - \alpha_n]$$
$$= \phi_1 \sin(2\pi + \theta) + \phi_n \sin[2n\pi + n\theta - \alpha_n]$$
$$= \phi_1 \sin\theta + \phi_n \sin(n\theta - \alpha_n)$$

or $\phi_{(2\pi+\theta)} = \phi_\theta$ for all integral values of n.

So the flux wave containing odd and even harmonics of any phase repeats exactly each 2π radius so long as the term harmonic is understood to infer a frequency which is an integral multiple of the fundamental frequency. (This terminology is, of course, so well understood that it may be thought unnecessary to mention it. But the fact that a wave can readily be synthesised experimentally in which the component frequencies are not multiples of that which might reasonably be regarded as the fundamental —as, for instance, with two or more alternators in series—makes a short comment of some utility.)

Case II.—Half-wave symmetry is peculiar to complex waves containing only odd harmonics and is independent of the phases of the latter. The equation to be considered is

$$f(t) = -f(\pi + t) \quad \ldots \quad \ldots \quad (3)$$

At angle $(\pi + \theta)$

$$\phi_{(\pi+\theta)} = \phi_1 \sin(\pi + \theta) + \phi_n \sin[n(\pi + \theta) - \alpha_n]$$
$$= \phi_1 \sin(\pi + \theta) + \phi_n \sin[n\pi + n\theta - \alpha_n]$$

If n is odd we have

$$\phi_{(\pi+\theta)} = -\phi_1 \sin\theta - \phi_n \sin[n\theta - \alpha_n]$$

or $\phi_{(\pi+\theta)} = -\phi_\theta$

That is, equation (3) is satisfied for all odd values of n.

If n is even

$$\phi_{(\pi+\theta)} = -\phi_1 \sin\theta + \phi_n \sin[n\theta - \alpha_n]$$

or $\phi_{(\pi+\theta)} \neq -\phi_\theta$

That is, equation (3) is not satisfied for even values of n. So a complex wave containing even harmonics does not possess half-wave symmetry. The interval π is not a typical interval if even harmonics are present, though it is typical if only odd harmonics occur, whatever their phases.

Case III.—Complex waves containing odd or even harmonics, all in phase with the fundamental,* have a special symmetry of the form

$$f(t) = -f(2\pi - t) \quad \ldots \quad \ldots \quad (4)$$

At angle $(2\pi - \theta)$

$$\phi_{(2\pi-\theta)} = \phi_1 \sin(2\pi - \theta) + \phi_n \sin[n(2\pi - \theta) - \alpha_n]$$
$$= \phi_1 \sin(2\pi - \theta) + \phi_n \sin[2n\pi - n\theta - \alpha_n]$$
$$= -\phi_1 \sin\theta - \phi_n \sin[n\theta + \alpha_n]$$

Thus

$$\phi_{(2\pi-\theta)} = -\phi_\theta \text{ only when } \alpha_n = 0 \text{ or } \pi.$$

Therefore symmetry of this form (which is not true half-wave symmetry) is possible with harmonics of any order so long as each harmonic is either in phase or in antiphase with the fundamental. (It is perhaps worth noting that the condition is *not* peculiar to waves containing only even harmonics. At least one well-known text-book is in error upon this point, and the slip may have found its way into others. The condition is characteristic of harmonic phasing.)

Case IV.—Quarter-wave symmetry is possible in complex waves containing only odd harmonics, which must be in phase or antiphase with the fundamental. The equation to be considered is

$$f(t) = f(\pi - t) \quad \ldots \quad \ldots \quad (5)$$

$$\phi_{(\pi-\theta)} = \phi_1 \sin(\pi - \theta) + \phi_n \sin[n(\pi - \theta) - \alpha_n]$$
$$= \phi_1 \sin(\pi - \theta) + \phi_n \sin[n\pi - n\theta - \alpha_n]$$

If n is odd and $\alpha_n = 0$ or π

$$\phi_{(\pi-\theta)} = \phi_1 \sin\theta + \phi_n \sin n\theta$$

that is $\phi_{(\pi-\theta)} = \phi_\theta$ and equation (5) is satisfied.

If n is even or if α_n is finite, equation (5) is not satisfied.

Therefore, quarter-wave symmetry is peculiar to complex waves containing only odd harmonics in phase or antiphase with the fundamental. (If harmonics are absent, the simple sine wave has, of course, quarter-wave symmetry. It also possesses all the other degrees of symmetry we have considered.)

Since, by Case II, all complex waves containing only odd harmonics, of any phase, possess half-wave symmetry, therefore

* *i.e.*, When $t = 0$ both fundamental and harmonic are zero and changing in the same direction.

Case IV is included by Case II, and waveforms having quarter-wave symmetry have also half-wave symmetry.

The cases considered demonstrate that the conditions in iron when excited by alternating current alone are much simpler than those which exist when both A.C. and D.C. excitation are applied. In the former case only odd harmonics appear, and the waveforms produced have mathematical symmetry which is never of an order less than that covered by Case II. This simplifies the theory of measurement appreciably. When D.C. and A.C. are present the even harmonics which occur render the degree of waveform symmetry never better than that of Case III. In general the waveform is mathematically quite unsymmetrical, since it is not certain that the harmonic phase requirements of Case III will be met. In any event, Case III does not open any avenue by which easy measurement may be approached, and the unsymmetrical waveforms may therefore be considered without further reference to this special case.

Methods of Measurement

Various methods of measurement may now be considered, the following symbols being used.

B. H. = steady values of induction and magnetising force respectively.

ΔB ΔH = increments of induction and magnetising force due to alternations superimposed upon the steady magnetisation.

u_{Δ} = incremental permeability.

L_{Δ} = inductance corresponding to u_{Δ}.

(1) *Static or Ballistic Method of Measurement of* u_{Δ}.

This method has been used by Elenbaas* and independently by the writer in experiments upon stalloy. It has probably found fairly general application.

A simple form of the circuit is shown in Fig. 4. The test coil is denoted by X, the exciting coil being shown as T_1, the coil T_2 forming a search coil with tappings for connection to a fluxmeter or ballistic galvanometer G. Current is taken from a battery B through variable resistances R_1 and R_2, the latter being short-circuited at will by a rotating commutator C. The current values so obtained are registered by a moving coil meter A.

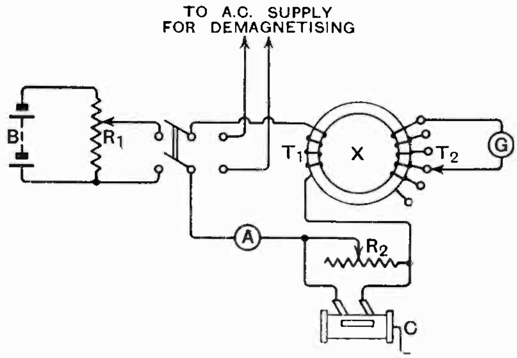


Fig. 4.

The magnetic cycle is illustrated approximately in Fig. 3. The following description of procedure will make it clear that the method is one of simulation. The variations of current produced by the commutator and resistances imitate the alternating component of exciting current experienced in practice by the iron with combined alternating and steady excitation, the alternating component being symmetrical about the steady value.

The test procedure is as follows:—

The current is adjusted to a value corresponding to $\left(H + \frac{\Delta H}{2}\right)$ by means of R_1, the commutator being in a position to short-circuit R_2. The commutator is then turned so as to bring R_2 into circuit, which is then adjusted until the current corresponds to $\left(H - \frac{\Delta H}{2}\right)$. The commutator is rotated about 50 times and the fluxmeter or ballistic galvanometer then connected to the appropriate search coil. The deflection is read for a further single movement of the commutator.

The iron has been excited between the point C on the reversals curve OA (Fig. 3) and the point D on the major hysteresis loop.

* See "De Effectieve Permeabiliteit bij Groote Amplituden." W. Elenbaas. Publication of the Philips Lamp Factory, Eindhoven (*Phipica II.* 209–214, September, 1931).

B

The slope of a straight line joining C and D gives the ratio ($\Delta B/\Delta H$) which is measured.

The excitation should be restored to the point C by the commutator before the next adjustment is made.

The method is very flexible and satisfactory so long as known increments of H are required. It is less satisfactory for stated increments of B as trial and error adjustments for the required ΔB become necessary. The accuracy does not depend mainly upon the fluxmeter or ballistic galvanometer, as might be supposed, as these can, if desired, be referred to a standard mutual inductor for each reading. The accuracy is limited rather by the ammeter, errors of observation becoming evident in measurements in which ΔH is small compared with H, since both have to be measured on the one scale. But this error is clearly only likely to be of importance in extreme cases, since the scale of a good moving-coil instrument enables very close observation to be made.

It is of interest to notice that the method strictly simulates the case of A.C. superimposed upon D.C. only for the case in which the A.C. is switched on, above the D.C., at the instant of passing through zero and growing. But in practice the switching instant must be ignored since it cannot be controlled, nor is it taken into account by other methods of measurement. It is of more importance to notice that the static or ballistic method of measurement takes into account the full amplitudes of ΔB and ΔH and therefore includes in the calculated μ_Δ and L_Δ all the odd and even harmonics as well as the fundamental. Since time does not enter as a factor in the calculations, the waveform does not complicate the measurement.

Other methods of measurement which are commonly used are of the so-called dynamic type—that is, they involve true superimposition of alternating and direct current in the coil under test. Of these, bridge methods form an important group.

(2) *Measurement by Bridge.*

Modifications of Hay's Bridge are usually employed. The British Post Office uses the arrangement shown in Fig. 5.*

* See Ryall, *Post Office Engineers Journal*, Vol. 21, Part IV, 1929.

$L_\Delta r_\Delta$ is the coil under test.

QSP are non-inductive resistances.

C_s is a standard condenser assumed free of loss.

C_1 and C_2 are isolating condensers.

C_3, R_1 and R_2 are components of the Wagner earth.

C_4 isolates the battery B from the detector telephones.

l is a choke to prevent undue shunt action by the battery branch on the detector.

r and mA enable the D.C. to be adjusted, and this can flow only through $L_\Delta r_\Delta$ and Q, in the external circuit.

mV is a Moullin valve voltmeter measuring by volt drop the alternating current passing through P and therefore through $L_\Delta r_\Delta$. It is required for the final specification of L_Δ, but is not essential to its measurement.

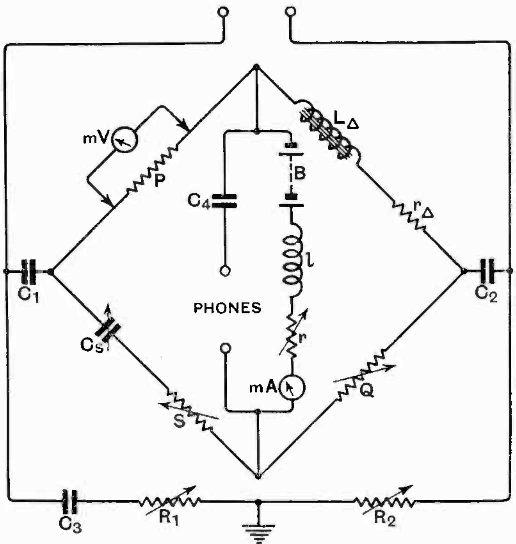


Fig. 5.

A simpler arrangement of the same bridge may be made as in Fig. 6. Here the D.C. passes through the A.C. source, whilst in the previous circuit it was isolated therefrom. There seems to be no great merit in isolating the source so long as the transformer T does not take excessive primary current due to the polarisation of its core. The source should preferably be capable of maintaining a sine wave of voltage despite the distorted current taken from it by T under the test conditions.

For both bridges we have at balance

$$(r_\Delta + j\omega L_\Delta)\left(S + \frac{1}{j\omega C}\right) = PQ$$

$$r_\Delta S + \frac{L_\Delta}{C} + \frac{r_\Delta}{j\omega C} + j\omega L_\Delta S = PQ$$

$$\therefore \frac{L_\Delta}{C} = PQ - r_\Delta S \text{ ....(1) and } r_\Delta = \omega^2 L_\Delta CS\text{....(2)}$$

Putting (2) in (1)

$$\frac{L_\Delta}{C} = PQ - \omega^2 S^2 L_\Delta C$$

whence $$L_\Delta = \left[\frac{PQC}{1 + \omega^2 C^2 S^2}\right] \quad .. \quad .. \quad (6)$$

It will be noticed that both the incremental inductance L_Δ and the loss equivalent resistance r_Δ depend upon ω^2.

It can therefore be seen that a clean balance cannot be expected on account of the current distortion introduced by the iron of the test coil $L_\Delta r_\Delta$, at any rate in those cases where the coil has a closed iron core. The bridge balance is then obtained only for that frequency which predominates, which will normally be the frequency of supply.

Consider now equation (6) in conjunction with Figs. 2 and 3*a*. Assuming that wave-form distortion of the type shown is occurring, the equation cannot yield a single result which represents the true excitation amplitude.

In general we have

$$L_\Delta \alpha \mu_\Delta \alpha \frac{\Delta B}{\Delta H}$$

But the ratio so obtained may differ appreciably from the true value, which is indicated by the oscillograms of Figs. 2 and 3*a*, and, as already stated, will only include the amplitude of the fundamental frequency component. This cannot readily be avoided when bridge measurements are employed. If telephones are used for detection, the effects of the harmonics are audible but have to be ignored, the balance being made by selecting the fundamental tone. If a vibration galvanometer is used as a detector, it is theoretically possible to obtain a series of balances corresponding to the fundamental and the more prominent harmonics by altering the tuning of the galvanometer and the adjustment of the bridge components, thus providing material for a series of solutions of equation (6). But, apart from the practical difficulties entailed, the solutions so obtained would be of little value since, in order to relate these with the true magnetisation cycle, the relative phases of the harmonics would need to be known and these could not be obtained.

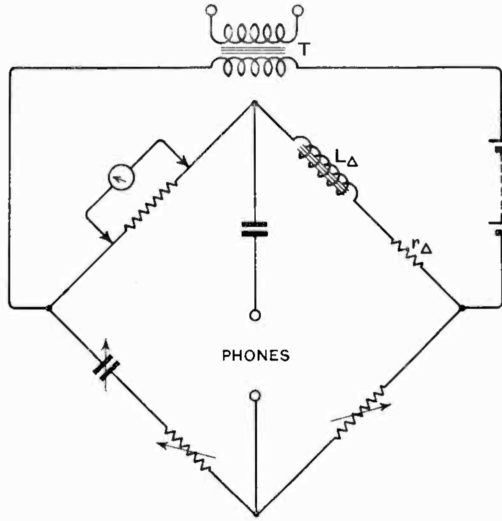


Fig. 6.

In general, therefore, the A.C. bridge must be regarded as a method of measuring sinusoidal quantities, usually of fundamental frequency, and most suitable for testing that type of inductance which, by reason of an air gap in its core, or the complete absence of iron, does not cause current or voltage distortion. Where this is not the case, results obtained by the bridge cannot be expected to agree closely with values obtained ballistically.

In addition, the author's experience has been that the A.C. bridge lacks flexibility where incremental inductance measurements upon a number of different types of coil are desired, for the combined demands of the A.C. and D.C. circuits call for a variety of components and sources of supply which is inconvenient and often difficult to provide.

(3) *Commutator Method.*

Spooner has described a series of incremental measurements using a commutator.

The exciting current was made approximately sinusoidal by the addition of resistance in the A.C. feed to the test coil. The resulting non-sinusoidal A.C. voltage was rectified by the commutator and measured by a high resistance D.C. moving-coil voltmeter, as shown in Fig. 7.

Spooner states that this arrangement gave the average voltage for one half cycle, the other being suppressed. The maximum induction was calculated from the D.C. voltmeter reading. The reason for the use of this method was the considerable distortion of the A.C. volt wave, "otherwise the induction amplitude would have been difficult to estimate accurately."

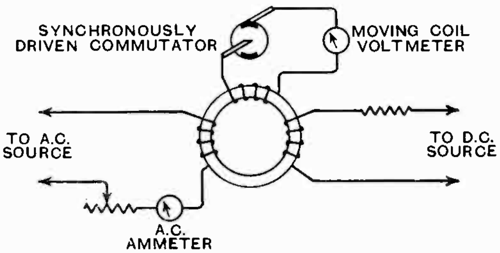


Fig. 7.

In the short description of his apparatus, the author concerned* gives hardly more detail than that contained in précis above, though the commutator would appear to have been of a type having fixed contact time, but variable phase. However this may have been, we shall endeavour to show that a commutator used for incremental permeability measurements ought theoretically to be of more complicated design than that commonly employed in measurements upon iron under pure A.C. excitation.

A commutator for the latter purpose is employed†, for example, in the Epstein test, in order to determine waveform. For this application a contact time extending over a half period is correct, but we shall show that this is theoretically not correct when the iron is polarised by a steady field.

Suppose a half-wave commutator is connected in the usual way to a moving-coil voltmeter. In general, the flux cycle may be expressed by the equation

$$\phi = \hat{\phi} \, . \, f(t)$$

* See *Physical Review*, Vol. 25, 1925, p. 529.
† See *Dictionary of Physics* (Electricity Section).

where $f(t)$ represents a Fourier series, the terms of which have different coefficients, and $\hat{\phi}$ may be taken as the peak value of the fundamental component.

Then the voltage at any instant will be

$$e = -\frac{N}{10^8} \cdot \frac{d\phi}{dt},$$

or

$$e = -\frac{N}{10^8} \cdot \hat{\phi} \cdot \frac{d}{dt} \cdot f(t),$$

where N represents the search coil turns.

The reading of the meter will be the average of e over the contact time of the commutator, or

$$E = -\frac{1}{10^8 \, . \, T} \int_{t_1}^{t_2} N\hat{\phi} \cdot \frac{d}{dt} f(t) \quad .. \quad (7)$$

or

$$E = -\frac{N\hat{\phi}}{10^8 T} \cdot \Big[f(t) \Big]_{t_1}^{t_2} \quad .. \quad .. \quad (8)$$

Equations 7 and 8 are quite general. The time interval T is the periodic time of the complex wave, and the interval of contact is measured from the instant at which the brush first makes contact. This instant can be altered at will by moving the brush. The brush is so moved until the voltage reading attains a maximum value.

Suppose we write

$$f(t) = \sin \theta + a_n \sin [n\theta - \alpha_n]$$

that is, employ the shortened harmonic series already used in the introduction. Let the contact interval be a half period, beginning at angle β. Then from (7)

$$E = -\frac{N\hat{\phi}}{10^8 \, . \, T} \int_{t=\beta/\omega}^{t=\frac{\pi+\beta}{\omega}} (\sin \theta + a_n \sin \overline{n\theta - \alpha_n}) d\theta.$$

where $\theta = \omega t$.

$$E = -\frac{N\hat{\phi}}{10^8 T} \left[\Big(-\cos \theta \Big)_{\beta}^{\pi+\beta} - \Big(\frac{a_n}{n} \, . \cos \overline{n\theta - \alpha_n} \Big)_{\beta}^{\pi+\beta} \right], \quad .. \quad .. \quad (9)$$

whence, if n is odd

$$E = -\frac{N\hat{\phi}}{10^8 \, . \, T} \cdot \left[2\cos\beta + 2\frac{a_n}{n} \cos \overline{n\beta - \alpha} \right] .. \quad (10)$$

We have seen from equation (3), Case II (Introduction), that, when n is odd, π is a typical interval for all values of α. The commutator of contact period π needs then only to be adjusted in phase until the bracketed quantity in (10) is maximum in order that the voltmeter may indicate a voltage proportional to the full amplitude of the complex flux wave.

The commutator suppresses one half wave of voltage, but the value of T will be $\left(\frac{2\pi}{\omega}\right)$ or $\frac{1}{f}$ where f is the frequency, and we have

$$E = -\frac{2N\hat{\phi}f}{10^8}\left[\cos\beta + \frac{a_n}{n}\cos n\beta - a\right] \quad .. \quad (11)$$

or

$$E = -\frac{Nf}{10^8}\cdot(2k\,.\,\hat{\phi}) \quad .. \quad .. \quad .. \quad (12)$$

where k represents the value of the bracketed quantity in (11), adjusted experimentally to a maximum.

Since the contact time of the commutator is a typical interval for the flux wave (with n odd), the factor $(2k\hat{\phi})$ then represents the full amplitude of the complex flux wave, and so the commutator and voltmeter enable this amplitude to be determined. The result can therefore be applied in permeability measurements in which only odd harmonics occur, as, for instance, when no superimposed steady polarisation exists.

Reverting to equation (9), suppose n is even. Then equation (10) becomes

$$E = -\frac{N\hat{\phi}}{10^8\,.\,T}[2\cos\beta + 0]$$

whence (12) becomes

$$E = -\frac{2N\hat{\phi}f}{10^8}$$

That is, the commutator of contact interval π ignores the even harmonics in a complex waveform and thus, in general, deals only with the fundamental component and the odd harmonics. The result also follows from equation (3), Case II (Introduction).

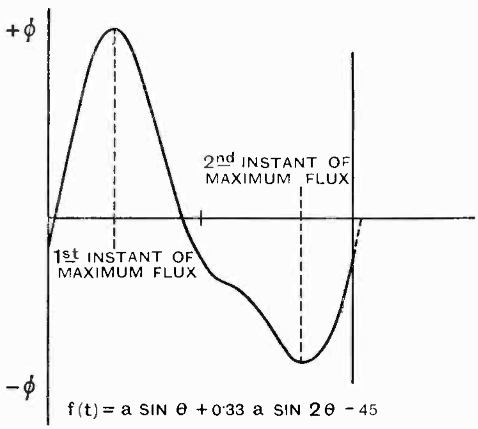
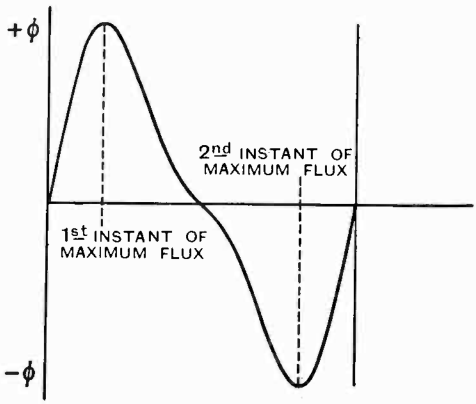


Fig. 7a.

Since even harmonics must occur during incremental magnetisation, the result shows that a commutator of special design is needed for such measurements. The design must be such that both phase and contact time are variable. The phase must be adjustable so that contact may be made at the instant of, say, positive maximum flux, and the contact period must then be varied until contact is broken at the instant of negative maximum flux. (See Figs. 7*a* and 7*b*.)



f(t) = a SIN θ + 0·33 a SIN 2θ

Fig. 7b.

We have seen that the contact period can then never be exactly π. It follows that there will always be two possible maximum readings of the voltmeter connected to the commutator: one corresponding to a contact period less than π and one to a contact period greater than π, the sum of the periods being 2π. These conditions can be shown in the voltage equation by restating (9) with different limits. Thus, when even harmonics are present and a variable phase variable time commutator with one contact segment per cycle is used we have

$$E = -\frac{N\hat{\phi}}{10^8\,.\,T}\left[\Big(-\cos\theta\Big)_{\beta}^{\pi\pm\gamma} - \left(\frac{a_n}{n}\,.\,\cos n\theta - a_n\right)_{\beta}^{\pi\pm\gamma}\right]$$

where $\theta = \omega t$ and $T = \frac{2\pi}{\omega}$.

The contact phase β and the limits are adjusted experimentally to give maximum E but, owing to the double valued upper limit, there will be two possible experimental settings giving maxima for E.

Since the value of T is not affected by the limits (it has the value $\left(\frac{\pi}{\omega}\right)$ or $\left(\frac{1}{f}\right)$ as in the case of the "odd harmonic" commutator) the flux amplitude can be evaluated in terms of either of the two voltage readings. Thus, by analogy with (12) we have

$$E_1 = -\frac{Nf}{10^8} \cdot (2k\hat{\phi})$$

and
$$E_2 = -\frac{Nf}{10^8} \cdot (2k\hat{\phi})$$

In either case the bracketed quantity is the required unknown.

It is perhaps worthy of note that the actual contact interval does not need to be known.

Possibly, incremental permeability measurements have usually been made with such a commutator. If not, then there may be scope for experiment, preferably with synthesised waveforms having pronounced even harmonics. In any case, it seems quite certain that the fixed contact time commutator is theoretically unsound for this class of measurement.

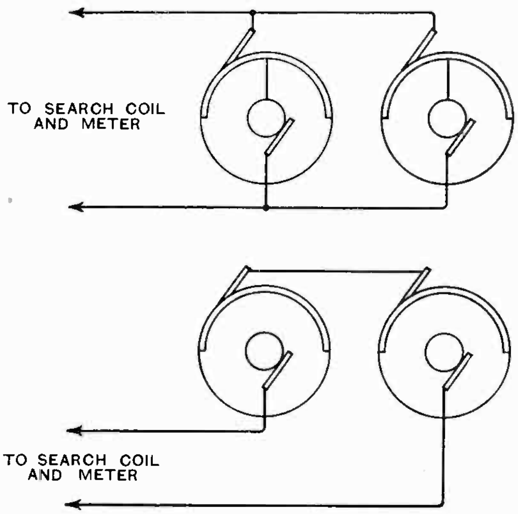


Fig. 7c.

It would appear feasible to obtain the variable contact time by the use of a barrel-type commutator with a tapering segment.

An alternative arrangement, using two commutators, has been suggested to the writer, in correspondence, by Professor G. W. O. Howe. It is as shown in Fig. 7c. The two commutators are mounted upon the same shaft. With the brushes connected in parallel the circuit is closed whenever either brush makes contact, and by moving the two brushes the contact period can be varied from π to 2π. The series connection requires both brushes to be on their conducting segments before the circuit can be complete, and so the contact interval can be varied from θ to π. Adjustment of phase could be made by a rocking gear operating equally upon both brushes.

The two possible maximum values of average voltage would be equal, so that in practice either the series or the parallel arrangement would suffice.

(To be concluded.)

Radio Communication, Part I: History and Development (Science Museum Handbook). By W. T. O'Dea, B.Sc., A.M.I.E.E., H.M. Stationery Office, Adastral House, Kingsway, London, W.C.2. Pp. 95, with 58 illustrations. Price 2/6 net.

The technician can always learn from reading the history of his subject, and this little book on the history and development of radio communication is very full of useful interest. The book is one of a series produced by the Science Museum dealing with technical subjects embraced in the wide collection of the Museum. This does not detract, however, from its value as a concise history of radio communication, the only references to the Museum in the text being the liberal use of asterisks to mark originals or replicas which are represented in the Museum collection.

The treatment is fairly conventional, starting with a brief account of early classical experiments and a quite general review of the fundamental processes of radio transmission and reception. The story then passes through early wireless experiments to a discussion of the valve and the development of valve transmitters and of broadcast receivers. The book closes with chapters on television (and picture transmission) and on miscellaneous matters such as microphones and loud speakers, all treated historically. One is mildly surprised to recall that the moving-coil loud speaker goes back to Siemens in 1877 and the "inductor dynamic" speaker to a patent of Cromwell Varley in the same year.

In every case the subject is brought very much up to date and the text is, throughout, readably and interestingly presented, well illustrated, as such books should be, mostly by photographs.

J. F. H.

Notes on the Theory of Diode Rectification*

By Jean Marique,

Eng.A.I.Br. and Radio-E.S.E., Lecturer at the University of Brussels.

Introduction

VARIOUS authors have studied the theory of operation of the diode feeding a load resistance shunted by a capacity. This study is capable of great simplification if one makes the following assumptions :—(1) the current-voltage characteristic of the diode is replaced by a straight line ; (2) the capacity between the extremities of the load resistance is negligible, or infinite.

In practice neither of these suppositions will be realised, but the simplifications that they bring about are such that they are generally allowed.

In studying the operation of a diode we have adopted either one or the other of these hypotheses ; for it seems unnecessarily complicated to reject both of them at the same time. The present article deals with the case where the first hypothesis is allowed, but not the second ; that is to say, we assume that the characteristic of the diode is linear during the passage of current, but recognise the existence of capacity.

The solution of the equations does not present any difficulty : this has already been done in various forms, notably by Colebrook[1], by Rocard[2] and by Lewis.[3]

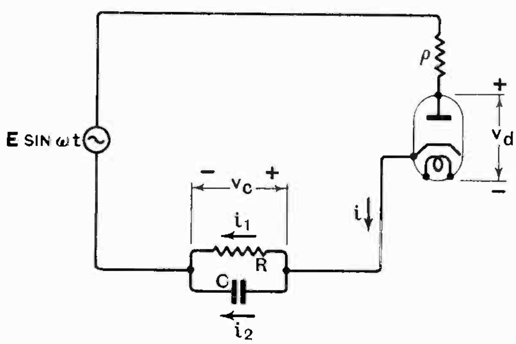


Fig. 1.

This last author has drawn curves representing the instantaneous values of the rectified voltage for arbitrarily assumed values of the initial angle of the passage of the current. Other authors, as, for example, McDonald[4] and Tanasescu,[5] have investigated the case where the capacity is infinite.

We have considered it to be of particular interest to study the condition met with in all rectifiers of transmitters and receivers and in certain measuring instruments. The solution of the equations has been made graphically ; if the calculations are long and often not precise, they nevertheless permit us to give evidence of certain phenomena that simpler theories are incapable of showing, and which merit theoretical justification.

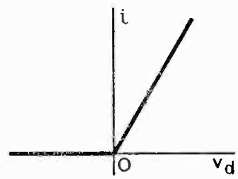


Fig. 2.

(1) Notation

The circuit considered in this article is represented in Fig. 1, and we assume that the characteristic of the diode can be replaced by a straight line as in Fig. 2. We will call ρ the resistance of the diode during the passage of current (this resistance also takes into account the resistance of the source) ; R the load resistance ; C the capacity of the condenser placed across this resistance ; $E \sin \omega t$ the e.m.f. applied to the whole ; i the total instantaneous current ; i_1 the instantaneous current in the resistance ; i_2 the instantaneous current in the condenser, v_d the difference of potential across the diode, and v_c the instantaneous difference of potential across the resistance.

(2) The Condenser Charge

During the passage of current we have

$$E \sin \omega t = v_d + v_c \quad \ldots \quad \ldots \quad (1)$$

$$\rho i = v_d \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

* MS. accepted by the Editor July, 1934.

[1] Colebrook, *W.E. & E.W.*, November, 1930, p. 595.

[2] Rocard, *L'Onde Electrique*, 1932, p. 23.

[3] Lewis, *W.E. & E.W.*, Sept. 1932, p. 487.

[4] McDonald, *W.E. & E.W*,. Oct., 1931, p. 522.

[5] Tanasescu, *W.E. & E.W.*, Feb., 1934, p. 68.

$$v_c = Ri_1 \quad \ldots \quad (3)$$

$$v_c = \frac{1}{C}\int i_2\,dt \quad \ldots \quad (4)$$

$$i = i_1 + i_2 \quad \ldots \quad (5)$$

Eliminating i, i_1, i_2, and v_d, we obtain

$$\frac{dv_c}{dt} + \left(\frac{1}{\rho C} + \frac{1}{RC}\right) v_c = \frac{E}{\rho C}\sin \omega t$$

which is a known differential equation of which the integral is

$$v_c = \frac{E}{\rho C}\left[\frac{\left(\frac{1}{\rho C} + \frac{1}{RC}\right)\sin \omega t - \omega\cos\omega t}{\left(\frac{1}{\rho C} + \frac{1}{RC}\right)^2 + \omega^2} + K \, . \, e^{-\left(\frac{1}{\rho C} + \frac{1}{RC}\right)t}\right]$$

where K is a constant dependent on initial conditions. This equation can easily be changed by substituting

$$\frac{\omega}{\frac{1}{\rho C} + \frac{1}{RC}} = tg\phi \quad \ldots \quad (6)$$

It then becomes

$$v_c = \frac{E\cos\phi}{1 + \frac{\rho}{R}}\left[\sin(\omega t - \phi) + K \, . \, e^{-\left(\frac{1}{\rho C} + \frac{1}{RC}\right)t}\right]$$

The initial condition is given by

$$v_c = E\sin\omega t_1$$

which enables us to calculate K. If we call α_1 the angle which corresponds to t_1, and replace ωt by α for the purpose of simplification, the formula becomes

$$\frac{v_c}{E} = \frac{\cos\phi}{1 + \frac{\rho}{R}}\left[\sin(\alpha - \phi) + \left\{\frac{1 + \frac{\rho}{R}}{\cos\phi}\sin\alpha_1 - \sin(\alpha_1 - \phi)\right\} e^{-\frac{\alpha - \alpha_1}{tg\phi}}\right] \quad \ldots \quad (7)$$

(3) Discharge of the Condenser

When the current no longer passes through the diode the current which traverses the resistance is due entirely to the discharge of the condenser; the equations are then

$$v_c = -\frac{1}{C}\int i_2 dt \quad \ldots \quad (8)$$

$$v_c = Ri_1 \quad \ldots \quad (9)$$

$$i_1 = i_2 \quad \ldots \quad (10)$$

If we put $v_c = Me^{-\frac{t}{RC}}$.

The beginning of this condition corresponds to the time t_2 or to the angle α_2 defined by

$$v_c = E\sin\omega t_2 = E\sin\alpha_2$$

From this it is possible to deduce M and by substitution one obtains

$$\frac{v_c}{E} = \sin\alpha_2 \, . \, e^{-\frac{\alpha - \alpha_2}{\omega RC}}$$

The time constant of the loaded circuit can conveniently be expressed $\theta = R.C.$

noting that $\omega = \frac{2\pi}{T}$ the equation is changed to

$$\frac{v_c}{E} = \sin\alpha_2 \, . \, e^{-\frac{\alpha - \alpha_2}{2\pi}\cdot\frac{T}{\theta}} \quad \ldots \quad (11)$$

and equation (6) becomes

$$tg\phi = \frac{2\pi}{T\left(\frac{1}{\rho C} + \frac{1}{RC}\right)} = 2\pi\frac{1}{1 + \frac{R}{\rho}}\cdot\frac{\theta}{T} \quad \ldots \quad (12)$$

(4) Steady Conditions

Equations (7) and (11) enable us to calculate the value of the voltage v_c for all the angles α. Equation (7) is valid for angles between α_1 and α_2, and equation (11) from α_2 to α'_1; from this point equation (7) again governs the phenomenon, and so on.

In the steady state it is apparent that

$$\alpha'_1 = \alpha_1 + 2\pi$$

because then one obtains

$$\left(\frac{v_c}{E}\right)_{\alpha'_1} = \left(\frac{v_c}{E}\right)_{\alpha_1}$$

The angle at the commencement of the discharge is obviously equal to the angle at the end of the charge; one must therefore have for the angle α_2

$$\left(\frac{v_c}{E}\right)_{\alpha_2} = \sin\alpha_2$$

By substituting $\sin\alpha_2$ for $\frac{v_c}{E}$ in equation (7) we obtain the condition

$$\left[\frac{1+\frac{\rho}{R}}{\cos\phi}\sin\alpha_2 - \sin(\alpha_2-\phi)\right] e^{\frac{\alpha_2}{tg\phi}}$$

$$= \left[\frac{1+\frac{\rho}{R}}{\cos\phi}\sin\alpha_1 - \sin(\alpha_1-\phi)\right] e^{\frac{\alpha_1}{tg\phi}} \quad .. \ (13)$$

The end of the discharge must be such that

$$\frac{v_c}{E} = \sin(\alpha_1 + 2\pi) = \sin\alpha_1$$

from which by substituting in (11)

$$\sin\alpha_2 \,.\, e^{\frac{\alpha_2}{2\pi}\cdot\frac{T}{\theta}} = \sin\alpha_1 \,.\, e^{\frac{\alpha_1}{2\pi}\cdot\frac{T}{\theta}} \,.\, e^{\frac{T}{\theta}} \quad .. \ (14)$$

The two equations (13) and (14) enable us to calculate, in relation to the given data,

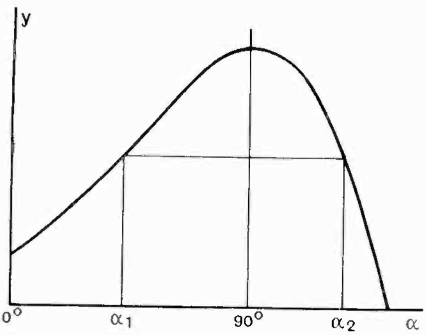


Fig. 3.

the angles α_1 and α_2 which correspond to the condition, which we are investigating; these two relations must be satisfied simultaneously.

To arrive at values of α_1 and α_2 which agree with the charging condition we plot as ordinates the value of

$$y = \left[\frac{1+\frac{\rho}{R}}{\cos\phi}\sin\alpha - \sin(\alpha-\phi)\right] e^{\frac{\alpha}{tg\phi}}$$

and as abscissae the angles, taking as parameters the ratios $\frac{R}{\rho}$ and $\frac{\theta}{T}$. We thus obtain curves similar to those of Fig. 3.

The values of α_1 and α_2 corresponding to the condition of discharge are obtained by taking as ordinates the values of

$$z = \sin\alpha \,.\, e^{\frac{\alpha}{2\pi}\frac{T}{\theta}} \,.\, e^{\frac{T}{\theta}}$$

for angles smaller than 90° and the values of

$$z = \sin\alpha \,.\, e^{\frac{\alpha}{2\pi}\frac{T}{\theta}}$$

for angles greater than 90°, the angles being plotted as abscissae; the only parameter

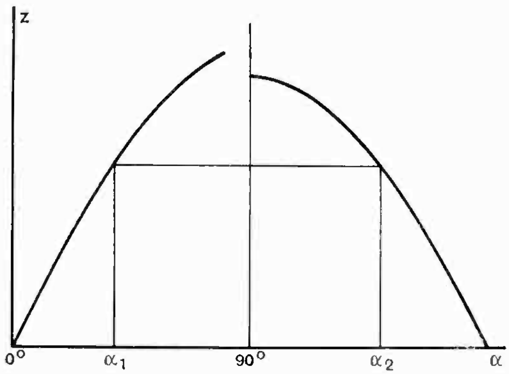


Fig. 4.

to be considered in this case is the ratio $\frac{\theta}{T}$ (Fig. 4). For each ordinate of Figs. 3 and 4 there are corresponding values of both α_1 and α_2. We thus obtain for each value of parameters $\frac{R}{\rho}$ and $\frac{\theta}{T}$, two series of values for (α_1, α_2) corresponding to the charge and discharge conditions.

In the steady state the angles must satisfy these two series simultaneously. If α_1 is plotted against α_2 we obtain for the two series the curves c and d (Fig. 5), the intersection of which gives the required value of the angles α_1 and α_2.

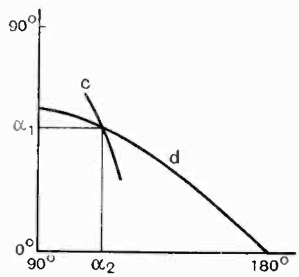


Fig. 5.

(5) The Angles α_1 and α_2 in the Steady State

We have plotted in Fig. 6 the results of the preceding graphical calculations which show the variation of α_1 and α_2 as a function of $\frac{\theta}{T}$ taking $\frac{R}{\rho}$ as parameter. In view of the difficulty of determining graphically with precision the angles corresponding to large values of $\frac{\theta}{T}$, these curves should be taken only as a general indication. We see that, other things being equal, when we increase the value of the capacity C, the angle during which the current flows diminishes; the beginning and the end of the flow of the current take place more and more symmetrically in relation to 90° as C is increased.

(6) Form of Rectified Voltage

From the steady state angles determined above, we have shown in Fig. 7 the approximate form of the rectified voltage for

$\frac{R}{\rho} = 20$ and $\frac{\theta}{T} = 1$; 2 ; 5 and 100.

The smoothing resulting from an increase of the time constant of the charging circuit is clearly shown in this figure.

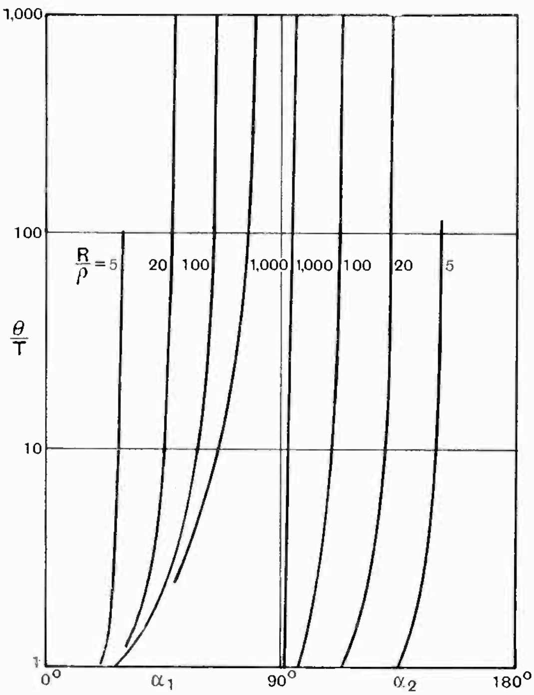


Fig. 6.

(7) Average Rectified Voltage

The ratios $\frac{R}{\rho}$ and $\frac{\theta}{T}$ being fixed, the ratio

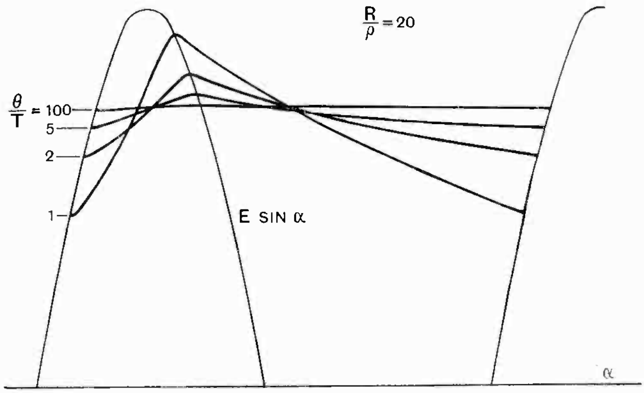


Fig. 7.

$\frac{v_c}{E}$ varies during each period between α_1 and α_2. Equation (11) enables us to calculate simply the average value $\frac{v_m}{E}$ of the ratio $\frac{v_c}{E}$, we have, in fact

$$\frac{v_m}{E} = \frac{1}{2\pi + \alpha_1 - \alpha_2}\int_{\alpha_2}^{\alpha_1 + 2\pi} \sin \alpha_2 \,.\, e^{\frac{-\alpha - \alpha_2}{2\pi}\frac{T}{\theta}} \,.\, d\alpha$$

$$= \frac{\theta}{T}\cdot\frac{2\pi}{2\pi + \alpha_1 - \alpha_2}\,.\,\sin \alpha_2\left[1 - e^{\frac{-2\pi + \alpha_1 - \alpha_2}{2\pi}\frac{T}{\theta}}\right] \qquad \ldots \quad \ldots \quad (15)$$

Fig. 8 shows how the average rectified voltage varies for different values of $\frac{R}{\rho}$ as a function of the time constant of the charging circuit.

These curves show the existence of a limiting value of $\frac{v_m}{E}$ for each value of $\frac{R}{\rho}$. They show also that apart from the question of smoothing, which is not considered here, the average rectified voltage increases, other things being equal, when the capacity C is increased.

However, beyond a certain value of C (or of θ), the increase becomes slight; and it would appear that there is no advantage in going beyond the following time constants

$\frac{R}{\rho}$	$\frac{\theta}{T}$
1,000	20
100	10
20	5
5	1

We find, therefore, a theoretical justification for the statement made by McDonald[4] and a less arbitrary basis for calculation than that given by this author.

We see, also, that by employing large values of $\frac{R}{\rho}$ we can obtain ratios $\frac{v_m}{E}$ very near unity; this is the well-known case of the diode used as a peak voltmeter.

In practice the ratio $\frac{v_m}{E}$ is independent of $\frac{\theta}{T}$ when $\frac{\theta}{T} > 100$ (see Fig. 8.) But when the frequency is changed the ratio $\frac{\theta}{T}$ varies, and in order that the voltmeter readings remain independent of frequency it is necessary that

$$f > \frac{100}{\theta}$$

Apart from the limitations due to the measuring apparatus, stray capacities, etc.,

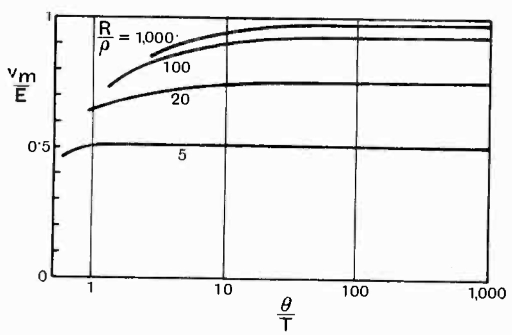


Fig. 8.

the necessity for such a condition should not be lost sight of if the same apparatus is to be used for both high and low frequencies.

(8) Output and Efficiency

The A.C. source $E \sin \omega t$ supplies during the period an average power

$$W_a = \frac{1}{2\pi}\int_{\alpha_1}^{\alpha_2} i \,.\, E \sin \alpha \,.\, d\alpha.$$

But equations (1) and (2) enable us to write

$$i = \frac{E \sin \alpha - v_c}{\rho}$$

From which we derive

$$W_a = \frac{E^2}{2\pi\rho}\left(\int_{\alpha_1}^{\alpha_2} \sin^2 \alpha \,.\, d\alpha - \int_{\alpha_1}^{\alpha_2} \frac{v_c}{E} \,.\, \sin \alpha \,.\, d\alpha\right)$$

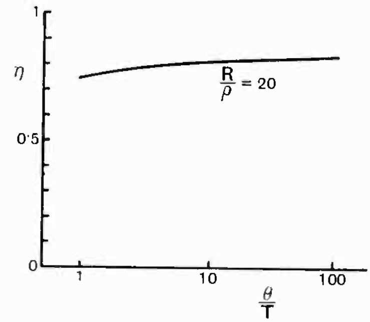


Fig. 9.

The instantaneous values of $\frac{v_c}{E}$ between α_1 and α_2 are given by equation (7), which can be put in the form

$$\frac{v_c}{E} = A\left[\sin(\alpha - \phi) + Be^{-\frac{\alpha - \alpha_1}{tg\phi}}\right] \quad \ldots \quad (7')$$

Putting

$$A = \frac{\cos \phi}{1 + \frac{\rho}{R}}$$

$$B = \frac{1 + \frac{\rho}{R}}{\cos \phi} \sin \alpha_1 - \sin(\alpha_1 - \phi)$$

The average value of the power supplied by the source is given by

$$W_a = \frac{E^2}{2\pi\rho}$$

$$\left\{\left(\frac{\sin 2\alpha_1 - \sin 2\alpha_2}{4} + \frac{\alpha_2 - \alpha_1}{2}\right)(1 - A \cos \phi) + \frac{A \sin \phi}{4}(\cos 2\alpha_1 - \cos 2\alpha_2) - A \,.\, B \sin^2 \phi\left[\left(\cos \alpha_1 + \frac{\sin \alpha_1}{tg\phi}\right) - \left(\cos \alpha_2 + \frac{\sin \alpha_2}{tg\phi}\right) e^{-\frac{\alpha_2 - \alpha_1}{tg\phi}}\right]\right\} \quad \ldots \quad (16)$$

From the values of α_1 and α_2 found for $\frac{R}{\rho}$ and $\frac{\theta}{T}$ we can calculate the power W_a. We can write the equation (16) in the form

$$W_a = \frac{aE^2}{2\pi\rho} \quad \ldots \quad \ldots \quad \ldots (16')$$

where a is the numerical value of the terms between brackets, and we can also write equation (15) in the form

$$\frac{v_m}{E} = b$$

The average rectified power has the value

$$W_r = \frac{v_m{}^2}{R} = \frac{b^2E^2}{R}$$

It increases with $\frac{\theta}{T}$.

The efficiency can then be written

$$\eta = \frac{W_r}{W_a} = 2\pi\frac{b^2}{a}\cdot\frac{\rho}{R}.$$

Fig. 9 drawn for $\frac{R}{\rho} = 20$ shows that the efficiency increases when the time constant of the charging circuit is increased. This increase is slight within the limits of $\frac{\theta}{T}$ which we have considered.

(9) Conclusion

It has been thought of interest to investigate the theoretical case of a diode with a linear characteristic feeding a resistance shunted by a condenser of given value. To avoid calculations disproportionate to the results we have limited our investigations to the influence of the ratios $\frac{R}{\rho}$ and $\frac{\theta}{T}$ on the angles α_1 and α_2, on the average rectified voltage and on the output. This study shows that independently of the improvement of smoothing, the increase of the time constant of the load circuit increases the average rectified voltage, the useful power and the output.

Correspondence

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

Receiver Performance Data

To the Editor, The Wireless Engineer.

SIR,—With reference to the articles appearing in your associated journal *The Wireless World* on Receiver Performance Data, by W. T. Cocking, it would seem desirable to point out some of the pitfalls which beset the path of the experimenter or research worker when attempting to obtain *absolute* measurements of receiver performance at radio frequencies.

It is within the knowledge of the writer that standard signal generators manufactured by different firms possess widely different characteristics, and though presumably delivering known voltages to the input circuit of a receiver, give sensitivity and selectivity curves which do not tally with each other. This would appear to suggest that the specified voltages from the attenuators incorporated are only delivered when the dummy aerial terminals are open-circuited or terminated with a known impedance, and consequently, if receivers with different input circuits are connected to the dummy aerial, their impedances will be reflected back through the attenuation pad and cause divergence in the actual voltages supplied.

If the impedance of the attenuation network is lowered to such an extent that sufficient current is passed through the network to render the effects of this reflected impedance negligible, it would appear that the damping introduced into the first tuned circuit of the receiver under test would be sufficient to cause serious flattening of the selectivity curve obtained. Also the R.F. currents necessary in the attenuator network could only be produced by a much more powerful oscillator than is usually incorporated in a portable signal generator, and this would also increase the screening necessary. These cumulative effects assume more serious effects as the frequency at which the measurements are taken is increased and it is doubtful whether any *absolute* accuracy is obtainable at frequencies above 1,500 kc/s.

As a means of comparison between different receivers of identical construction the signal generator undoubtedly has its uses, and when used by a manufacturer to check the maintenance of the excellence, or otherwise, of his products as they come off the assembly belt, it is invaluable; but it is questionable whether the performance curves of differently designed receivers taken with the same signal generator have any great bearing upon the actual performance of the receivers under working conditions.

Finally, the means of checking the modulation depth of the signal supplied by some signal generators has been found to be not above suspicion, and measurements taken with an independent modulation meter of the dual rectifier type sometimes show startling discrepancies.

It would be interesting to obtain the opinions of readers of *The Wireless Engineer* as to the relative accuracy of measurements obtained by the complicated constant high impedance attenuation networks incorporated in the majority of signal generators as against the simple low impedance attenuator, consisting of a thin straight resistance wire carrying a known R.F. current suspended centrally in a screening tube and tapped off at known intervals. It is held by some engineers that unnecessary complications have been introduced into signal generators for R.F. measurement and more consistent results are obtainable with the simplest of apparatus.

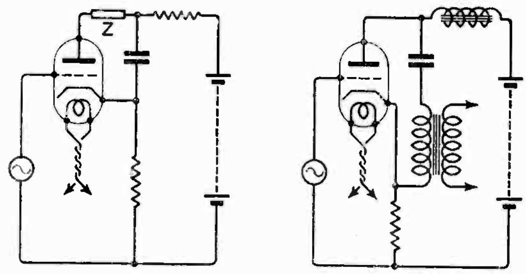
Sutton, Surrey. H. E. STOAKES.

Self-Bias Circuits

To the Editor, The Wireless Engineer

SIR,—I take the liberty of submitting to you supplementary considerations concerning the note on Self-Bias Circuits by Emrys Williams which appeared in the November issue of *The Wireless Engineer*.

Instead of the author's decoupling devices we believe that the ordinary plate decoupling with return to the cathode, as shown hereunder, would be preferable for the same purposes.



There is no loss of amplification, and the frequency response is absolutely flat. The impedance of the bias resistor need not be a negligible part of the load impedance as assumed in the calculations of Mr. Emrys Williams.

Experiments lately carried out have confirmed these results.

Finally, no further elements are necessary except those for the plate decoupling. G. HANSEN.

Brussels.

Transmitters on the Same Wavelength

The Editor, The Wireless Engineer

SIR,—Your editorial of December 1934 describes the remarkable perfection with which two transmitters (radiating at say 10^6 c/s) may be tied together by a cable connection (carrying current of say 2,000 c/s). The imperfection of tying claimed by the Lorenz Co. is described as "a variation of 1 in 10^9." If this were a statement of the difference between two frequencies maintained constant for a long time, its meaning would be clear. But the situation under discussion is that of two nearly like oscillations which are not strictly periodic, whose non-periodicity is the very feature we wish to assess. What meaning, then, is to be attached to the terms frequency or frequency-difference at any instant? I submit that what we should specify about the relation between two such oscillations is their phase-difference θ, where θ may be defined as that angle which makes $\theta/2\pi n$ the time interval between instants of zero value of the two oscillations to which both actual oscillations approximate.

A statement in this form has the advantage of meaning something; moreover, it corresponds closely with those observable effects of the situation with which the communications engineer has to cope. Taking for simplicity the case of equal amplitudes, the carrier waves from the two transmitters may be written

$$A \sin (2\pi n_1 t + \alpha_1) \text{ and } A \sin (2\pi n_2 t + \alpha_2)$$

where either the n-s or the α-s are not constant, but where n_1 and n_2 are both at least very nearly equal to a constant n. In a receiver (provided with a linear detector), during any one of a few cycles near $t = 0$, the two carrier waves produce a rectified quantity proportional to $\cos \frac{1}{2}(\alpha_1 - \alpha_2)$. It is the phase-difference θ, or more precisely the cosine of its half, which matters: a fluctuation in $\cos \theta_2$ entails an equal fluctuation in the strength of a programme which perforce is being received simultaneously from the two transmitters. The values of n_1 and n_2 are themselves of practical significance only if $n_1 \sim n_2$ becomes large enough to lie within the audible range of frequencies.

That the foregoing rather obvious remarks are not mere hair-splitting is seen on applying them to the sentence in your editorial: "We would emphasise that the amazing figure of 1 in 10^9 given for the frequency variation of the most recent system employing cable-connected tuning forks is not really so amazing as it looks, for it only refers to the variation which occurs in 4 seconds." If we were considering the wandering of two should-be synchronous but untied transmitters (such as have been used by the B.B.C.), a discrepancy of 1 in 10^9 reached after 4 seconds would indeed be less amazing than if it occurred only after say 4 minutes. But we are, on the contrary, considering the synchronising coercion of one transmitter by another transmitter through their interconnection by tuning forks and cable. The coercive action, whatever the details of its mechanism, must, it would seem, be called into play by a change of phase between the two transmitters. If correction is applied within 4 seconds it is effected by a change of phase which is not less but more amazingly small than if the change of phase had been permitted to grow during 4 minutes.

If we interpret the "variation of frequency of 1 in 10^9" as I have indicated above, in 4 seconds the change of phase between the carrier waves is

$$10^{-9} \times (4 \times 10^6 \text{ cycles}) \times (2\pi \text{ radians per cycle})$$
$$= 0.025 \text{ radian.}$$

Since the control is effected *via* the fork system, the operative change of phase between the two forks is 1/500 of this, viz., 5×10^{-5} radian. Thus if when synchronisation is perfect, currents I from the two forks are made exactly to balance each other, control is effected when the out-of-balance current is $5 \times 10^{-5} I$. A description of the means by which so small a fork discrepancy is made to draw the transmitters back into step would be a welcome addition to G.W.O.H.'s very interesting summary of the practical achievements in tying transmitters together.

Engineering Laboratory, Cambridge. L. B. TURNER.

Some Principles Underlying the Design of Spaced-Aerial Direction-Finders

Paper by R. H. Barfield, M.Sc. (Eng.), A.M.I.E.E., read before the Wireless Section, I.E.E., on Dec. 5th, 1934

Abstract

THE paper gives a theoretical and experimental account of the chief forms of the spaced-aerial or Adcock direction-finder, which is designed to reduce the error due to "night effect" or abnormal polarisation of the downcoming electrical component of the signal wave. The treatment is concerned with the determination of two main important properties of the various systems specifying respectively their performances under the influence of downcoming waves and their efficiencies as receivers of wireless energy. On account of the difficulty of specifying the former in all conditions, the author devises a quantity which he describes as the "Standard wave-error" of a system, defining the "standard wave" as one for which the angle of incidence and the angle of polarisation are both 45 deg. and the standard wave error as that produced in the system under the influence of such a wave. As regards efficiency of reception he also introduces a "pick-up factor" which he defines as the ratio of the p.d. (in volts) obtainable across the output terminals of the aerial system to the strength (in volts-per-metre) of the vertical electric field of the incoming wave.

The various spaced-aerial arrangements are then discussed with the object of showing how these factors may be predicted for any given system.

The four chief types of aerial system discussed are those shown in Fig. 1, while those shown in Fig. 12 provide variants of the coupled type.

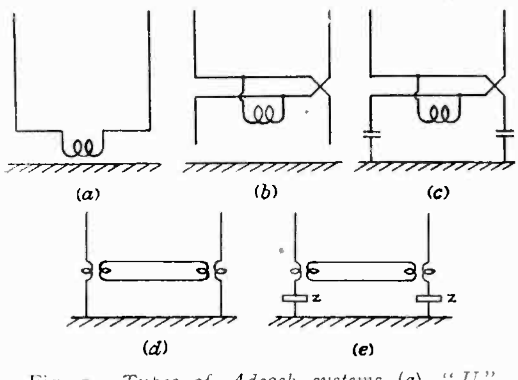


Fig. 1.—*Types of Adcock systems* (*a*) *"U" (unscreened)*, (*b*) *Elevated*, (*c*) *Balanced*, (*d*) *Coupled*, (*e*) *Balanced-coupled.*

Beginning with the closed coil system, the author develops the value of standard wave error and shows that it is approximately 35 deg. for a large range of wavelengths, and that, within wide limits, this value is independent of ground conductivity and of the dimensions of the loop.

He then points out that similar calculation for the various spaced aerial systems is not so simple, except in the case of the simplest (unscreened) U-type, which is, therefore, considered first, both theoretically and experimentally. Expressions for the standard-wave error are then derived. In

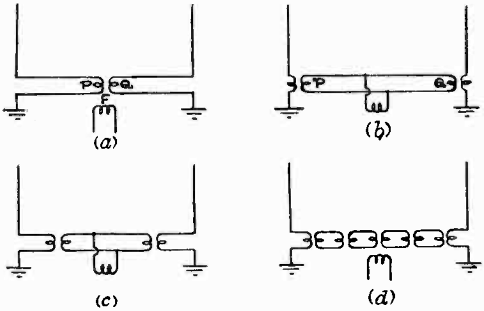


Fig. 12.—*Variations of coupled type.*

practice with this type, however, the horizontal members are usually screened in an earthed screening tube. No quantitative formula can be deduced for the theoretical calculation of the effect of the screen, and instead the author discusses the effect qualitatively and describes a series of experiments in which the system was tested by means of locally generated downcoming waves of controllably variable polarisation. This method was employed to measure the effect of screening and burying the horizontal limb of the U Aerial, as well as to determine the standard-wave-error of the unscreened system and its agreement with calculations.

The author then turns to the elevated type in which the aerials are un-earthed dipoles raised some distance above the ground. Experiments are described with a rotating (two dipole) form of this system, these including determinations of the standard-wave error by means of an elevated transmitter of variable polarisation, an investigation of the effect of shortening the lower limbs of the dipoles, and an investigation of the effect of increasing the height of the apparatus above the ground. A working formula is obtained for calculating the standard wave-error for such a system.

The next form discussed is the coupled type, and the paper gives a description of a coupled system for medium waves. This was tested by means of downcoming waves from a transmitter elevated by a large box kite, and also by a method of local injections which is discussed in the paper. A formula for calculating the performance of the coupled type of aerial is derived from theoretical reasoning based on these measurements. Fig. 12 shows variants of the coupled type, designed to increase the impedance between the horizontal and vertical members so as to reduce that current flowing into the aerials which is produced by the horizontally polarised component acting upon the feeder.

The discussion is then directed to the balanced type, in which an impedance is introduced into the lower part of the aerial so that it has the same impedance as the upper portion above the horizontal feeder. This leads to the arrangement of Fig. 17 which is a combination of the coupled and balanced systems and was found to have a standard wave-error too low to be measured.

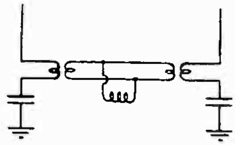


Fig. 17.—*Balanced-coupled type.*

The pick-up factor of the various systems is then discussed, starting with the closed loop aerial which is used as a standard of reference for the others. Each of the spaced wave systems is then examined in turn with regard to its pick-up properties. A comparison of the various types dealt with in the paper can be summed up in the table below.

Discussion

MR. T. L. ECKERSLEY, in opening the discussion, referred to the great value of the author's measurements in helping the design. He did not, however, understand the values given in relation to the U type, and discussed the theory of screening in this case, including the effect of extending the length of the feeders.

MR. C. E. HORTON said that the author's conception of standard-wave-error gave a very useful comparision between different systems. Referring to the error of loop d.f. in receiving from aircraft, he hoped that aircraft tests of the author's coupled type might be possible. Practical difficulties of using the Adcock system lay in the way of spacing, for example, on shipboard, for wavelengths of 1,000 metres, where the coil, despite its disadvantages, was favourable in respect of pick-up related to its small area.

COL. J. P. WORLLEDGE said that standard-wave error did not specify the performance of the Adcock to all conditions of downcoming wave and that in certain circumstances even an Adcock might give an error of 90 deg., although this would only be on amplitudes impractically small for d.f. He considered that the problem of direction finding should be approached statistically, as a means of determining the performance of different types in different circumstances. Lastly, he referred to site error, quoting differences of bearing observed on sites only 50 yards apart.

MR. F. P. SMITH referred to an American "transmission line" system of Adcock d.f., working more or less on the coupled system, and also queried the author's values in relation to the screened U type. Statistical reduction of a number of bearings showed a "standard deviation" of 2.4 for this system and 12.4 for the coil, which was in agreement with the author's 6 to 1 ratio as between the standard wave-errors of these systems.

MR. J. F. COALES referred to several applications in which the coil was useful and accurate. In the U Adcock complete screening of the horizontal lead was most important as was also freedom from coupling between the vertical pairs.

AIR-COMMODORE BOWEN enquired as to the possibilities of using an Adcock or similar directional system for the guidance of aircraft in maintaining a position approximately vertically over the area of an aerodrome.

MR. J. F. HERD referred to measurements of ground ray and ionospheric ray in which, at just over 12 miles distance on 85 metres in daytime, the latter was about half the strength of the former and liable to give big error. He also referred to observations with the cathode ray apparatus confirming the remarks of COL. WORLLEDGE as regards the very low amplitude on Adcock aerials in conditions of large error.

MR. A. J. GILL mentioned recent Adcock aerials erected by the P.O. at Cullercoats, and referred also to the use of Bellini Tosi aerials at Niton, with the aerials remote from the receiver and communicating to it by transmission lines.

COMPARISON OF TYPES BASED ON EXPERIMENTAL MEASUREMENTS

Type.	Dimensions h, h'† metres.		Standard-wave-error (degrees).	Pick-up factor.
Loop (1 metre square)	Small compared with wavelength		35 (This value is not affected by changes in soil conductivity)	10 to 20
"U"	24	0.5	12	100 to 200
Screened "U"	24	0.5	6 (Reduction effect of screen taken is the most favourable of values found from all experiments)	—
Elevated or "H" type	24	15	2	100 to 200
Coupled	24	0.5	1 (Untuned aerial system. Interwinding capacitance of transformer = 10 $\mu\mu$F)	50 to 100
Balanced	24	2.0	6 (Untuned aerial system)	100 to 200
Balanced-coupled	24	2.0	Less than 1 (Untuned aerial system)	50 to 100

The value of the standard-wave-error corresponds to a wavelength of 300 m and a soil conductivity of 1.5×10^8 electrostatic units, and only holds for the aerial dimensions given with a spacing between vertical aerials of 16 m. It will be realised from the matter contained in the paper that variations of any of the above quantities may very considerably alter the standard-wave-error of the systems tabulated. † h = height of aerial system, h' = height above ground of horizontal members.

Abstracts and References

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PROPAGATION OF WAVES

1. REPORT ON MEASUREMENT OF IONOSPHERIC HEIGHTS AT CALCUTTA DURING THE POLAR YEAR, 1932–33.—H. Rakshit. (*Phil. Mag.*, October, 1934, Vol. 18, No. 120, pp. 675–695.)

The wavelength used was 75 metres, at vertical incidence. Curves are given showing the midday and midnight [fortnightly] values of the equivalent heights of the ionised regions throughout the year, and also monthly records of diurnal variation of height. No indications of an ionised region below the normal E region were obtained, though some echoes came from an equivalent height of 75–80 km; this low height may be due to the geographical position of Calcutta. The results are discussed in detail; they appear to agree in general with those of other workers. "Evening concentration" of ionisation and multiple splitting were noted. For a preliminary account of the apparatus *see* 1933 Abstracts, p. 148.

2. LAYER HEIGHTS DURING THUNDERSTORMS: E LAYER LOWERED FROM 78 MILES TO 65 MILES ON ARRIVAL, MOUNTING AGAIN TO 78 MILES ON CESSATION AND TO 93 MILES WITHIN 15 MINUTES.—Ratcliffe. (*Sci. News Letter*, 15th Sept. 1934, Vol. 26, No. 701, p. 169.) Paragraph on British Association paper. *See* also *Science*, 14th Sept. 1934, Vol. 80, No. 2072, Supp. p. 6.

3. SOME EXPERIMENTAL INVESTIGATIONS OF THE POLARISATION OF DOWNCOMING [Long] WIRELESS WAVES.—R. Witty. (*Proc. Camb. Phil. Soc.*, October, 1934, Vol. 30, Part 4, pp. 540–542.)

The writer has used the method of Ratcliffe and White (1933 Abstracts, p. 559, r-h col.) and finds that on the whole the polarisation of downcoming long waves is left-handed, although there is a tendency for right-handed polarisation in the region of 1 500 metres.

4. DIFFICULTY OF LONG-WAVE TRANSMISSION IN SUMMER.—S. C. Bagchi. (*Nature*, 3rd Nov. 1934, Vol. 134, p. 701.)

This note refers to a theory of sub-electrons put forward by Peczalski (in 1927) and finds that "in summer conditions, when the sun is shining, photoelectric processes will produce electrons and sub-electrons which collide with the molecules of air and act as resonators absorbing the energy of long electromagnetic waves."

5. EXPERIMENTAL CONTRIBUTION TO THE STUDY OF THE PROPAGATION OF SHORT WAVES [including Data from Tokio–Paris and Shanghai–Paris Services].—J. Maire. (*L'Onde Élec.*, Aug./Sept. 1934, Vol. 13, No. 152/153, pp. 347–358.)

Continuation of the work dealt with in 1933 Abstracts, p. 404. The data are from 1932 results, and the writer examines certain special effects which seem to be due to the 11-year solar cycle influences; also, briefly, the question of round-the-earth echoes.

6. STRUCTURE OF THE IONOSPHERE [Group-Time Considerations indicate Continuous Ionisation Distribution].—J. Hollingworth. (*Nature*, 22nd Sept. 1934, Vol. 134, p. 462.)

7. AUSTRALIAN RADIO RESEARCH BOARD: SIXTH ANNUAL REPORT (for the Year ended 30th June, 1934).—(*Journ. of Council for Scient. and Ind. Res.*, Australia, August, 1934, Vol. 7, No. 3, pp. 134–138.)

(1) Work on fading and the ionosphere. A marked degree of lateral deviation has been found at Liverpool, and the point of reflection at the K-H layer has been observed to sweep through distances of as much as 50 km in a few seconds. "The inconsistent values previously obtained in England, India and Australia for the angle of incidence of the downcoming waves have been shown to be due to the consequences of lateral deviations in these waves." Sydney/Melbourne path measurements: several waves are normally received in transmission between these cities, the strongest being the one reflected once from the E layer. Other waves frequently present were those singly and doubly reflected from the F layer, while doubly and triply reflected waves from the E layer were sometimes apparent. The ionosphere is found to be normally relatively constant in characteristics over the 700 km stretch. The height of the layers was found to vary but little with the angle of incidence—showing that the gradient of ionisation, particularly the E layer, is very sharp. From these measurements the average E-layer ionisation density each night has been determined, and a close correlation found with barometric

pressure at ground level (Martyn, Abstracts, 1934, p. 199), which is supported by the analysis of 1931/32 fading records. "This result suggests a closer connection between the troposphere and the ionosphere than has previously been thought probable."

Data on intensity of sky wave at broadcasting frequencies: this material has been put into a form suitable for the determination of the fading radii of stations, and has also been used to calculate the reflection coefficient of the E layer. "It has been found possible to show that the gradient of ionisation in this layer—a quantity about which little was formerly known—must approach the exponential form. It has also been shown that the existence of an absorbing D layer is unlikely. A reasonably accurate determination of the collision frequency of the electrons with the air molecules at the level of the E layer has been possible." Bailey's work on the analysis of the "Luxembourg effect" (1934, p. 199: *see* also p. 606) and on conformal representation applied to ionosphere investigation (*ibid.*, p. 606) is mentioned. "Conformal representation has also been used to obtain graphically the complex admittance or impedance of a tuned circuit having resistance in the inductance arm." It has now been found possible to explain certain anomalous results in the propagation of very long radio waves, obtained some years ago in England by Hollingworth, by the application of the magneto-ionic theory, using a ray treatment. Other anomalies recently obtained in England are also explained by the theory.

(2) Work on atmospherics. Besides confirming previous conclusions, the recent work has shown, among other things, that the great majority of lightning flashes around Toowoomba (2 000 ft altitude) are from cloud to cloud and some thousands of feet above the earth: also that the complexity and duration of flashes as observed with the eye are always consistent with the resultant output from a receiver, whether observed aurally or on the cathode-ray-tube screen with a time base to separate the component impulses.

8. THE INFLUENCE OF MAGNETIC DISTURBANCES ON THE PROPAGATION VELOCITY OF LONG ELECTROMAGNETIC WAVES.—N. Stoyko. (*Comptes Rendus*, 29th Oct. 1934, Vol. 199, No. 18, pp. 845–847.)

The writer remarks that no one up to the present has dealt with this effect. His results, based on 14 000 observations over four years, on different long wave services, at different times of day, indicate a definite increase of apparent velocity with increase of magnetic disturbance. The mean increase, as between a calm and a magnetic storm, is given as 15 949 km/s; as between a calm and a slight disturbance, 5 748 km/s. Since a magnetic disturbance is due to solar corpuscles which also produce an abnormal ionisation in the E layer, and since a variation of ionisation affects the group velocity of propagation by changing both ϵ, the dielectric constant, and γ, a coefficient depending on the ionisation and the internal friction, a disturbance will cause an increase in velocity provided $\Delta\epsilon + \epsilon\Delta\gamma < 0$. During the night the long waves suffer successive reflections similar to those of short waves, and the apparent velocity is increased by the decrease in effective height of the layer due to the increased ionisation during the magnetic disturbance. For the writer's work on short waves *see* Abstracts, 1931, p. 434; 1933, p. 437 (two); and 1934, p. 375.

9. A [Phase-Difference] METHOD OF MEASURING THE VELOCITY OF PROPAGATION OF HERTZIAN WAVES, AND ITS APPLICATION TO "RADIO-TELEMETRY" [and to the Study of Short-Wave Propagation].—Fayard. (*See* 150.)

10. INTERACTION OF WIRELESS WAVES [U.R.S.I. Discussion of "Luxembourg Effect"].—(*Wireless World*, 28th Sept. 1934, Vol. 35, p. 263.)

11. THE PASSAGE OF HIGH-FREQUENCY ALTERNATING CURRENTS THROUGH IONISED GASES.—A. Székely. (*Ann. der Physik*, No. 3, Vol. 20, Series 5, 1934, pp. 279–312.)

This paper first discusses the present theories of the mechanism of the passage of alternating currents through ionised gases and finds formulae for the conductivity and dielectric constant for the case in which the electricity carriers at low pressures move through the gas in various directions and experience no collisions. Formulae are also deduced which take account of the action of quasi-elastic and frictional forces.

The second part of the paper gives measurements of the conductance and capacity of a condenser in ionised argon at a pressure of 10^{-3} mm for frequencies from 2×10^6 to 5×10^7 c/s. This condenser consisted of the two pairs of plates in a cathode-ray oscillograph, connected in parallel. The conductivity was found to increase with the frequency and showed a kind of resonance effect at a definite frequency (about 3.55×10^7 c/s). The capacity was increased by the ionisation. The current/voltage curves were linear only for very small voltages and the writer is of the opinion that considerable errors in other writers' experiments may have arisen from measurement at too high voltages.

In the third part of the paper the writer attempts to explain her experimental results; she finds that free electrons are responsible for the conductivity only at very low frequencies; as the frequency increases, the effect of the bound electrons in negative ions becomes more marked, and at very high frequencies these alone are the carriers of the conduction current. The apparent resonance effect mentioned above is ascribed to the presence of a small number of specially loosely bound electrons in the ionised gas. [The writer has not considered the effect of the shape and limited size of the oscillograph containing the ionised gas, nor the possibility that the phenomena may be influenced by the boundary conditions.]

12. THE COEFFICIENT OF ELECTRON IONISATION FOR NITROGEN AT LOW PRESSURE [1 to 15 mm Hg].—R. Hellmann. (*Zeitschr. f. Physik*, No. 7/8, Vol. 91, 1934, pp. 556–568.)

The nitrogen was ionised by photoelectrons and the current produced was measured with constant gas pressure and electric field, the distance between the electrodes being varied. It was found that at pressures below 3.5 mm Hg the ionisation was more than was expected from the usual similarity formula $\alpha/p = f(E/p)$ [α ionisation coefficient, p pressure, E electric field, f a function of E/p]. At pressures above 3.5 mm Hg, the formula

$$\alpha/p = c_1 e^{-c_2 . p/E}$$

was satisfied; c_1 and c_2 were no longer constant at lower pressures.

13. THE HIGH-FREQUENCY GLOW DISCHARGE [Initiation and Maintenance: Electrostatic Theory of Ionisation].—J. Thomson. (*Phil. Mag.*, October, 1934, Vol. 18, No. 120, pp. 696–719.) *See* also 1930 Abstracts, p. 646.

14. IONISATION BY POSITIVE IONS IN HELIUM [Ionisation Processes the same as in Diatomic Gases].—J. S. Townsend and G. D. Yarnold. (*Phil. Mag.*, October, 1934, Series 7, Vol. 18, No. 120, pp. 594–606.)

15. CALCULATION OF THE VERTICAL COMPONENT OF THE MAGNETIC FIELD IN THE NEIGHBOURHOOD OF A VERTICAL MAGNETIC DIPOLE ON THE BOUNDARY BETWEEN TWO DIFFERENT MEDIA.—W. Nunier. (*Ann. der Physik*, No. 5, Vol. 20, Series 5, 1934, pp. 513–528.)

This paper uses the method of G. J. Elias (*Physica*, 1922) to evaluate Sommerfeld's formula (*Riemann-Weber*, Vol. 2) for the potential function of a vertical magnetic dipole on a boundary surface, and discusses the vertical component of the field due to the dipole at points near the dipole in both media and on the surface.

16. A DETERMINATION OF THE ELECTRICAL CONSTANTS OF THE EARTH'S SURFACE AT WAVELENGTHS OF 1.5 AND 0.46 METRE.—J. S. McPetrie. (*Proc. Phys. Soc.*, 1st Sept. 1934, Vol. 46, No. 256, pp. 637–648.)

The experiments described in this paper were concerned with measurements of the wave reflected from the earth's surface at vertical incidence. The dielectric constant of soil was found to lie between 7 and 16, and the conductivity below about 10×10^8 e.s.u., for radiation at a wavelength of 1.5 m. For a wavelength of 0.46 m the values of these quantities lay between 7 and 20, and up to 40×10^8 e.s.u., respectively.

17. THE MEASUREMENT OF THE ELECTRICAL CONSTANTS OF SOIL BY A LECHER-WIRE METHOD AT A WAVELENGTH OF 1.5 METRES.—R. L. Smith-Rose and J. S. McPetrie. (*Proc. Phys. Soc.*, 1st Sept. 1934, Vol. 46, No. 256, pp. 649–658.)

The dielectric constant was found to have a value of 10 or 12, while the conductivity lay within the range 10 to 28×10^8 e.s.u. For measurements on longer waves *see* 1934 Abstracts, p. 609.

18. RESEARCHES ON ATMOSPHERIC OZONE CARRIED OUT AT SCORESBY SOUND DURING THE POLAR YEAR.—A. Dauvillier. (*Journ. de Phys. et le Rad.*, September, 1934, Series 7, Vol. 5, No. 9, pp. 455–462.)

19. RECORDS OF THE ULTRA-VIOLET SOLAR SPECTRUM IN THE STRATOSPHERE AND THE VERTICAL DISTRIBUTION OF OZONE.—E. Regener and V. H. Regener. (*Physik. Zeitschr.*, 1st Oct. 1934, Vol. 35, No. 19, pp. 788–793.)

The maximum concentration of ozone is thought, as a result of measurements with self-registering instruments up to heights of 31 km, to occur at a height of about 24 km. This agrees with the deductions of Goetz, Meetham and Dobson (Abstracts, 1933, p. 560, and 1934, p. 553).

20. OBSERVATION OF THE EMISSION SPECTRUM OF THE NIGHT SKY IN THE ULTRA-VIOLET, *and* THE ULTRA-VIOLET END OF THE NIGHT-SKY SPECTRUM.—Dufay: Gauzit. (*Journ. de Phys. et le Rad.*, October, 1934, Series 7, Vol. 5, No. 10, pp. 523–526 and 527–532.)

21. DETERMINATION OF THE QUANTITY OF OZONE IN THE ATMOSPHERE NEAR SHANGHAI [and Some Conclusions].—P. Lejay. (*Comptes Rendus*, 29th Oct. 1934, Vol. 199, No. 18, pp. 879–881.)

"The contradiction between our results and those of other observers would be explained if we suppose that the variations in the quantity of ozone are not connected with the actual state of the atmosphere but with its movements. This hypothesis would also explain the apparently paradoxical fact that the amount of ozone is closely connected with meteorological conditions while remaining independent of the pressure at the ground."

22. ON THE INTERPRETATION OF ATMOSPHERIC OZONE MEASUREMENTS [Solution of Integral Equation for Ozone Distribution].—C. L. Pekeris. (*Gerlands Beitr.*, No. 2, Vol. 41, 1934, p. 192.)

23. THE DISTRIBUTION OF ATMOSPHERIC OZONE AS A FUNCTION OF ALTITUDE [only Determinable by Combination of Fabry-Buisson Method with Simultaneous Balloon Data].—D. Barbier. (*Journ. de Phys. et le Rad.*, June, 1934, Series 7, Vol. 5, No. 6, pp. 243–252.)

24. THEORETICAL CONSIDERATIONS ON THE LUMINESCENCE OF THE UPPER LAYERS OF THE ATMOSPHERE [The Mechanism of Formation of Metastable Nitrogen N_2(A) and Ozone, and Their Rôle in the Luminosity of the Night Sky: etc.].—J. Cabannes. (*Comptes Rendus*, 5th Nov. 1934, Vol. 199, No. 19, pp. 909–911.)

25. PHOTOGRAPHY BY SHORT ELECTRICAL WAVES [Micro-Waves: "Fixing on White Paper the Point of Incidence or Track"].—W. Arkadiew. (*Physik. Zeitschr. der Sowietunion*, No. 3, Vol. 6, 1934, p. 327: in English.)

By the use of a number of coherers, about 1 cm long, each provided with electrodes of two different metals which rest on the moistened paper impregnated with a chemical indicator. "By using a mirror or optical lens a diffraction image of the source of the rays can be obtained." *See* also 26.

26. The Diffraction of Electric Waves recorded Chemically [using Small Coherers distributed over an Impregnated Paper: Diffraction Records of 2.9 cm Waves].—W. Arkadiew. (*Comptes Rendus*, 29th Oct. 1934, Vol. 199, No. 18, pp. 848–849.) *See* also 25.

27. Anomalous Absorption and Dispersion of the Primary Alcohols in the Ultra-Short-Wave Region.—K. Krause. (*Physik. Zeitschr.*, 1st Sept. 1934, Vol. 35, No. 17, pp. 684–691.)

28. Measurements of Absorption in Liquids [Wavelength 180 Centimetres].—Malsch. (*See* 283.)

29. Determination of the Dielectric Constant of Some Dilute Aqueous Solutions of Electrolytes, using Rapid Electrical Oscillation [Wavelength 15 m: Agreement with Debye-Falkenhagen Theory].—F. P. Henninger. (*Ann. der Physik*, No. 4, Vol. 20, Series 5, 1934, pp. 413–440.)

30. Mathematical Aspects of the Propagation of Light [Physical Basis of Maxwell's Theory].—H. M. Macdonald. (*Nature*, 29th Sept. 1934, Vol. 134, pp. 482–483.) From British Association Presidential Address. *See* also *Science*, 14th Sept. 1934, Vol. 80, No. 2072, pp. 233–238.

31. Sources of Various Kinds near a Plane Boundary separating Two Different Media [Reflected and Refracted Wave-Trains—Theoretical Paper].—G. Green. (*Phil. Mag.*, October, 1934, Series 7, Vol. 18, No. 120, pp. 625–640.)

32. A Duality Principle in Optics.—M. Herzberger. (*Zeitschr. f. Physik*, No. 5/6, Vol. 91, 1934, pp. 323–328.)

33. The Dispersion of the Phase Change on Reflection of Light at Thin Metallic Films [Internal Reflections in Film].—J. Bauer. (*Ann. der Physik*, No. 5, Vol. 20, Series 5, 1934, pp. 481–501.)

34. Radiation and Electrical Power Transmission.—W. E. Sumpner. (*Journ. I.E.E.*, October, 1934, Vol. 75, No. 454, pp. 512–526.)

"The aim of the present paper is to justify the view that the processes at work in steady current systems of electrical power transmission are the same as those involved in radiation, and that the fluxes have the same characteristics as those in a wave of light. This is not the normal view. Maxwell's theory is an electromagnetic theory of light, but does not seem to have been used as an optical theory of electromagnetic processes. No one seems to have applied to it two principles always admitted about light: (i) the individuality and independence of light waves, and (ii) the production of reflections when light waves are incident on matter." The analysis (Part II) is an example of Heaviside's vector methods and is based on assumptions whose physical aspects and justification are discussed in Part I.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

35. Localisation at a Great Distance of Sources of Atmospheric Parasites without the Use of the Radiogoniometer [by Timing the Sudden Falling-Off just before Sunrise: Polar Year Results].—J. Lugeon. (*Comptes Rendus*, 12th Nov. 1934, Vol. 199, No. 20, pp. 1059–1061.)

After outlining this particular part of his procedure for "sounding the atmosphere" (1934 Abstracts, p. 375, and back refs.) the writer deals with the results thus obtained by Centkiewicz from 180 days' records at Bear Island and Jablonna (Poland): they "coincide remarkably" with the storms of the three continents and the Atlantic Ocean, as given by the meterological charts. They are also confirmed by radiogoniometric observations at Jablonna and Saint Cyr. The Kennelly-Heaviside layer height was taken as 100 km. The estimated angle α between the ray and the horizon averaged 2° for the recorders used, tuned to 11 000 m; on 7 000 m it had about the same value, but with aperiodic recording it tended towards zero, suggesting that the refracting region for very low frequencies is sometimes below the horizon at the receiver.

36. Static from Hurricanes may aid in Locating Them [Proposed Puerto Rico Research].—Kenrick. (*Sci. News Letter*, 8th Sept. 1934, Vol. 26, No. 700, p. 151.)

37. Australian Radio Research Board: Sixth Annual Report. (*See* end of 7.)

38. The Earth's Electric Field, Thunderstorms and Lightning [Critical Account of Modern Theories].—A. von Hippel. (*Naturwiss.*, 19th Oct. 1934, Vol. 22, No. 42, pp. 701–712.)

39. The Discharge from Raindrops in Intense Fields.—J. J. Nolan and J. P. Ryan. (*Gerlands Beitr.*, No. 2, Vol. 41, 1934, pp. 185–191.)

40. The Rate of Evaporation of Small Droplets in a Gas Atmosphere.—N. Fuchs. (*Physik. Zeitschr. der Sowietunion*, No. 3, Vol. 6, 1934, pp. 242–243: in German.)

41. Development of the Spark Discharge.—T. E. Allibone and B. F. J. Schonland. (*Nature*, 10th Nov. 1934, Vol. 134, pp. 736–737.)

The phenomena of the preliminary discharge observed in lightning flashes by Schonland and Collens (1934 Abstracts, p. 262, where the volume number is wrongly given as 193 instead of 143) have now been observed in laboratory discharges, using a camera of high resolving power. Leader strokes are found to form whether the high-tension electrode is positive or negative. For relevant work on time-lag of spark-over, *see* Allibone, Hawley and Perry, 42.

42. CATHODE-RAY OSCILLOGRAPH STUDIES OF SURGE PHENOMENA.—T. E. Allibone, W. Hawley, and* F. R. Perry. (*Journ. I.E.E.*, November, 1934, Vol. 75, No. 455, pp. 670–688.)

Extending the work dealt with in Abstracts, 1932, p. 655*. The rubber-insulated delay cable between potential divider and oscillograph, for recording uncontrolled transients (Burch and Whelpton, 1933, p. 339) was replaced by a special air-insulated concentric cable which gave several advantages. Voltages up to 1 million were used, and records are given of the impulse spark-over, for surges of different wave-form, of the point/plane and sphere/plane gaps in air and oil, and of the spark-over of porcelain suspension insulators.

43. SOME STUDIES ON THUNDERSTORMS. PART I. REPORT OF THE OBSERVATION OF LIGHTNINGS [Number of Partial Discharges in a Flash: Average Interval: etc.].—H. Noto. (*Physik. Ber.*, 15th Aug. 1934, Vol. 15, No. 16, p. 1351.)

44. CONTRIBUTION TO THE EXPERIMENTAL STUDY OF THE DISCHARGE OF A CONDENSER BY AN ELECTRIC SPARK [High-Speed Photographic Recording reveals a Series of "Principal" Sparks and "Partial" Sparks covering only Part of the Gap].—I. C. Purcaru. (*Journ. de Phys. et le Rad.*, May, 1934, Series 7, Vol. 5, No. 5, pp. 114–115S.) *See* also 1934 Abstracts, p. 201.

45. THE INITIATION OF DISCHARGES IN ION FREE GASES [by Electrons arising from Field Emission from Cathode].—J. W. Flowers and J. W. Beams. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, pp. 338–339: abstract only.)

46. A STUDY OF THE INITIAL STAGES OF SPARK BREAKDOWN IN GASES [Phenomenon due to Electron Motion from Cathode].—H. J. White. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 330: abstract only.)

47. SPARK INVESTIGATION BY THE WILSON CHAMBER [Forms of Positive and Negative Ion Clouds].—U. Nakaya and F. Yamasaki. (*Nature*, 29th Sept. 1934, Vol. 134, pp. 496–497: preliminary letter.)

48. LIGHTNING CURRENTS MEASURED [with Curve showing Percentage of Records greater than 5 000, 10 000, 15 000 and 25 000 Amperes]. —H. W. Collins. (*Elec. World*, 12th May, 1934, Vol. 103, No. 19, pp. 688–689.) The measuring method was based on the puncturing of special paper between 2-inch diameter copper blocks, the size of the opening being found later by an air-flow measurement.

49. LIGHTNING FLASHOVERS—ON THE LINE OR AT THE STATION?—L. V. Bewley. (*Elec. World*, 14th July, 1934, Vol. 104, No. 2, pp. 52–54.)

50. HIGH- AND LOW-TENSION LIGHTNING PROTECTORS.—C. Ledoux. (*Rev. Gén. de l'Élec.*, 15th and 22nd Sept. 1934, Vol. 36, Nos. 11 and 12, pp. 373–386 and 413–422.)

51. THE MAGNETIC FIELDS OF SUNSPOTS.—J. Larmor. (*Monthly Not. Roy. Astron. Soc.*, No. 5, Vol. 94, 1934, pp. 469–471.)

52. THE INFLUENCE OF MAGNETIC DISTURBANCES ON THE PROPAGATION VELOCITY OF LONG ELECTROMAGNETIC WAVES.—Stoyko. (*See* 8.)

53. THE DIURNAL INCIDENCE OF DISTURBANCE IN THE TERRESTRIAL MAGNETIC FIELD.—A. C. Mitchell. (*Trans. Roy. Soc. Edinburgh*, No. 3, Vol. 57, 1934, pp. 617–632.)

54. EARTH'S MAGNETIC FIELD AFFECTED BY SOLAR ECLIPSE [Japanese Results]. — Akiyosi. (*Science*, 14th Sept. 1934, Vol. 80, No. 2072, Supp. p. 8: summary only.)

55. INVESTIGATIONS OF THE POLARISATION AND THE SPECTRUM OF THE SKY LIGHT DURING THE TOTAL SOLAR ECLIPSES OF AUGUST, 1932, AND FEBRUARY, 1934 [Sky Light may be composed of Scattered Solar Light and Self-Luminescence from Excited Gases].—W. M. Cohn. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 328: abstract only.)

56. THE DIURNAL VARIATION OF THE SPACE CHARGE AND ITS EFFECT UPON THE POTENTIAL GRADIENT.—C. H. Dwight. (*Phil. Mag.*, October, 1934, Vol. 18, No. 120, pp. 719–724.)

57. DIURNAL VARIATIONS OF THE ELECTRICAL CONDUCTIVITY OF THE AIR.—G. Viel. (*Rev. Gén. de l'Élec.*, 28th July, 1934, Vol. 36, No. 4, pp. 117–119.)

58. HARMONIC ANALYSIS OF THE DIURNAL VARIATION OF THE NORTH/SOUTH EARTH CURRENTS RECORDED AT THE PARK ST. MAUR OBSERVATORY [and the Question of Lunar Influence].—P. Rougerie. (*Comptes Rendus*, 5th Nov. 1934, Vol. 199, No. 19, pp. 964–966.)

59. A POLAR AURORA EXPEDITION TO TRONDHEIM IN MARCH, 1933 [with Tables: Sunlit Auroras invisible to Eye but recorded Photographically, at Heights of 250–450 Kilometres].—C. Störmer. (*Gerlands Beitr.*, No. 3, Vol. 41, 1934, pp. 382–386.)

60. RECONSTRUCTION OF AURORAL OBSERVATIONS RECORDED ON A REVOLVING SPHERE AT SCORESBY SOUND DURING THE POLAR YEAR, AND RESULTS.—Habert. (*Journ. de Phys. et le Rad.*, May, 1934, Series 7, Vol. 5, No. 5, pp. 99–101 S.)

61. STUDY OF THE POLAR AURORAS AT SCORESBY SOUND DURING THE POLAR YEAR.—A. Dauvillier: Maurain. (*Journ. de Phys. et le Rad.*, May, 1934, Series 7, Vol. 5, No. 5, pp. 98–99 s.) For corrections see *ibid.*, September, 1934, No. 9, p. 462. On p. 101 s of the May number Maurain gives some arguments against Dauvillier's theory. For the latter's long report *see* 1934 Abstracts, p. 610.

62. The Passage of Charged Particles through the Magnetic Field and the Atmosphere of the Earth [Theoretical Work].—R. M. Langer. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 330: abstract only.)

63. The Displacement, in an Electrostatic Field, of Magneto-Electronic Spirals [Calculation applicable to Cosmic Rays, Aurora-Producing Secondary Electrons, etc.].—L. Cartan. (*Journ. de Phys. et le Rad.*, June, 1934, Series 7, Vol. 5, No. 6, pp. 256–261.)

64. Cosmic Rays and the Earth's Potential [Theoretical Consequences of Magnetised Charged Spherical Earth].—L. G. H. Huxley. (*Nature*, 13th Oct. 1934, Vol. 134, pp. 571–572.) *See* also 1934 Abstracts, p. 610.

65. The Significance of J. Clay's Ionisation Depth Data in Relation to the Nature of the Primary Cosmic Radiation.—W. F. G. Swann. (*Phys. Review*, 1st Sept. 1934, Series 2, Vol. 46, No. 5, pp. 432–434.)

The data in question were referred to in 1934 Abstracts, p. 316, r-h col. This note draws attention to the fact that these data are completely in harmony with predictions of the present writer (Abstracts, 1933, p. 499; 1934, p. 223; and elsewhere) on the assumption that high energy cosmic rays (with energy comparable to 10^{10} volts) do not ionise in the ordinary sense but produce occasional showers of secondary rays of lower energy.

66. Cosmic Rays studied 820 Feet under Water [Results indicating Presence of High-Speed Particles].—J. Clay. (*Sci. News Letter*, 15th Sept. 1934, Vol. 26, No. 701, p. 164.)

67. A Coincidence Test of the Corpuscular Hypothesis of Cosmic Rays [Coincidences are due to Penetrating Ionising Particles].—D. S. Hsiung. (*Phys. Review*, 15th Oct. 1934, Series 2, Vol. 46, No. 8, pp. 653–658.)

68. A General Interpretation of Cosmic-Ray Effects [Summary of Results to Date].—R. A. Millikan. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 329: abstract only.)

69. A Very High Altitude Survey of the Effect of Latitude upon Cosmic-Ray Intensities and an Attempt at a General Interpretation of Cosmic-Ray Phenomena.—I. S. Bowen, R. A. Millikan and H. V. Neher. (*Phys. Review*, 15th Oct. 1934, Series 2, Vol. 46, No. 8, pp. 641–652.)

For preliminary reports of the survey of which this is a detailed account *see* Abstracts, 1933, pp. 388 and 617, and 1934, p. 316. More than 85 per cent of the sea-level ionisation is attributed to photons. The energies actually found in cosmic rays can apparently only come from the partial annihilation of matter and the complete annihilation of atoms.

70. American Stratosphere Ascent of July 29, 1934 [Records show Cosmic Ray Energies due to Matter Annihilation].—(*Nature*, 3rd Nov. 1934, Vol. 134, pp. 707–708.)

71. The Annihilation of the Proton [High Energy Proton Cosmic Rays converted by Collision into Photon and Positron].—A. Bramley. (*Phys. Review*, 1st Sept. 1934, Series 2, Vol. 46, No. 5, pp. 438–439.)

72. Composition of Cosmic Rays [Recognition of Three Components].—A. H. Compton and H. A. Bethe. (*Nature*, 10th Nov. 1934, Vol. 134, pp. 734–735.)

Recent information on the absorption of high energy photons and electrons leads to the recognition of three distinct components *A*, *B*, and *C* of cosmic rays. *A* may be alpha-particles or (more probably) photons, *B* positive or negative electrons, and *C* protons. Several phenomena are explained by this classification.

73. Further Measurements of Cosmic Radiation in the Upper Atmosphere with Open Ionisation Chambers.—E. Regener and R. Auer. (*Physik. Zeitschr.*, 1st Oct. 1934, Vol. 35, No. 19, pp. 784–788.)

For previous work *see* 1934 Abstracts, p. 88 (two). The newest apparatus and results are here described; the number of ion pairs formed at pressures lower than about 150 mm Hg falls sharply in all the measurements made.

74. Mountain Measurements of Cosmic Radiation in Various Geographical Latitudes.—H. Hoerlin. (*Physik. Zeitschr.*, 1st Oct. 1934, Vol. 35, No. 19, pp. 793–795.)

75. [Measurements of] the Azimuthal Asymmetry of Cosmic Radiation on Mount Evans, Colorado.—J. C. Stearns and D. K. Froman. (*Phys. Review*, 15th Sept. 1934, Series 2, Vol. 46, No. 6, pp. 535–536.)

76. Measurement of Cosmic Radiation in the Upper Atmosphere [up to 28 km] with a Counter [Description of Self-Registering Apparatus: Number of Counts Constant above 18 km, agreeing with Ionisation Chamber Method].—E. Regener and G. Pfotzer. (*Physik. Zeitschr.*, 1st Oct. 1934, Vol. 35, No. 19, pp. 779–784.)

77. The Mean Penetrating Power of Cosmic Radiation.—B. Gross. (*Physik. Zeitschr.*, 15th Sept. 1934, Vol. 35, No. 18, pp. 746–747). Theoretical proof that the mean penetrating power of a bundle of radiation incident from all sides is half as great as when the incidence is on one side only.

78. Energy-Loss and the Production of Secondaries by Cosmic-Ray Electrons.—C. D. Anderson and S. H. Neddermeyer. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 325: abstract only.)

79. Effects of Cosmic Radiation in a Wilson Chamber at the Hafelekar Observatory (2 300 m) near Innsbruck [Nature of Observed Tracks].—F. Rieder and V. F. Hess. (*Nature*, 17th Nov. 1934, Vol. 134, pp. 772–773.)

80. Rock-Salt Absorption of Cosmic Rays [High Transparency].—S. Ziemecki. (*Nature*, 17th Nov. 1934, Vol. 134, p. 773.)

PROPERTIES OF CIRCUITS

81. Self-Sustained Oscillations [and particularly Relaxation Oscillations].—J. Haag. (*Comptes Rendus*, 5th Nov. 1934, Vol. 199, No. 19, pp. 906–909.)

"The investigation of periodic oscillations resolves itself into the determination of the cycles of a certain first-order differential equation, of which M. Liénard has given a very simple geometrical interpretation (1928 Abstracts, p. 469). From this interpretation it follows that every cycle is a closed curve characterised by the condition that the normals at two points P and P_1 of the same abscissa intersect at Q on Oy. The point M, where PP_1 cuts the line through Q parallel to Ox, describes the curve Γ, whose ordinate is the primitive of the coefficient of resistance. I propose to determine the most general cycle and the curve Γ associated with it." Coming later to the cycles corresponding to relaxation oscillations, which must be much elongated in the direction Oy, the writer supposes the ordinates of the curve Γ to be increased in a large ratio k. He arrives at formulae (1) and (2), for the upper and lower arcs, which he finds accurate within 10^{-4} for $k = 100$, very good for $k = 10$ and fairly good even for $k = 5$. It would be possible to obtain Γ curves presenting angular points, as would occur, for instance, if the resistance had a different analytical expression according to whether it were negative or positive.

82. Calculations and Remarks on the Efficiency of Machines [including Simple Sinusoidal and Relaxation Oscillators].—Ph. le Corbeiller. (*Ann. des P.T.T.*, October, 1934, Vol. 23, No. 10, pp. 893–907.)

83. "Kippen" [Instability Effects] in a Parallel Connection of Saturable Choke and Condenser [with a Resistance in Series].—W. Volkers. (*E.T.Z.*, 27th Sept. 1934, Vol. 55, No. 39, pp. 950–952.) For the writer's paper on the better known "kipp" effects in *series* circuits *see* 1934 Abstracts, p. 204.

84. The Statistical Conception of Dynamic Systems.—Pontrjagin, Andronoff and Witt. (*Physik. Zeitschr. der Sowietunion*, No. 1/2, Vol. 6, 1934, pp. 1–24: in German.)

85. On Self-Oscillating Systems approximating to the Hamiltonian Type.—L. S. Pontrjagin. (*Ibid.*, pp. 25–28: in German).

86. Anode Retroaction in Various Valve Circuits [Calculation for Ohmic, Capacitive, and Inductive Anode-Circuit Resistance: Grid/Anode Capacity increased in Each Case: Effect on Apparent Grid Leak Resistance: etc.].—M. Dick. (*Physik. Ber.*, 1st Sept. 1934, Vol. 15, No. 17, p. 1414.)

87. Linear Rectification [with Pliotrons and Thyratrons: particularly the "Holding-Arc" Circuit for Thyratrons].—K. C. De Walt. (*Electronics*, August, 1934, p. 252.)

88. Application of Kirchhoff's First Law to the Composition of Equivalent Electrical Circuits for Mechanical Systems.—I. S. Rabinovitch. (*Russian Journ. of Tech. Phys.*, No. 3, Vol. 4, 1934, pp. 678–685.)

TRANSMISSION

89. The Generation of Electromagnetic Waves below 50 cm with Split-Anode Magnetrons [Power in Aerial up to 25 W at 30 cm, 35 W at 47 cm].—Slutzkin, Leljakow, Kopilowitsch, Wyschinski and Usikow. (*Physik. Zeitschr. der Sowietunion*, No. 1/2, Vol. 6, 1934, pp. 150–158: in German.)

Anodes of small diameter are desirable so as to decrease the electron path-time; at the same time an increase in their length is objectionable since the conditions for self-excitation become worse as the ratio L/C decreases (*cf.* Slutzkin, below). The consequent limitation in anode area is a difficulty if the recognised maximum permissible anode load, of a few watts per cm², has to be adhered to. By improving the outgassing process and by conducting the heat away by way of the oscillatory circuit, the writers have increased the permissible load to 40–60 w. The oscillatory circuit is contained in the bulb; its inductance is that of the rectangular connection of molybdenum strip joining the two anodes, and its capacity is merely that between the two anodes combined with the self-capacity of the connection. The anode voltage is applied at the mid-point of this connection, through a high-resistance choke and a variable "protecting" resistance (1934 Abstracts, p. 612).

It was found that the sense of the tuning adjustment often affects the results. Thus if the tuning is done by varying the magnetic field, oscillation is produced more readily by a gradual *decrease* of the field. The best method, for obtaining high output, is to tune by adjusting the anode current. The external aerial is coupled inductively to the internal oscillatory circuit.

It was found that the generation of waves of or below 30 cm was attended with great difficulties (need of high anode voltage, etc.) with the 5 mm diameter anodes used, even when their length was shortened. The diameter was therefore reduced to 3 mm. Aerial powers of 25 w at 30 cm (efficiency 40%) and 10 w at 24 cm (efficiency 25%) were thus obtained. A further reduction of diameter to 2 mm brought in mechanical difficulties (already inclined to appear at 3 mm) which made the valves vary in their properties from one to another. With some of these valves an output of 15 w at 30 cm was obtained, with an anode voltage of only 350 v instead of the previous 500–600 v for the 3 mm anodes and 1 000–2 400 v for the 5 mm. The efficiency here was 60%.

90. The Theory of the Split-Anode Magnetron Generator.—A. A. Slutzkin. (*Physik. Zeitschr. der Sowietunion*, No. 3, Vol. 6, 1934, pp. 280–292: in German.)

The type of split-anode magnetron oscillation studied is the "second" type whose frequency is determined by the associated oscillatory circuit, as distinct from the "first" type (similar to those occurring in the "whole-anode" magnetron) whose period depends on the electron path-time from filament to anode. For the "second" type the path-time must be small compared with the natural period of the circuit. Equation 3 is obtained for the oscillatory circuit connected to the two half-anodes (Figs. 1b for decimeter waves and 1a for longer waves): on the assumption of complete system symmetry this becomes equation 4. Characteristic curves (Figs. 3—magnetic field below critical value—and 4, 5 and 6—magnetic field above) are plotted showing the variation of the difference between the two half-anode currents as the potential difference between the half-anodes is changed.

The condition for self-oscillation is found to be $r/L - \frac{3}{4} K/C < O$, where K is the average slope of the I_m/V_m characteristic and C the total capacity (including the two half-anodes). Here V_m is that potential difference between the half-anodes for which the difference between the two anode currents reaches its extreme value, while I_m is the largest absolute value which the difference between the currents can reach. The limiting value for the amplitude attainable by the oscillatory potentials may be obtained by the approximate solution of equation 6. It can also be obtained from power considerations, which on certain approximations give equation 13, which shows that the oscillation potential amplitude first increases with increasing V_m, passes through a maximum, and then decreases. The oscillatory power has a similar curve. For the optimum value of V_m (which means the choice of the optimum magnetic field) the oscillatory power is proportional to the value of the equivalent resistance of the oscillatory circuit and to the value I^2_m, which in a first approximation can be regarded as proportional to the square of the emission current. If the mean emission current is i_0, then at maximum power output the efficiency is given by equation 16. Under favourable conditions, efficiencies well over 50% can be obtained: the author has often succeeded in obtaining values exceeding 60%. The final section deals with the dependence of V_m on the strength of magnetic field and on the anode voltage, and with the effect of differently shaped characteristic curves on the results obtained.

91. Magnetron Oscillations of a New Type ["Rotating-Field" Oscillations].—K. Posthumus. (*Nature*, 3rd Nov. 1934, Vol. 134, p. 699.)

This letter refers to magnetron oscillations described in a previous letter, which Megaw suggested were dynatron oscillations (*see* Megaw, 1934 Abstracts, p. 612). The present writer finds that the static negative resistance necessary for dynatron oscillations could never be measured; and there was both an upper and a lower frequency limit for every adjustment of anode voltage and magnetic field, which is not in favour of the dynatron theory. The oscillations may be called "rotating field oscillations," as they may be generated by the influence of the tangential alternating electric field, resolvable into two rotating fields.

The equation for the upper frequency limit is given; this is confirmed by experiment and its physical significance is explained. This type of oscillation has been obtained on wavelengths ranging from 80 cm to 5 m for a two-plate magnetron, and from 35 cm to 250 cm for a four-plate magnetron.

92. The Generation of Ionic Currents in a High Vacuum with the Help of the Magnetic Field [based on Phenomena in the Whole-Anode Magnetron].—A. A. Slutzkin, S. J. Braude and I. M. Wigdortschik. (*Physik. Zeitschr. der Sowietunion*, No. 3, Vol. 6, 1934, pp. 268–279: in German.)

Arising from the work dealt with in Abstracts, 1929, p. 326, and 1934, p. 612, where the appearance of a sudden jump in the cathode heating, at definite values of magnetic field always above the "critical" value, is shown to be a special case of a general phenomenon due to the formation, under certain conditions, of a rotating space charge. This greatly increases the electron path-length and consequently the probability of collision with a gas molecule, and the heightened ionisation leads (when the p.d. between anode and cathode is large enough) to the extra heating of the cathode by ion bombardment.

Making use of this fact that a magnetic field of suitable strength greatly increases the ionisation of the residual gas, the writers have constructed a special valve with a tubular anode 60 mm long which generates ionic currents up to 140 μA in a vacuum of 10^{-5}–10^{-6} mm Hg. A second valve was designed specially for the analysis of the emergence of secondary electrons due to the ions. With this tube the simultaneous occurrence of the ion currents and of electronic oscillations along the cathode was demonstrated and measured.

93. The Magnetron as Generator of Micro-Waves [Examination of Hull's Theory and Experimental Investigation of the Žáček-Okabe Law: etc.].—G. de Fassi and G. Salom. (*Alta Frequenza*, August, 1934, Vol. 3, No. 4, pp. 396–422.)

The work includes a deduction of the Z.-O. law ($\lambda . H =$ const.) from a hypothesis on the radial acceleration of the electrons emitted from the cathode, and a confirmation of Okabe's value of 13 000 for the constant (*see* Megaw: Hoag, 1934 Abstracts, p. 150). Measurements of frequency and power output of several magnetrons are described, and the results compared with those from a B.-K. triode oscillator.

94. The Theory of Ultra-Short Wave Generators.—E. W. B. Gill. (*Phil. Mag.*, November, 1934, Series 7, Vol. 18, No. 121, pp. 832–838.)

This paper collects some of the main experimental results on the generation of ultra-short waves of Gill-Morell type and discusses the production of successive pulses of rarefaction and compression of electrons in the valve, with grids of (1) close and (2) open mesh.

95. A New Procedure for the Generation of Ultra-Short Waves [Micro-Waves down to 19 cm obtained with Plate Positive and Grid near Filament-Potential, in a Normal Triode].—E. Pierret. (*Journ. de Phys. et le Rad.*, April, 1934, Series 7, Vol. 5, No. 4, pp. 79–80 S.)

96. An Experimental Investigation of the Synphase Circuit for the Generation of Ultra-Short Waves.—A. L. Joffe. (*Izvestia Elektroprom. Slab. Toka* [Reports of the Light-Current Elec. Industry, U.S.S.R.], Jan./Feb. 1934, No. 1, pp. 41–46.)

An account is given of experiments with Holborn and Mesny circuits on wavelengths between 3.7 and 5.42 metres. The results obtained are shown in tables and graphs. A comparative study is made of synphase circuits, *i.e.*, circuits in which both voltages and currents at symmetrical points are in phase, and the following main conclusions are drawn :—

(*a*) The efficiency of the synphase circuit on the longer wavelengths is the same as that of the Mesny circuit and on the shorter wavelengths is slightly lower than that of the Holborn circuit. (*b*) The circuit easily lends itself to continuous variation of the operating wavelength. (*c*) More than two valves can be used with an almost proportional increase in the power output. (*d*) When several valves are employed marked directive effects can be obtained.

97. A Synphase Circuit for the Generation of Ultra-Short Waves.—A. G. Arenberg. (*Izvestia Elektroprom. Slab. Toka*, April, 1934, No. 3, pp. 27–31.)

The difficulty of producing an ultra-short-wave oscillator of large output has led to the development in the Electrical Institute of Moscow of a two-valve synphase circuit. This is derived from a capacity-coupled push-pull oscillating system in which a condenser is connected between the centre points of the grid and anode circuits. If the grid circuit is detuned, push-pull oscillations first become unstable and then cease. Further detuning gives rise to synphase oscillations, first unstable and finally stable. In this connection considerable potentials exist between the centre points, and a number of new nodal points appear, to any of which the grid and anode supplies can be connected. Two transmitters have been developed, one giving about 500 watts with air-cooled valves and the other, more powerful, for a 4.5 m wave, with water-cooled valves. Both have proved satisfactory in service.

98. The [Frequency] Stabilisation of Valve Oscillators by Systems with Distributed Constants [Lecher Wires].—Wwedensky, Michailow and Skibarko. (*Russian Journal of Technical Physics*, No. 2, Vol. 4, 1934, pp. 337–357.)

Authors' summary :—The method of stabilising valve generators [particularly for ultra-short waves] by means of parallel-wire systems, given by Conklin, Finch and Hansell [1932 Abstracts, p. 93] was investigated experimentally ; about the same stability was obtained as in that work. An approximate theory (on the assumption of linearity and neglecting grid current) brings to light the cause of the stabilisation and yields curves for the frequency variation for a given change of anode or heating voltage, as a function of the length of the Lecher system, which agree satisfactorily in shape with the experimental results.

The experimentally observed stability, however, is from 2 to 5 times higher than the calculated, indicating the need of a stricter theory. A variation of the method is given in which the parallel-wire system is replaced by a pair of helically coiled wires, thus considerably reducing the size of the apparatus and yet retaining about the same stability.

99. Mercury Vapour Lamp as Oscillation Generator [or Amplifier : Frequencies 50–20 000 c/s].—Cisman and Jonescu. (*See* 157.)

100. Design of Auto-Parametric Excitation Oscillator Systems.—S. I. Tetelbaum. (*Izvestia Elektroprom. Slab. Toka*, March, 1934, No. 2, pp. 32–44.)

If the back coupling of a self-excited oscillator is reduced below the critical value, oscillation will cease. If then the grid is excited from an independent source at twice the natural frequency, oscillations will begin again at the natural frequency. Approximate methods are indicated for designing such systems, and in particular the following points are examined :—

(*a*) The determination of the amplitude of the resultant oscillations ; (*b*) the operation of the oscillator when it is modulated by varying either the amplitude of the drive or the grid bias ; and (*c*) the time required for the oscillations to build up to the steady state.

101. Predetermination of the Working Conditions for High-Frequency Power Amplifiers [with General Formulae and Abacs for Class A, B and C Amplifiers : Confirmation on Philips 65 kW Valve].—L. Rubin. (*L'Onde Élec.*, Aug./Sept. 1934, Vol. 13, No. 152/153, pp. 317–346.)

102. The Effect of a Transmission Line on the Frequency Characteristic of a Radio Transmitter.—T. S. Ramm. (*Izvestia Elektroprom. Slab. Toka*, April, 1934, No. 3, pp. 10–24.)

A theoretical study of transmission lines to determine the high frequency cut-off due to varying lengths of line. The conclusions reached have been checked experimentally and a comparison is given of the theoretical and experimental characteristic curves.

103. High-Efficiency Anode Modulation.—S. Z. Person and E. I. Gorodnichev. (*Izvestia Elektroprom. Slab. Toka*, March, 1934, No. 2, pp. 1–18.)

A detailed theoretical investigation is given, with numerical examples, of a Class B push-pull modulator, transformer-coupled to the anode circuit of a modulated amplifier. The efficiency of the system is shown to be 55 to 60 per cent. during the silent periods and about 57 per cent. at 100 per cent. modulation, while the corresponding figures for grid modulation are approximately 35 per cent. and 53 per cent. Further, the total power capacity of the valves required is about 25 per cent. lower than for grid modulation. The advantages of the system are, however, somewhat off-set by the greater number of l.f. amplifier stages required. An account is also given of an experimental study of the system, and characteristic curves obtained are shown.

104. THE MODULATOR VALVE AS A VARIABLE RESISTANCE IN AN ANODE-MODULATION CIRCUIT.—A. B. Sapojnikov. (*Izvestia Elektroprom. Slab. Toka*, April, 1934, No. 3, pp. 24–27.)

In order to simplify the design calculations of an anode-modulation circuit the modulator valve can be regarded as a variable resistance. Methods are indicated for determining the equivalent resistance, and various formulae are derived.

105. SINGLE SIDEBAND WORKING.—(*Wireless World*, 2nd Nov. 1934, Vol. 35, pp. 347–349.)

Dealing with practical methods of single sideband working as used in commercial radiotelephony stations and discussing their future possibilities, with particular reference to their possible application to broadcasting. An introductory article on the formation of sidebands was in the issue for 5th October, pp. 278–280.

RECEPTION

106. FUNDAMENTAL LAWS FOR THE APPLICATION OF THE SUPER-REGENERATIVE RECEIVER.—G. Hässler. (*Hochf:tech. u. Elek:akus.*, September, 1934, Vol. 44, No. 3, pp. 80–93.)

Author's summary :—(1) In the super-regenerative receiver the amplification of the signal results from a periodically repeated building-up process of the form $\mathfrak{U} = \mathfrak{U}_0 e^{\delta t}$. The initial amplitude $\mathfrak{U}_0$ is connected with the signal e.m.f. $\mathfrak{E}$ by the equation $\mathfrak{U}_0 = \mathfrak{E} . \rho_{eff}$, where the effective resonance sharpness factor ρ_{eff} is made up of positive and negative resonance factors : $\rho_{eff} = \rho_d + |\rho_a|$. [This terminology is taken from Barkhausen's "Elektronenröhren II" : $\rho = \pi/d = (1/R)\sqrt{L/C}$. The suffixes *d* and *a* represent the damped and "undamped" zones respectively]. If the receiver is undamped *gradually*, ρ_{eff} is up to about twice as large as $(\rho_d + |\rho_a|)$ [*see* p. 81, r-h column, for a discussion of the two cases].

(2) As regards the amplification ratio of the super-regenerative receiver, two zones can be distinguished. In the "K" zone the ratio has a constant value whose highest attainable value depends on the background-noise level. In the "L" zone on the other hand the amplification ratio sinks logarithmically as the signal increases. In this zone there is always a non-linear distortion factor [klirr-factor] $k = (m/4)(1 - m^2/4)$.

(3) If the building-up processes are "incoherent," that is, if the excited oscillation dies completely away before a fresh start, the optimum adjustment of the receiver is at the edge of the "K" zone just before entering the "L" zone. At this point the greatest volume obtainable from the minimum signal (dependent on the noise level) is found. An increase of the signal above the minimum will only produce a quite unimportant increase of volume. The optimum quenching frequency is thus always the "border" value f_{pgr} which separates the incoherent and coherent states and whose value can be chosen according to the selectivity required. The maximum attainable volume, on the other hand, is independent of f_{pgr}, and is dependent only on the valve constants. In the "K" zone it is easy to obtain an indirect but distortionless automatic fading compensation, while in the "L" zone there is an innate freedom from fading but never a freedom from distortion.

(4) The resonance curve for the initial amplitude closely resembles the usual resonance curve only if the undamping is sudden [Fig. 11] : if the undamping is gradual the curve takes a band-filter shape. In the "K" zone the receiver resonance curve is of the same form, but in the "L" zone there is a flattening which, however, involves no decrease in selectivity for telephony [on the same grounds as in a receiver with automatic fading compensation, which has almost the same resonance curve : but "the comparison of Fig. 13a and b with c and d shows that in the 'L' zone the telegraphy receiver is extraordinarily unselective." With regard to the selectivity of the super-regenerative receiver the writer remarks, on p. 88, r-h column, that it has sufficient selectivity of its own —*i.e.*, without pre-selecting circuits—for telephony on short waves ($\lambda = 30$ m, $\rho_{eff} = 300$), but that for television even on short waves difficulties in selectivity arise : "for 500 000 picture elements per second a carrier wavelength of 1 m is necessary in order to attain a value $\rho_{eff} = 100$."]

(5) The response threshold of the receiver, *i.e.* the minimum necessary signal, can be lowered by raising the effective sharpness of resonance, ρ_{eff}. This can be done by decreasing either the damping [by using lower-loss circuit components] or the building-up, [since $\rho_{eff} \approx \rho_d + |\rho_a|$—see earlier] the latter method being preferable in practice. ρ_{eff} alone determines the threshold, which is independent of the other circuit values. (6) There is a definite relation between the "border" quenching frequency [f_{pgr}—see earlier], the effective sharpness of resonance, and the highest permissible modulation frequency, which for practical conditions is given by $f/f_{pgr} \approx 1.6 . \rho_{eff}$ and $f/f_m \approx 6.5 . \rho_{eff}$. Consequently by lowering the "border" quenching frequency a lowering of the response threshold of the receiver can be attained.

(7) In the "coherent" condition, which occurs on exceeding the "border" q.f., the oscillations have not died away before the next building-up sets in. The receiver then, according to the adjustment, either suffers continuous oscillations or else works in the "K" zone with amplifications which are the smaller the more the "border" q.f. is exceeded. In the latter case, theoretically, a high sensitivity can be reached, but with long building-up and long decay times. In practice, in either case, the appearance of the coherent condition brings with it a marked decrease of sensitivity. A noteworthy point is the breaking-up of the receiver resonance curve into several (sometimes very sharp) resonance points, which is liable to occur in the coherent condition. The reason for this is a stroboscopic process occurring in the undamping period in connection with the long building-up times. The coherence effects, unfavourable in general to reception, can be avoided even when $f_p > f_{pgr}$ by sacrificing sensitivity, *e.g.* by the use of very strong signals. For a quenching frequency

double the "border" frequency the sensitivity is thereby decreased 150 times. (8) To avoid unexpected and anomalous effects the grid bias should be made so negative that the grid potential is modulated only to the maximum of the valve slope. In this case only one building-up process occurs in each quenching period.

107.—REVERSAL OF RECTIFIED [Crystal] DETECTOR CURRENT AT ULTRA-HIGH FREQUENCIES.—E. A. Kopilowitsch and A. N. Tschernez. (*Physik. Zeitschr. der Sowietunion*, No. 1/2, Vol. 6, 1934, pp. 182–183: in English.)

The current characteristic in a receiving dipole (wavelength about 30 cm) with a galena/steel detector is given, showing a reversal of the direction of the rectified current when the field strength reaches a certain value. The curve demonstrates the difficulties involved in the use of a crystal as a micro-wave indicator—the lack of proportionality between the value of rectified current and the oscillator output, and the existence of points of zero current when the r.f. field is considerable. The phenomenon varies considerably for different sensitive points of the same detector pair: in some cases the reversed part is very small. The dependence of the effect on the frequency, etc., is being investigated.

108. THE BRAKE-FIELD VALVE AS AN AUDIO-FREQUENCY AMPLIFIER.—O. Groos. (*Hochf: tech. u. Elek:akus.*, September, 1934, Vol. 44, No. 3, pp. 93–95.)

Fig. 1 gives the brake characteristics (*cf.* Hollmann, Abstracts, 1934, pp. 34–35, 151, 205, and 381—three) of a type RS 296 valve, showing slopes up to 10 mA/v which could be considerably increased, as suggested by Hollmann, by diminishing the voltage drop along the filament, choosing a correct emission current, and increasing the ratio of grid-mesh opening to grid-wire thickness. Table 1 gives the results of some measurements on this valve as a l.f. amplifier, which agree well with the calculated values: the slopes here were from 5.0 to 6.4 mA/v, and the voltage amplification ratios from 33 to 40.

Table 2 gives calculated results for certain assumed working data, a slope of 10 mA/v being assumed throughout. It shows that "considerable amplification ratios can be obtained with a single brake-field valve. An amplification of 1 000 can be attained directly if the input resistance is sufficiently small. If, for instance, the output alternating voltage is limited by the supply voltages to 300 v, a thousand-fold amplification can only be reached with input voltages smaller than 0.3 v. For larger modulating voltages the saturation condition is not fulfilled, the 'current interchange' relation no longer holds [Hollmann, *loc. cit.*], and the controlling action of the anode decreases. The high a.c. output resistances of about 10^5 ohms, necessary for such a high amplification, can be obtained in the form of resonance resistances with sufficiently small d.c. resistance."

The writer continues: "The high voltage amplification partly compensates for the great disadvantage that the control is not without power expenditure [Hollmann, *loc. cit.*]. In particular, advantage can be taken of a matching of resistances on the modulating side, by transforming down the modulating voltages. The matching is here proportional to $\ddot{u}^2$, whereas the voltage is only reduced in proportion to $\ddot{u}$ [the transformation ratio]. For instance, if the low frequency from an audion of internal resistance 5000 ohms is taken direct to the anode of a brake-field valve, the amplification (by equation 3a) will be only 9.8 times; while by interposing a transformer of ratio 7 it will be 250 times, giving an overall amplification of 250/7 or 36 times (S = 10 mA/v, output resistance 10^5 ohms)." On the other hand, the brake-field valve has the disadvantage that a cascade of several amplifiers adds hardly anything to the amplification, since the high output resistance of one valve has to be transformed down to match the low input resistance of the succeeding valve. Finally it is pointed out that the brake-field valve gives a power-amplification equal to the voltage-amplification, owing to the equality of anode and grid alternating currents.

109. TECHNICAL PROGRESS IN THE ELIMINATION OF RADIOELECTRIC INTERFERENCE.—M. Adam. (*Rev. Gén. de l'Élec.*, 21st July, 1934, Vol. 36, No. 3, pp. 97–109.)

Including the suggested replacement of the contact mechanism for electric signs, etc., by a relaxation oscillation circuit; various types of screened down-lead; and a survey of the steps taken in various countries.

110. RADIO INTERFERENCE FROM DISCHARGES ON HIGH-VOLTAGE LINE INSULATORS [Experimental Investigation: the Use of Lead Insets to Stirrup Clips and Compound Lining for Interlink Type: etc.].—J. L. Langton and E. Bradshaw. (*Journ. I.E.E.*, November, 1934, Vol. 75, No. 455, pp. 643–652.)

111. THE SUPPRESSION OF INTERFERENCE WITH BROADCAST RECEPTION, AND THE EARTHING OF A.C. MOTORS.—(*Rev. Gén. de l'Élec.*, 20th Oct. 1934, Vol. 36, No. 16, p. 556: summary of German paper.)

112. INTERFERENCE QUENCHING ON THE CREED TELEPRINTER.—H. Subra. (*Ann. des P.T.T.*, October, 1934, Vol. 23, No. 10, pp. 970–974.) Following on the paper referred to in 1934 Abstracts, p. 321.

113. INTERACTION OF WIRELESS WAVES (Luxembourg Effect).—(*See* 10.)

114. RECEIVER PERFORMANCE DATA.—W. T. Cocking. (*Wireless World*, 12th, 19th, and 26th Oct. and 2nd Nov. 1934, Vol. 35, pp. 294–296, 315–316, 333–334 and 356.) Modern methods of measuring sensitivity, selectivity and quality of reproduction.

115. THE STANDARD TWO [Battery-Driven].—(*Wireless World*, 28th Sept. 1934, Vol. 35, pp. 260–263.)

116. THE 11TH GREAT GERMAN RADIO SHOW.—Flanze. (*E.T.Z.*, 20th, 27th Sept. and 4th Oct. 1934, Vol. 55, Nos. 38, 39 and 40, pp. 925–927, 953–956, and 980–982.)

117.—Novelties in Receiver Construction from the 1934 Berlin Exhibition.—J. Gross. (*Radio, B., F. für Alle*, September, 1934, pp. 139–145.)

AERIALS AND AERIAL SYSTEMS

118. Directive Properties of a Dipole Receiving Aerial [and of a "Crossed Dipole" Combination].—A. A. Pistolkors. (*Izvestia Elektroprom. Slab. Toka*, April, 1934, No. 3, pp. 1–10.)

The directive properties of a horizontal dipole aerial with a transmission line connected to the centre are examined. Polar diagrams are given for various angles of incidence of the incoming waves, and the similarity in the directive properties of an aerial receiving waves at a given angle and one transmitting waves at the same angle is proved.

An account is given of experiments with a "crossed" aerial consisting of two perpendicular dipoles connected to a common transmission line. Transmission during these tests was carried out from an aeroplane circling round the aerial at a height of 500 metres and a distance of 3 km. A contour map is shown of the locality of the tests together with the polar diagram of reception obtained.

119. Calculation of the Vertical Component of the Magnetic Field in the Neighbourhood of a Vertical Magnetic Dipole.—Nunier. (*See* 15.)

120. Increased Efficiency from Tower Antennas—a Review.—E. A. Laport. (*Electronics*, August, 1934, pp. 238–241.) Including data on Budapest, Breslau, WFEA, WEBC and others.

121. Self-Supporting Antenna Tower [Insulated, with Great Width at Top: the Use of Round Bars to reduce Wind Load].—Truscon Steel Company. (*Electronics*, August, 1934, p. 261.)

122. The Metal Pylon of the Budapest Broadcasting Station [314 Metres High].—*Génie Civil*, 15th Sept. 1934, Vol. 105, No. 11, p. 251: summary only.)

123. American Harmonic [Short-Wave] Aerial.—P. N. Ramlau and V. K. Zavarikhin. (*Izvestia Elektroprom. Slab. Toka*, March, 1934, No. 2, pp. 18–31.)

A theoretical investigation into the operation of a short-wave aerial system consisting of four parallel conductors, each 8 wavelengths long, with the line joining their centres at an angle to their length. The considerations determining the choice of this angle and of the spacing between the conductors are dealt with. Polar diagrams are given and combinations of two and four systems inclined at an angle to each other ("V" and "VV" aerials) are discussed.

124. The Troubles due to Hoar Frost on Electrical Lines.—J. Drappier. (*Rev. Gén. de l'Élec.*, 27th Oct. 1934, Vol. 36, No. 17, pp. 577–585.)

VALVES AND THERMIONICS

125. The Influence of Residual and Occluded Gases on Very High-Frequency Oscillations [particularly Micro-Waves of the order of 17 cm: Necessity for High Vacua, Robust Grids, and Electrodes free from Occluded Gas].—E. Pierret. (*Rev. Gén. de l'Élec.*, 6th Oct. 1934, Vol. 36, No. 14, p. 478: long summary only.) For the previous paper referred to *see* 1934 Abstracts, p. 437.

126. An Electron Multiplier: a New Type of Cold-Cathode Tube of High Current Amplifying Ability.—Farnsworth. (*See* 207 and 208.)

127. [Triode] Valve Design allowing for Bends in the Characteristic Curve.—B. F. Tsomakion and J. M. Kravets. (*Izvestia Elektroprom. Slab. Toka*, Jan./Feb. 1934, No. 1, pp. 17–24.)

An analytical method of determining the operating conditions, the curved characteristic being replaced by three straight lines representing the average slopes of the centre portion and top and bottom bends. Results are compared with those obtained by the usual method assuming a perfectly straight characteristic, and by the graphical method.

128. [Automatic] Graphical Recording of the Characteristic Curves of Multi-Electrode Valves.—R. Schmidt. (*Journ. de Phys. et le Rad.*, April, 1934, Series 7, Vol. 5, No. 4, pp. 72–73 S.)

129. Predetermination of the Working Conditions for H.F. Power Amplifiers.—Rubin. (*See* 101.)

130. On Choosing the Optimum Operating Conditions for a Pentagrid [as Combined Beating Oscillator and First Detector: Theoretical Investigation leading to Conditions for Maximum Ratio I.F./Signal Voltages].—V. I. Siforov. (*Izvestia Elektroprom. Slab. Toka*, Jan./Feb. 1934, No. 1, pp. 25–31.)

131. Theoretical Design and Experimental Investigation of the Screen-Grid Valve [Fundamental Equation for Anode Current, and Methods of determining Correct Operating Conditions for Grid, Anode, Anode and Screen, and Screen Modulation].—V. G. Karpov. (*Izvestia Elektroprom. Slab. Toka* [Reports of the Light-Current Elec. Industry, U.S.S.R.], Jan./Feb. 1934, No. 1, pp. 9–16.)

132. The Brake-Field Valve as an Audio-Frequency Amplifier.—Groos. (*See* 108.)

133. Tetrode with "Perpendicular" Anode (subdivided into Four Parts) abolishing usual "Kink" in Characteristic: No Reflection of Electrons on to Screen Grid.—362 Valve Company. (*Engineer*, 24th Aug. 1934, Vol. 158, No. 4102, p. 186: paragraph only.)

134. NEW VALVES AT THE 11TH BERLIN RADIO SHOW [Fading-Mixing Hexodes ACH 1 and BCH 1, Octodes, Battery-Saving Valves for People's Receiver, etc.].—Flanze. (*E.T.Z.*, 20th Sept. 1934, Vol. 55, No. 38, pp. 925–926.)

135. NEW FREQUENCY-CHANGER [Triode-Hexode].—E. E. Shelton. (*Wireless World*, 5th Oct. 1934, Vol. 35, pp. 283–284.)

136. FLUCTUATION NOISE IN VACUUM TUBES [including Method of Accurate Rating].—G. L. Pearson. (*Physics*, September, 1934, Vol. 5, No. 9, pp. 233–243: *Bell S. Tech. Journ.*, Oct. 1934, Vol. 13, No. 4, pp. 634–653.)

Author's summary:—The fluctuation noises originating in vacuum tubes are treated theoretically under the following headings: (1) *thermal agitation* in the internal plate resistance of the tube, (2) *shot effect and flicker effect* from space current in the presence of space charge, (3) *shot effect* from electrons produced by collision ionisation and secondary emission, and (4) *space-charge fluctuations* due to positive ions. It is shown that thermal agitation in the plate circuit is the most important factor and should fix the noise level in low-noise vacuum tubes; shot noise and flicker noise are very small in tubes where complete temperature saturation is approached; shot noise from secondary electrons is negligible under ordinary conditions; and noise from space-charge fluctuation due to positive ions is usually responsible for the difference between thermal noise in the plate circuit and total tube noise. A method is deduced for the *accurate rating of the noise level of tubes* in terms of the input resistance which produces the equivalent thermal noise. *Quantitative noise measurements* by this method are reported on four different types of vacuum tubes which are suitable for use in the initial stage of high-gain amplifiers. Under proper operating conditions the noise of these tubes approaches that of thermal agitation in their plate circuits at the higher frequencies and is 0.54 to 2.18 $\times 10^{-16}$ mean square volts per cycle band-width in the frequency range from 200 to 15 000 c/s. Below 200 c/s the noise is somewhat larger. *The minimum noise in different types of vacuum tube circuits* is discussed. These include input circuits for high-gain amplifiers, ionisation chamber and linear amplifier for detecting corpuscular or electromagnetic radiation, and photoelectric cell and linear amplifier for measuring light signals. With the aid of these results it is possible to design circuits having the maximum signal/noise ratio obtainable with the best vacuum tubes now available.

137. STATISTICS OF THERMIONIC EMISSION.—A. Gehrts. (*Physik. Zeitschr.*, 1st Sept. 1934, Vol. 35, No. 17, pp. 692–699.)

A theoretical investigation discussing whether it is necessary to assume that there is a free electron gas within a metal, when calculating the thermionic emission current from the metal surface. Sommerfeld has shown that Fermi statistics must be used for this calculation, and the present paper shows that the above assumption is really unnecessary. The thermionic emission is to be regarded as a splitting of electrons from the surface atoms; the disturbance in the surface is propagated through the metal and causes the conducting electrons to rearrange themselves. A formula is calculated for the thermionic emission which is very similar to that deduced by Sommerfeld.

138. "THERMIONIC EMISSION" [Book Review].—A. L. Reimann. (*Rev. Gén. de l'Élec.*, 29th Sept. 1934, Vol. 36, No. 13, p. 426.)

139. EXPERIMENTAL RESEARCHES ON THE SECONDARY EMISSION OF TANTALUM [Nine Critical Potentials found causing Sudden Variation of Secondary Emission: Curves of Velocity-Distribution for Different Primary Velocities: etc.].—R. Warnecke. (*Journ. de Phys. et le Rad.*, June, 1934, Series 7, Vol. 5, No. 6, pp. 267–282.)

140. THE [Radiant] EMISSIVE POWER OF TUNGSTEN IN THE ULTRA-VIOLET REGION AT HIGH TEMPERATURES.—F. Hoffmann and H. Willenberg. (*Physik. Zeitschr.*, 15th Sept. 1934, Vol. 35, No. 18, pp. 713–715.)

The arrangement used was described in a paper by the same authors, "Measurements with Temperature Radiators in the Ultra-Violet Region" (*ibid.*, 1st Jan. 1934, Vol. 35, No. 1, pp. 1–3). The present note gives a table and curve of the measured values.

141. APPLICATION OF THE FORSYTHE-WATSON TEMPERATURE SCALE FOR TUNGSTEN.—W. B. Nottingham. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 341: abstract only.)

For the temperature scale in question *see* 1934 Abstracts, p. 326. The present note suggests that the "derived functions" $VA^{1/3}/l$ and $A/d^{3/2}$ of Langmuir–Jones (V = potential drop over uniform filament in volts, A = current in amperes, l = length in cm, d = diameter in cm) are more useful for the determination of the temperature in well-evacuated tubes than the values of resistivity R and total radiation W published by Forsyth and Watson. Relevant tables and curves have been computed and correction formulae are given. "Temperatures calculated from the two scales agree remarkably well over the range 900° K to 2 200° K."

142. THERMIONIC ELECTRON EMISSION FROM TUNGSTEN [Numerical Data for Current from Equipotential Surface as Function of Potential].—W. B. Nottingham. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 339: abstract only.)

143. THE DISINTEGRATION OF A MONOATOMIC THORIUM FILM ON A TUNGSTEN CATHODE IN A DISCHARGE IN MERCURY VAPOUR [Discrepancy between Thermal Theory of Cathode Disintegration and Experimental Results].—N. Morgulis and M. Barnadiner. (*Physik. Zeitschr. der Sowietunion*, No. 3, Vol. 6, 1934, pp. 309–311: in English.)

144. [Thermal] IONISATION OF ATOMS OF ALKALI METALS ON TUNGSTEN, MOLYBDENUM, AND THORIATED TUNGSTEN.—L. Dobrezow. (*Zeitschr. f. Physik*, No. 11/12, Vol. 90, 1934, pp. 788–801.)

145. THE PHOTOELECTRIC EMISSION FROM THORIATED TUNGSTEN.—Smith and Du Bridge. (*See* 233.)

146. THE DESIGN OF TUNGSTEN SPRINGS TO HOLD TUNGSTEN FILAMENTS TAUT.—K. B. Blodgett and I. Langmuir. (*Review Scient. Inst.*, September, 1934, Vol. 5, No. 9, pp. 321–333.)

147. EMISSION OF ELECTRONS FROM COLD METAL SURFACES.—C. C. Chambers. (*Journ. Franklin Inst.*, October, 1934, Vol. 218, No. 4, pp. 463–484.)

This paper discusses previous work on cold emission, with particular reference to that of Del Rosario (*ibid.*, 1927 and 1928, Vols. 203 and 205) and describes a repetition of his experiments. It is found that, in agreement with previous observations, the Fowler-Nordheim formula for the relation between current and voltage (1928 Abstracts, pp. 400–401) applies as regards the general form but not as regards the actual magnitude of the field calculated from the dimensions of the wire. The effect of heat-conditioning the surface, and the breakdowns caused by it, account for erratic curves obtained by previous investigators and are thought to be due to "immeasurably small currents of electrons knocking ions from the anode."

148. CHANGES IN THE ENERGY DISTRIBUTION OF THERMIONICALLY EMITTED ELECTRONS PRODUCED BY HIGH ELECTRICAL FIELDS.—R. K. Dahlstrom and J. E. Henderson. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, pp. 323–324: abstract only.)

149. THE BEHAVIOUR OF THE NORMAL CATHODE DROP AT THE MELTING POINT OF METALS [Change of Work Function on Passage through Melting Point].—A. Wehnelt and H. Kurzke. (*Ann. der Physik*, Series 5, No. 8, Vol. 20, 1934, pp. 919–920.)

DIRECTIONAL WIRELESS

150. A METHOD OF MEASURING THE VELOCITY OF PROPAGATION OF HERTZIAN WAVES, AND ITS APPLICATION TO "RADIO-TELEMETRY" [Distance-Finding: also to Distant Control].—G. Fayard. (*L'Onde Élec.*, Aug./Sept. 1934, Vol. 13, No. 152/153, pp. 359–371.)

The underlying principle is the deduction of the time of propagation of a h.f. oscillation between two stations A and B from the *frequency* of the sinusoidal modulating voltage which must be applied to the oscillation emitted by station A in order that the phase difference between this modulating voltage and the voltage of the high frequency detected at station B may have a given value; or, alternatively, the deduction of the propagation time from the measurement of the phase difference between modulating and detected voltages when the modulating voltage has a given frequency.

The writer suggests that the usual methods, depending on obtaining, with the help of recording apparatus, the time between the emission and reception of a very short signal, are only accurate to the extent that the interpretation of the transient régimes governing the shape of the signal is accurate; and that his method is therefore preferable. No mechanical devices are necessary; no retroaction phenomenon varying with distance is involved in the procedure, which uses a permanent régime of modulated oscillations; and the accuracy of the results depends only on the calibration and sensitivity of the phase- and frequency-control devices, which deal with musical frequencies for distances ranging from a few to several thousand kilometres. A second scale of distances, *e.g.* up to 500 metres, can be dealt with by applying the principle to modulated supersonic waves instead of radio waves. Finally, the writer discusses the effect on the results (especially if *short* radio waves are employed) of reflection from the ionosphere, and the actual employment of the technique as a tool for the study of short-wave propagation: here both stations would be provided with transmitter-receiver equipments for short and for medium waves.

151. THE MEASUREMENT OF ALTITUDE AND INCLINATION OF AIRCRAFT BY THE ECHO METHODS.—Delsasso. (*See* 1934 Abstracts, p. 622.)

152. STUDY OF THE MAGNETIC FIELD PRODUCED IN THE PRESENCE OF THE GROUND BY A CONDUCTOR TRAVERSED BY AN ALTERNATING CURRENT.—C. Bourgonnier. (*Rev. Gén. de l'Élec.*, 10th Nov. 1934, Vol. 36, No. 19, pp. 643–654.) For a previous paper *see* 1934 Abstracts, p. 620.

153. VISUAL INDICATOR FOR AIRCRAFT RADIO-RANGE BEACON RECEPTION [Vertical Needle indicating Deviation from Course, Horizontal Indicator showing Signal Volume].—Jackson and Harding. (*Electronics*, August, 1934, p. 248.)

154. ARE ULTRA-SHORTS DIRECTIONAL?—H. B. Dent. (*Wireless World*, 28th Sept. 1934, Vol. 35, pp. 264–266.) Discussing the results obtained from a series of practical experiments on the directional properties of wavelengths of the order of five metres. *See* also 155.

155. DIRECTION-FINDING WITH ULTRA-SHORT WAVES.—D. A. Bell. (*Wireless World*, 2nd Nov. 1934, Vol. 35, pp. 344–345.) The question of the directional properties of wavelengths of the order of five metres is considered. *See* also 154.

ACOUSTICS AND AUDIO-FREQUENCIES

156. THE INDUCTIVE GLOW-DISCHARGE OSCILLATOR AND ITS POSSIBLE APPLICATIONS [particularly as Sine-Wave Generator and for Electrical Music].—W. E. Kock. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 15, 1934, pp. 377–384.)

Author's summary:—"The introduction of an inductance into the circuit of a glow-discharge oscillator produces special oscillation conditions. The conditions are investigated for the development of first-type oscillations [the usual discontinuous oscillations]. It is possible to obtain either damped or constant-amplitude oscillations. Of the first-type oscillations only the damped are of practical importance; they are very good for tone-formant production. The oscillations of the second type [in which the glow-discharge current is always different from zero], which can also be produced with this circuit, are very stable, and their use for sine-wave generators [Fig. 14] and for electrical musical instruments is described. The investigations are extended to grid-controlled glow-discharge lamps."

It is pointed out that for second-type oscillations the grid-glow lamp has the advantage that increasing grid bias raises the discharge potential and that this fact can be used, by introducing retroaction between anode and grid circuits, to decrease the effect of anode-voltage fluctuation on the frequency by making the latter more dependent on the circuit resonance-frequency.

157. Mercury Vapour Lamp as Oscillation Generator [or Amplifier].—A. Cisman and T. V. Jonescu. (*Ann. der Physik*, No. 2, Vol. 20, Series 5, 1934, pp. 183–195.)

The current in the lamp is controlled by magnetic reaction. The lamp has two iron anodes and a mercury cathode. It can be used as a low-frequency amplifier or an oscillator. Its characteristics are given and the oscillation conditions calculated: frequencies from 50 to 20 000 c/s can be generated. Oscillograms show that under certain conditions the current and voltage curves are sinusoidal. Lamps with metal electrodes, working *in vacuo* or at atmospheric pressure, have also been constructed.

158. A Variable Frequency Generator for furnishing Odd Harmonics of 60 Cycle Current of Pure Sinusoidal Form.—D. L. Soltau, D. H. Loughridge and L. M. Applegate. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, pp. 328–329: abstract only.)

159. Portable A.C. Operated Heterodyne Beat Apparatus [Beat-Note Generator] of Unusual Frequency Stability.—Stranathan. (*See* 264.)

160. A Valve-Maintained Stretched-Wire Vibrator [Laboratory Generator of Audio-Frequency Currents].—W. S. Stuart. (*Phil. Mag.*, October, 1934, Series 7, Vol. 18, No. 120, pp. 566–571.) For other recent work on stretched-wire generators see 1934 Abstracts, pp. 43 (l-h) and 621 (r-h column).

161. The Brake-Field Valve as an Audio-Frequency Amplifier.—Groos. (*See* 108.)

162. Applying Neutralisation to Audio-Frequency Amplifiers [Improvement of Response Characteristics by Neutralising High-Note Loss due to Grid/Earth Capacity].—P. W. Klipsch. (*Electronics*, August, 1934, pp. 252–253.)

163. Low-Frequency Luminous Piezo-Quartz Resonators.—Zaks and Uftiujaninov. (*See* 245.)

164. Some Acoustical Measurements on Loudspeakers.—M. Federici. (*Alta Frequenza*, August, 1934, Vol. 3, No. 4, pp. 423–436.)

Author's summary:—The most important properties of a loudspeaker, the fidelity and efficiency, are defined and the nature of the sound field generated by a moving-coil cone speaker, in the open air or in an enclosed space, is then examined. The method is described of measuring the sound pressure produced by such an instrument by means of a condenser microphone calibrated by Rayleigh disc or by thermophone. Finally the results are given of some measurements on moving-coil loudspeakers, and the usefulness of such measurements in judging the quality of reproduction is shown.

165. Power [and Efficiency] Measurements on Electrodynamic Sound Generators [Loudspeakers, Supersonic-Wave Generators, etc.].—O. Schäfer. (*Hochf:tech. u. Elek:akus.*, September, 1934, Vol. 44, No. 3, pp. 101–103.)

By a combination of the ordinary (or modified) three-voltmeter method with the use of a valve-voltmeter for measuring effective values. The method is particularly valuable in the two extreme cases of the supersonic generator and the high-power loudspeaker: with the former it allows sound energies to be measured which are ordinarily difficult to obtain quantitatively owing to the small difference in voltage-drop (compared with the total voltage) in the braked and working conditions, while with the latter, thanks to its high efficiency, the method can be much simplified. It has also the merit of giving, by a single series of measurements, the resistance operator (so important for the matching of valve circuits), the output power, and the efficiency; all with an accuracy sufficient for most purposes.

166. The Sound Prism [for Rapid Sound Analysis].—Schuck. (*Proc. Inst. Rad. Eng.*, November, 1934, Vol. 22, No. 11, pp. 1295–1310.) *See* 1934 Abstracts, p. 388.

167. Variation of the Dielectric Constant of Rochelle Salt Crystals with Frequency and Applied Field Strength.—Zeleny and Valasek. (*See* 252.)

168. Inverse Piezoelectric Properties of Rochelle Salt [Piezoelectric Modulus determined from Inverse Effect is Larger than that determined from Direct Piezoelectric Effect].—C. I. Vigness. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, pp. 255–257.)

169. The Piezoelectric Microphone.—Brush Development Corporation. (*Wireless World*, 28th Sept. 1934, Vol. 35, p. 275.)

170. Discussion on "Some Experiments upon the Carbon Microphone" [and the Cause of "Frying"].—Truscott: Snoek. (*Journ. I.E.E.*, November, 1934, Vol. 75, No. 455, pp. 690–691.) *See* 1934 Abstracts, p. 271.

171. Discussion on "Characteristics of Telephone Receivers" [and the Meaning of "Series" Connection of Mechanical or Acoustical Impedances]. — West and McMillan: Sutton. (*Journ. I.E.E.*, November, 1934, Vol. 75, No. 455, p. 660.) *See* 1934 Abstracts, p. 621, r-h column.

172. Researches on Acoustic Quadripoles [Effect of Porous Materials on Sound Propagation treated like Effect of Resistance in Wave Propagation in Lecher Wires].—H. Wüst. (*Hochf:tech. u. Elek:akus.*, September, 1934, Vol. 44, No. 3, pp. 73–79.)

Author's summary:—" The behaviour of porous materials in a tubular conduit on normally incident sinusoidal sound waves is investigated. A method is given by which the sound pressure and volume flow at every point of the tube can be measured as regards amplitude and phase. In this way the quadripole constants of the material can be determined in complex form, and from them all the other characteristic values [a thin layer of porous material introduced into an acoustic tube being taken as equivalent to an added resistance in a Lecher wire system, an extension of the analogy represents a thick layer as an acoustic quadripole].

" Measurements were made in the range between 180 and 1 300 c/s. The results showed no difference between 'ideal' materials, with pores running as straight canals in the axial direction, and natural materials of isotropic structure. The condition that the quadripole determinant [*D—see* pp. 74 and 77, l-h columns] must equal unity is practically strictly fulfilled. For the compressibility a general value of about 8° is found for the loss angle. With the materials examined these elastic losses form up to 20% of the total damping. No frequency dependence could be found for the energy component of the longitudinal resistance: it is equivalent to the resistance measured with direct current. The effective inert mass of air in the pores is considerably increased by wall friction.

" So long as, at low frequencies, the shape of the flow is predominantly determined by the viscosity, the compressions occur isothermally; the transition to adiabatic elasticity occurs at about the frequency zone where the inertial resistance of the air becomes more prominent in comparison with the wall friction."

173. Experimental Investigation of the Acoustic Properties of Building Materials, by the Short Tone [Pulse Reflection] Method.—F. Spandöck. (*Ann. der Physik*, No. 3, Vol. 20, Series 5, 1934, pp. 328–344.)

174. Experiments with Acoustic Models.—F. Spandöck. (*Ann. der Physik*, No. 4, Vol. 20, Series 5, 1934, pp. 345–360.)

Measurements of the total acoustic disturbance produced by a sudden sound (such as a shot) in various model rooms are used to obtain some impression of the acoustic effects probable in the full-scale rooms. The effects in a room in the shape of a parallelopiped are not good, but a room where the walls are skew to one another gives better results; the addition of a rotunda has an unfavourable effect. The architectural form is of greatest importance acoustically when the total attenuation of the sound in the space lies in the range which, according to Sabine (1929 Abstracts, p. 276), gives the best acoustic results.

175. On the Problem of the Calculation of the Sound Pressure in the Field of an Orchestra.—I. G. Dreisen. (*Russian Journ. of Tech. Phys.*, No. 3, Vol. 4, 1934, pp. 649–660.)

176. Low-Frequency Volume Control [and the Influence of Volume-Range Adjustment on the "Emotional Effect" of Music: etc.].—W. Nestel. (*Radio, B., F. für Alle*, November, 1934, pp. 180–182.) *See* also 1934 Abstracts, p. 620.

177. A Phase-Shifting Transformer [for Audio-Frequencies: Air-Core Instrument with Energy Loss made up for by Two Resistance/Capacity Stages: Calibrated by Cathode-Ray Oscillograph].—F. H. Gage. (*Journ. Scient. Instr.*, September, 1934, Vol. 11, No. 9, pp. 289–295.)

178. Scientific and Technical Vocabularies: Remarks on the Proposal for an Acoustical Vocabulary.—(*Rev. Gén. de l'Élec.*, 15th Sept. 1934, Vol. 36, No. 11, pp. 361–362.)

179. Vowel Theories.—V. Engelhardt. (*Naturwiss.*, 12th Oct. 1934, Vol. 22, No. 41, pp. 690–693.)

180. Observations on the Velocity of Sound in Arcs.—C. G. Suits. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 339: abstract only.)

181. Logarithmic Units: a Need in Acoustics.—A. H. Davies. (*Proc. Phys. Soc.*, 1st Sept. 1934, Vol. 46, No. 256, pp. 631–633.)

This note proposes the word "decibrig" or "decibel" for intensity relations and "phon" for expressing loudness: two numbers N_1 and N_2 differ by $10n$ "decibrigs" when $n = \log_{10} (N_1/N_2)$.

182. The Foundations of the Subjective and Objective Measurement of the Loudness of Sounds [including the "Old" and "New" Phon Scales and a Survey of Recent Work].—C. Trage. (*E.T.Z.*, 20th Sept. 1934, Vol. 55, No. 38, pp. 931–934.)

183. Non-Linear Distortions in the Ear.—G. von Békésy. (*Ann. der Physik*, Series 5, No. 8, Vol. 20, 1934, pp. 809–827.)

Measurements of the overtones and difference tones arising in the ear show that these are not due to the nerves but are of purely mechanical origin, though they are not caused by the ear-drum. They arise in the cochlea and are probably due to eddies in the liquid there. The distortion of the fundamental is selective in character. Difference tones are connected with the oscillating condition of the middle ear.

184. The Minimum Perceptible Change of Intensity of a Pure Tone.—B. G. Churcher, A. J. King, and H. Davies. (*Phil. Mag.*, November, 1934, Supp. No., Series 7, Vol. 18, No. 122, pp. 927–939.)

This paper gives a more detailed account of the relevant part of the authors' paper referred to below (185).

185. THE MEASUREMENT OF NOISE, WITH SPECIAL REFERENCE TO ENGINEERING NOISE PROBLEMS.—B. G. Churcher, A. J. King, and H. Davies. (*Journ. I.E.E.*, October, 1934, Vol. 75, No. 454, pp. 401–422: Discussions pp. 422–446.) The full paper, summaries of which were referred to in 1934 Abstracts, p. 327, r-h col. The work follows on that dealt with in 1930 Abstracts, p. 514. *See* also 184.

186. NOISE. No. II. PART 3: THE AURAL MEASUREMENT OF NOISE. PART 4: THE INVESTIGATION AND SUPPRESSION OF NOISE.—A. H. Davis. (*Engineer*, 24th Aug. 1934, Vol. 158, No. 4102, pp. 181–183.)

187. REDUCTION OF TRAFFIC NOISE.—(*Nature*. 20th Oct. 1934, Vol. 134, p. 633.) Short account of the discussion at the Aberdeen meeting of the British Association.

188. REDUCTION OF TRAFFIC NOISE [Streets Less Noisy than Sixty Years Ago].—H. Maxwell. (*Nature*, 3rd Nov. 1934, Vol. 134, p. 701.)

189. THE HEAT OF SOUND [Very Thin and Delicate Thermocouple Sound "Thermometer" for Frequencies up to 10 000 c/s, extensible to 300 000 c/s].—E. A. Johnson. (*Science*, 5th Oct. 1934, Vol. 80, No. 2075, Supp. p. 11.)

190. EXPERIMENTAL TEST OF THE THERMOPHONE THEORY.—E. Franke. (*Ann. der Physik*, No. 7, Vol. 20, Series 5, 1934, pp. 780–782.)

Experimental test of a formula given by Geffcken and Keibs (1933 Abstracts, p. 276).

191. NOISE MEASURING SET, TYPE ZB 175 [and Its Sensitivity Curve compared with that prescribed by CCIF].—(*L. M. Ericsson Review*, No. 3, 1934, pp. 135–137.)

192. ON DETECTORS OF MECHANICAL VIBRATIONS [Thermodynamical-Mechanical Investigation of Action of Rayleigh Disc, Sensitive Flame, Microphone, Bolometer, etc.].—J. Zahradníček. (*Physik. Ber.*, 1st Sept. 1934, Vol. 15, No. 17, p. 1372.)

193. PULSATING CURRENT TELEPHONY.—M. Marro. (*Phil. Mag.*, October, 1934, Series 7, Vol. 18, No. 120, pp. 571–575.)

See 1934 Abstracts, p. 621. The attenuation curve for the loaded telephone cable there described is found to be much more constant for pulsating current (in which half-waves are suppressed by a rectifier) than for alternating current. Improved quality of voice transmission and greater frequency range are obtained by the use of pulsating current. *See* also *Rev. Gén. de l'Élec.*, 15th Sept. 1934, Vol. 36, No. 11, pp. 367–370.

194. NEW DIFFRACTION PHENOMENA WITH OSCILLATING CRYSTALS [shown by Sound Waves in a Fluid].—C. Schaeffer and L. Bergmann. (*Naturwiss.*, 12th Oct. 1934, Vol. 22, No. 41, pp. 685–690.) On the work referred to in 1934 Abstracts, p. 492. A description is given of a possible diffraction method of investigating the elastic properties of crystals.

195. MAKING VISIBLE THE STANDING SUPERSONIC WAVES IN TRANSPARENT SOLID BODIES. I. OPTICAL INVESTIGATION WITH A PIEZO-QUARTZ CRYSTAL [Measurement of Frequency of Harmonics].—E. Hiedemann, H. R. Asbach and K. H. Hoesch. (*Zeitschr. f. Physik*, No. 5/6, Vol. 90, 1934, pp. 322–326.)

196. SOME INTERFERENCE EXPERIMENTS WITH SUPERSONIC WAVES.—C. Bachem and E. Hiedemann. (*Zeitschr. f. Physik*, No. 5/6, Vol. 91, 1934, pp. 418–421.)

197. ERRATA:—ACOUSTIC RESONATOR INTERFEROMETER.—J. C. Hubbard. (*Phys. Review*, 15th Sept. 1934, Series 2, Vol. 46, No. 6, p. 525.) *See* 1932 Abstracts, p. 647.

198. THE COMPRESSIBILITY OF DILUTE SOLUTIONS OF ELECTROLYTES [Measured by Diffraction of Supersonic Waves].—A. Szalay. (*Physik. Zeitschr.*, 15th Aug. 1934, Vol. 35, No. 16, pp. 639–643.)

199. A PHASE-DIFFERENCE METHOD OF DISTANCE-FINDING AND DISTANT CONTROL, USING SUPERSONIC WAVES.—Fayard. (*See* 150.)

200. A HIGH-FREQUENCY WATER JET, AND ULTRASONIC FLAME.—J. J. Hopfield. (*Nature*, 10th Nov. 1934, Vol. 134, pp. 737–738.)

201. SUPERSONIC WAVES: A SURVEY [Editorial Correction].—Rodewald. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 15, 1934, p. 398.) A change in the text, relating to the work of Malov and Rschevkin, in the survey referred to in 1934 Abstracts, p. 389.

PHOTOTELEGRAPHY AND TELEVISION

202. SOME POINTS IN THE DESIGN AND WORKING OF GAS-FILLED CATHODE-RAY TUBES FOR TELEVISION.—F. Michelssen. (*Hochf:tech. u. Elek:akus.*, September, 1934, Vol. 44, No. 3, pp. 95–100.)

Further development of the work dealt with in Abstracts, 1933, pp. 105–106. Particular attention is paid to the following necessary points:—(1) Curing the fluctuating de-focusing effect on the spot, produced by the intensity modulation of a ray which depends only on gas-concentration for its focusing. This is a serious defect and prevents the attainment of high-definition images even with a large number of picture elements. It can be rectified by superposing, on the varying concentration due to the ionic lenses, an additional constant concentrating action as, for example, that of the magnetic field of a ring coil situated between the anode and the deflecting elements. Such a magnetic lens must be situated far enough from the deflecting elements for its lines of force to keep clear of the deflecting space, where their entry would cause displacement and distortion of the picture format. This can be arranged by using an iron-screened coil with internal slit, and by increasing slightly (in comparison with the total length of ray) the anode/deflecting-plate distance. Lengthening of the glass tube, to accommodate the magnetic lens in this way, may be avoided by splitting the coil into two parts, one on either side of the deflecting plates and close to these. Constant-potential, suitably designed auxiliary electrodes may also be used in place of the magnetic lens.

(2) Prevention of a complete breaking-off of the ray by the intensity modulation: this is accomplished by rectifying the modulating impulses *before* they reach the intensity-control organ (*e.g.* the Wehnelt cylinder). It is unexpectedly found that with the use of such already rectified modulation there is a greater tendency for disturbing effects due to wall-charges than with the older method: these effects are, however, easily eliminated by suitable conducting screening.

When both the above points have been attended to, the gas-concentrated tube can deal with the extremely fine picture raster which hitherto could only be attained by the use of inconveniently long high-vacuum tubes. The next point dealt with is the indirectly heated "point" cathode (*cf.* Dobke, 1932, p. 653) and the elimination of subsidiary emission surfaces, at cathode potential, which are liable (at any rate with anode potentials of 1 000 v and upwards) to prevent the formation of a small, sharp point-image. The discussion of this problem, and of the desirability of intensity modulation with small variations of potential on the modulating organ, leads to a description of the special "lead-pencil" cathode (Fig. 5), which is advantageous in both these respects. Section V deals with the reduction of the necessary modulating potentials, to the extent of some 10 times, by the device of two-stage ray-acceleration. Section VI deals with the elimination of the "null-point anomaly," particularly by the use of containers with eccentric necks (*cf.* Hudec, 1933, pp. 453–454); and finally Section VII, in discussing the construction of fluorescent screens and the binding materials, refers to the advantages of the writer's use of potassium-metasilicate (potash water-glass) and to Schleede's technique by which the fluorescent particles are no longer screened by being enclosed by the binding agent.

203. The Theoretical and Practical Sensitivities of Gas-Focused Cathode-Ray Oscillographs, and the Effects of the Gas on Their Performance.—J. T. MacGregor-Morris and J. A. Henley. (*Journ. I.E.E.*, October, 1934, Vol. 75, No. 454, pp. 487–496 and Plates.)

The experimental work was done with a tube with the Cossor electrode structure. The following conclusions are arrived at among others:—the actual electrostatic sensitivity of a gas-focused tube is about 30% higher than that calculated from simple theory, probably owing to the retarding effect of a negative charge on the insulated screen. To obtain the full spot brightness, certainty as to the actual sensitivity, and other advantages, it is desirable to line the inside of the envelope, including the screen, with some form of conductor and to anchor its potential. Origin distortion accompanies the use of gas-focusing when deflection is effected by simple condenser plates. At low frequencies it is independent (for a given degree of focusing) of the nature of the gas used, since the focusing and the distortion depend on the same properties of the gas; but at frequencies above about 50 kc/s there is a considerable increase of origin distortion, and this increase depends on the atomic weight of the gas. "The advantage of using a light focusing gas to obtain smaller variation of sensitivity with frequency is clearly shown by the measurements." The results do not agree with von Ardenne's result of a greatly increased frequency range when using hydrogen instead of argon (1932 Abstracts, p. 653).

204. The Position of Television [with Particular Attention to Cathode-Ray Methods].—F. Schröter. (*Zeitschr. V.D.I.*, 22nd Sept. 1934, Vol. 78, No. 38, pp. 1097–1102.)

205. The Mutual Action of Electron Beams [in Multiple Cathode-Ray Tubes].—Wendt. (*See* 288.)

206 Electrostatic Lenses for Cold-Cathode Cathode-Ray Oscillographs with Single Vacuum [including the new Rogowski Retarding Lens]. — Malsch and Becker. (*See* 290.)

207. Television by Electron Image Scanning.—P. T. Farnsworth. (*Journ. Franklin Inst.*, October, 1934, Vol. 218, No. 4, pp. 411–444.)

This paper describes a television system (*see* also 1934 Abstracts, p. 568) in which the image to be scanned is formed on a sensitive photoelectric cathode surface and produces an "electron image" of photoelectrons at the surface. Uniform electric and magnetic fields, perpendicular to the surface, focus the image in a plane parallel to the cathode surface, and scanning is performed by magnetic sweeping of the electron image across a fixed aperture. The resolution obtainable in the electron image is discussed; the image-dissector tube and the deflection and focusing-coil systems are described. A new method of "Secondary Electron Multiplication," using cold cathodes, is used to amplify very feeble electron currents (*see* also next abstract); it may also be applied to produce, amplify or receive radio oscillations of high frequency. The generation and synchronisation of the deflecting currents for scanning are described.

The receiving tube or "Oscillight" is a cathode-ray tube giving a beam of 1 to 15 mA within an angle of 15°. The tube, with its focusing and scanning arrangements, is described and reference is made to miscellaneous design factors.

208. An Electron Multiplier: A New Type of Cold-Cathode Tube of High Current Amplifying Ability.—Farnsworth. (*Electronics*, August, 1934, pp. 242–243.)

Illustrated account of a demonstration of the device outlined in Brolly's paper on the Farnsworth television system (1934 Abstracts, p. 568: *see* also above). The electron, produced photoelectrically (when the "multiplier" is used in conjunction with the Farnsworth "image dissector") or otherwise, is accelerated towards a central ring anode but, being prevented from hitting this by a steady magnetic field, passes on through it to strike a cold cathode (specially coated to enhance secondary emission) where it sets free additional carriers by secondary emission. These secondary electrons then travel through the ring anode and meet a second cold cathode, where the same process occurs. "The actual current amplification is enormous since the electrons may make as many as 100 complete circuits of the two cathodes, each time producing a many as 6 secondary electrons per original carrier." A rapidly alternating accelerating field is produced by an auxiliary 50 Mc/s circuit. Tubes on this principle can also be used as oscillators (giving 100 watts or more in spite of the cold cathodes), for detection, or for modulation.

209. FUNDAMENTAL IDEAS AND PROBLEMS OF TELEVISION [General Account].—E. Hudec. (*Naturwiss.*, 9th Nov. 1934, Vol. 22, No. 45, pp. 749–756.)

This paper gives an elementary account of the fundamental principles of indirect film television and discusses questions of size of picture element, photocell amplifier, ultra-short wave emitter and receiver, use of cathode-ray tube, synchronisation, and the difficulties of flicker elimination, improvement of picture quality and direct television. References to more technical papers are as follows: Schröter, Abstracts, 1930, p. 107, and 1934, p. 330 (*see* also p. 567); Hudec, 1931, pp. 331 and 506, and 1934, p. 390; Schubert, 1932, p. 530, and 1933, p. 630 (*see* also 1934, p. 45); and Zworykin, 1934, p. 101.

210. "LES BASES PHYSIQUES DE LA TELEVISION" [Book Review].—B. Kwal. (*Rev. Gén. de l'Élec.*, 22nd Sept. 1934, Vol. 36, No. 12, p. 394.)

211. FACSIMILE NOW IN COMMERCIAL STAGE, *and* HOME FACSIMILE IS ON THE WAY [including References to the "Tabloid Radio Newspaper" and the "Lawnmower" Printer].—(*Electronics*, September, 1934, pp. 269–270 and 288.) For a "carbon-paper" printer *see* p. 289.

212. ALTERNATIVES TO HOME TELEVISION ["Retarded" Television: Improved Home Facsimile Reception].—(*Wireless World*, 12th Oct. 1934, Vol. 35, pp. 297–298.)

213. ON THE COLOUR SENSITIVITY OF PHOTOCELLS AND THE NECESSARY CONDITIONS FOR CORRECT COLOUR TRANSMISSION IN TELEVISION.—J. A. Riftin. (*Russian Journ. of Tech. Phys.*, No. 2, Vol. 4, 1934, pp. 368–371.)

For correct transmission of a monochromatic image the current flowing through the transmitting photocell must always be proportional to the intensity of the light falling on the cell. On the other hand, for undistorted one-colour reproduction of a polychromatic image the colour sensitivity of the cell must bear a definite relation to the spectral distribution of the energy emitted by the source of light.

The author finds the following equation for this relation: $\epsilon_\lambda = kV_\lambda . I(\lambda T_0)/I(\lambda T)$, where ϵ_λ is the colour sensitivity of the cell, k a constant, V_λ the factor of visibility (ratio of eye sensitivity on wavelength λ to maximum sensitivity on 0.555μ), $I(\lambda T_0)$ the spectral distribution of the energy of daylight, and $I(\lambda T)$ the spectral distribution of the energy emitted by the source of light. In the particular case when the object to be reproduced is illuminated by daylight, $I(\lambda T) = I(\lambda T_0)$, and therefore $\epsilon_\lambda = kV_\lambda$.

Formulae are quoted for calculating the above factors, and curves are drawn for the case when incandescent lamps are employed with the filaments at a temperature of 2 500° K. In conclusion it is pointed out that correct monochromatic reproduction of a polychromatic image is impossible if the visible part of the spectrum or any portion of this is excluded from the illuminating light.

214. A CAESIUM PHOTOCELL SENSITISED BY SULPHUR.—W. Roschdestwenskij. (*Russian Journ. of Tech. Phys.*, No. 3, Vol. 4, 1934, pp. 669–670.)

215. THE INFLUENCE OF DEGASSING POTASSIUM ON THE SELECTIVE PHOTOELECTRIC EFFECT.—F. Klauer. (*Ann. de Physik*, Series 5, No. 8, Vol. 20, 1934, pp. 909–918.)

This paper describes a repetition of the Hallwachs-Wiedmann experiment (*Verhandlungen de deutschen physikalischen Gesellschaft*, 1914, Vol. 17; Wiedmann, *ibid.*, 1915, Vol. 17, and Pohl and Pringsheim, 1914, Vol. 16) which gave a marked decrease in the number of photoelectrons obtained from potassium with the amount of gas it contained. Other writers have been unable to obtain the same result as Hallwachs and Wiedmann. In this experiment specially purified potassium was used; the photoelectric saturation currents were measured with a very sensitive quadrant electrometer. The main results, referred to incident energies of equal strength, were: (1) the sensitivity of freshly evaporated films is extremely small; (2) the sensitivity increases when the film is allowed to remain in a vacuum (probably owing to absorption of gas in the walls); (3) the sensitivity seems to tend to a constant value which is attained after a relatively short time; (4) the introduction of very dry hydrogen to a pressure of some tenths of a millimetre had practically no effect on the sensitivity, even after a period of ten hours; (5) sensitising by a glow discharge in hydrogen at 1/10 mm pressure gave, near the maximum, an increase of current to 160 times that given by the pure metal.

Comparison with the large effects observed by Suhrmann and Theissing (1929 Abstracts, p. 396) showed that the sensitivity of the pure metal was 500–1 000 times smaller than their value. The selective photoelectric effect for alkali metals is therefore to be ascribed to the adsorbed hydrogen and it is not permissible to deduce theoretical photoelectric curves from the properties of the metal itself.

216. SOME DATA ON THE EMISSION OF SECONDARY ELECTRONS FROM THE SURFACE OF POTASSIUM.—L. Groschew. (*Russian Journ. of Tech. Phys.*, No. 2, Vol. 4, 1934, pp. 363–367.)

"The secondary emission from potassium hydride surface is nearly the same as that from pure potassium, though the photocurrent increases 15 times."

217. THE ENERGY DISTRIBUTION OF PHOTOELECTRONS FROM SODIUM AND THE PHOTOELECTRIC DETERMINATION OF h/e.—L. A. Du Bridge and A. G. Hill. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 339: abstract only.)

218. SELF-GENERATING PHOTOCELL [" Photox "].—(*Electronics*, August, 1934, p. 261.)

219. USE OF SELENIUM BARRIER-LAYER PHOTOCELL FOR RADIATION MEASUREMENTS [in Meteorology].—R. Sewig: Grundmann and Kassner. (*Physik. Zeitschr.*, 1st Aug. 1934, Vol. 35, No. 14/15, pp. 564–565.)

Referring to the paper dealt with in 1934 Abstracts, p. 216, which gave reasons for regarding selenium barrier-layer photocells as unsuitable for meteorological measurements, Sewig here gives a list of advantages of the cells: (1) no auxiliary voltage is needed and there is independence of voltage fluctuation; no amplification is necessary in general; (2) the spectral distribution of sensitivity can be made very similar to that of the human eye; (3) the short-circuit current is practically proportional to the illuminating current; (4) the deviations from the cosine law are smaller than for any other cell based on the external photoelectric effect; (5) the temperature variation is small; for large changes in temperature, suitable correcting resistances may be used. The effects observed by Grundmann and Kassner were probably due to gross overloading of the cell; this may be avoided by stopping down the light or using grey filters. In their reply (*ibid.*, pp. 566–567) the latter workers point out (1) the very high degree of weakening of the sun's light necessary to avoid overloading the cell; (2) the short times during the year when the cosine law of illumination is valid; and (3) the necessity and difficulty of calibrating the cell empirically. The difficulties could be overcome if the cell could be given a spherical or hemispherical form. The whole apparatus would, however, become too complicated, sensitive, and expensive to be of much use in meteorological observations.

220. PAPERS ON THE SPECTRUM AND FLUORESCENCE OF SELENIUM.—S. Gawronski. (*Journ. de Phys. et le Rad.*, October, 1934, Series 7, Vol. 5, No. 10, pp. 533–534 and 535–537.)

221. PHOTO-EFFECTS IN SEMI-CONDUCTORS [New Theory of Barrier-Layer Photocells, involving " Chemically Active " Intermediate Layer, not necessarily Rectifying: Exponential Relation between Long-Wave Limit and Molecular Weight].—B. Lange. (*Physik. Ber.*, 15th July, 1934, Vol. 15, No. 14, p. 1182.)

222. ON A NEW PHOTOELECTRIC EFFECT IN CUPROUS OXIDE [in Liquid Air and subjected to a Magnetic Field].—I. Kikoin. (*Physik. Ber.*, 1st Sept. 1934, Vol. 15, No. 17, p. 1407.) For a preliminary Note *see* 1933 Abstracts, pp. 454–455.

223. RECTIFICATION AND PHOTOELECTRIC EFFECT WITH THE SILICON CARBIDE DETECTOR.—Specht. (*See* 335.)

224. CONDUCTION IN POOR ELECTRONIC CONDUCTORS [*e.g.* Crystals—Formula for Dependence of Potential Difference on Temperature].—J. Frenkel. (*Nature*, 26th Aug. 1933, Vol. 132, pp. 312–313.) *See* also Mönch, 225.

225. THEORY OF THE PHOTOELECTRIC EFFECT IN CRYSTALS.—G. Mönch. (*Zeitschr. f. Physik*, No. 3/4, Vol. 91, 1934, pp. 264–271.)

This note contains a discussion of the effects predicted by (1) the classical electron theory and (2) Fermi statistics. The writer finds that Frenkel's formula (*see* 224) gives the best available representation of the dependence of the crystal photoelectric effect on temperature.

226. CONTRIBUTIONS TO THE STUDY OF THE PHOTOELECTRIC EFFECT IN CRYSTALS.—G. Mönch and R. Stühler. (*Zeitschr. f. Physik*, No. 3/4, Vol. 91, 1934, pp. 253–263.)

This paper deals first with the effect of impurities on the photoelectric effect in cuprous oxide crystals. Transparent crystals prepared in the laboratory show no effect (Mönch, Abstracts, 1934, p. 46). The diffusion equation referred to in Abstracts, 1933, p. 573 (Joffé), 1934, p. 46 (Mönch and Stühler) and 1933, p. 631 (Engelhard) was tested experimentally and confirmed for a natural cuprite crystal from Cornwall. If the equation is assumed true for artificial crystals, the photoelectric effect at room temperatures should be below the limit of observation but should be observable at low temperatures. No effect however was found even at 200° absolute. The fall in the photoelectric effect for cuprite results from the rise in temperature of the crystal on illumination (as found by Teichmann, 1934, p. 160) and not from an electrolytic effect as found by Deaglio (1933, p. 573). Temporal changes in the transition layer between metal and semi-conductor also seemed to cause a drop in the photoelectric voltage.

227. THE BEHAVIOUR OF A COPPER OXIDE PHOTO-ELECTROLYTIC [Photovoltaic] CELL WHEN USED WITH SINUSOIDALLY VARYING ILLUMINATION.—W. E. Meserve. (*Physics*, September, 1934, Vol. 5, No. 9, pp. 244–249.) For previous work *see* 1932 Abstracts, p. 650.

228. THE BEHAVIOUR OF PHOTOVOLTAIC CELLS UNDER X-RADIATION.—M. F. Griffith and P. E. Boucher. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 341: abstract only.)

229. THE PHOTOLYSIS OF WATER AND THE ACTION OF LIGHT ON THE ELECTRODES.—R. Audubert. (*Journ. de Phys. et le Rad.*, September, 1934, Series 7, Vol. 5, No. 9, pp. 486–496.)

230. THE THEORY OF THE SURFACE PHOTOELECTRIC EFFECT IN METALS.—I. K. Mitchell. (*Proc. Roy. Soc.*, Series A, 1st Sept. 1934, Vol. 146, No. 857, pp. 442–464.)

This paper criticises the theories of Wentzel and Fröhlich (*see* Fröhlich, Abstracts, 1931, p. 104) and Tamm and Schubin (1931, p. 392). Methods are outlined for calculation of the effect due to a single surface; the effect of reflection and refraction of the light wave is considered and theoretical spectral distribution curves are given for potassium and compared with experiment.

231. RESEARCHES ON METALLIC PHOTO-RESISTANCE AT HIGH FREQUENCIES [up to 16 000 Interruptions per Second].—Q. Majorana. (*Physik. Ber.*, 15th July, 1934, Vol. 15, No. 14, p. 1178.) For previous work on thin metal films *see* 1934 Abstracts, p. 448.

232. THE PHOTOELECTRIC EFFECT IN VERY THIN FILMS OF ORGANIC MOLECULES AT A WATER/AIR BOUNDARY.—H. Cassel and E. Tohmfor. (*Zeitschr. f. Physik*, No. 5/6, Vol. 90, 1934, pp. 427–432.)

233. THE PHOTOELECTRIC EMISSION FROM THORIATED TUNGSTEN.—R. E. Smith and L. A. Du Bridge. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, pp. 339–340: abstract only.)

The writers have obtained a complete set of frequency/photocurrent curves for a 12-mil thoriated tungsten filament in various stages of activation, at the temperature of 900° K and with an accelerating field of 100 v on the collector, with gas-free conditions throughout. It was found that (1) Fowler's theory applies to composite surfaces as well as clean; (2) beyond 1.3 volts from the threshold, the points fall below the Fowler curve; (3) at each stage of activation the photoelectric work function ϕ_p at 900°K (by Fowler's method) agrees with the thermionic work function ϕ_t for an average temperature of 1 400°K, the values ranging from 2.6 to 4.52 v; (4) at higher temperatures, there is a tendency for ϕ_p to be less than ϕ_t by an amount just about equal to the possible error (0.05 v); and (5) the value of the constant B in Fowler's equation is the same for all surface conditions.

234. THE PHOTOELECTRIC METHOD OF DETERMINING THE ELASTIC LIMIT OF A ROCK-SALT CRYSTAL [Effect of Plastic Deformation on Primary Internal Photocurrent in X-Rayed Crystals].—M. N. Podaschewsky. (*Zeitschr. f. Physik*, No. 1/2, Vol. 91, 1934, pp. 97–104.)

235. [The Similarity of the Physical Principles underlying] THE ACTION OF [Geiger-Müller] COUNTERS AND GAS-FILLED PHOTOCELLS.—H. Teichmann. (*Physik. Zeitschr.*, 15th Aug. 1934, Vol. 35, No. 16, pp. 637–639.)

236. FURTHER PRACTICAL EXPERIENCE WITH THE LIGHT COUNTER [Combination of Geiger-Müller Counter with Photocell]. PART I: DESCRIPTION OF DIFFERENT TYPES OF LIGHT COUNTER.—B. Rajewsky. (*Ann. der Physik*, No. 1, Vol. 20, Series 5, 1934, pp. 13–32.) *See* also 1934 Abstracts, p. 54.

237. AN AMPLIFIER OF CONTINUOUS CURRENT FOR THE RECORDING MICROPHOTOMETER.—Meunier and Andriot. (*Journ. de Phys. et le Rad.*, October, 1934, Series 7, Vol. 5, No. 10, pp. 538–540.) A two-tetrode circuit easy to regulate and giving reliable results.

238. FURTHER STUDIES ON THE MOTION OF PHOTO-ELECTRONS IN A GAS [Theoretical Work].—A. M. Cravath. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 323: abstract only). For previous work *see* 1934 Abstracts, p. 283, r-h column.

239. [Magnetic Spectroscopy of] THE PHOTO-ELECTRONS EXPELLED FROM ELEMENTS BY CHROMIUM *K* RADIATIONS.—H. R. Robinson. (*Proc. Phys. Soc.*, 1st Sept. 1934, Vol. 46, No. 256, pp. 693–702.)

240. THE THEORY OF INTERFERENCE PHENOMENA IN "LINSENRASTERFILMEN" [Cylindrical-Lens-Grid Film for Colour Photography].—J. Picht. (*Zeitschr. f. Physik*, No. 11/12, Vol. 88, 1934, pp. 779–785: No. 5/6, Vol. 90, 1934, pp. 421–426.)

241. HIGH-FREQUENCY [Electrodeless and otherwise] DISCHARGE IN GASES AND VAPOURS AS A SOURCE OF LIGHT [especially as a Modulated Source].—W. I. Romanoff. (*Russian Journ. of Tech. Phys.*, No. 3, Vol. 4, 1934, pp. 512–522)

Experimental investigation using a 100 m generator of about 700 w. Fig. 3 shows the variation of the discharge current with temperature (or pressure) for mercury, Figs. 4 and 5 the same for argon and neon. Figs. 6 and 7 show the variation of luminosity with gas pressure and oscillator power respectively (abscissae in Fig. 7 represent primary current, which is proportional to the power). Figs. 8, 9 and 10 give a comparison between the experimental curves (B) and the theoretical (A) from J. J. Thomson's formula (1). For mercury vapour the agreement is good; for argon and neon the minima of discharge current only coincide if the electron free path length λ_0 is replaced by $10\lambda_0$ and $15\lambda_0$ respectively. Such an increase is not justified in the electron velocity range 10–15 v.

Fig. 11 shows a tube which is specially suitable for the electrodeless discharge in mercury vapour. Zinc and cadmium vapours were also investigated, and the h.f. discharge *between electrodes* in the various gases and vapours was also studied, externally heated oxide electrodes being used. In this way a brilliant discharge can be obtained which is readily modulated and is specially suitable for mirror-screw illumination.

242. THE LUMINOSITY OF THE MIXTURE OF ARGON AND NITROGEN.—Konowalowa and Frisch. (*Ibid.*, pp. 523–533.)

243. SOME IMPROVEMENTS IN THE TECHNIQUE OF KERR CELLS.—H. J. White. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 323: abstract only.)

244. [Glow-Discharge] LAMPS FOR TELEVISION RECEPTION [Tests on Russian and other Types].—B. A. Ostroumov. (*Izvestia Elektroprom. Slab. Toka* [Reports of the Light-Current Elec. Industry, U.S.S.R.], Jan./Feb. 1934, No. 1, pp. 46–54.)

MEASUREMENTS AND STANDARDS

245. LOW-FREQUENCY LUMINOUS PIEZO-QUARTZ RESONATORS.—E. S. Zaks and V. P. Uftiujaninov (*Izvestia Elektroprom. Slab. Toka* [Reports of the Light-Current Elec. Industry, U.S.S.R.], Jan./Feb. 1934, No. 1, pp. 32–40)

A report of the Central Radio Laboratory of Leningrad on the calibration of a number of quartz crystals having a natural frequency within the audio range and mounted in bulbs filled with a rarefied mixture of helium and neon. To avoid using crystals of excessive length on such low frequencies transverse oscillations in a plane perpendicular to the long axis of the crystal were employed instead of the usual longitudinal oscillations. A preliminary calibration was obtained by making the crystals oscillate in air and observing the intensity of the sound emitted by them near the point of resonance. When mounted in the bulbs the appearance of the glow at the antinodes of the oscillating crystal was taken as an indication of the resonant condition. It was found that this indication is very accurate, the error being of the order of 0.001%. The resonant frequencies were measured by comparison with a standard oscillator, and a detailed description of these measurements is given. The temperature co-efficient of the natural frequency of the crystals was roughly determined and was found to be approximately 5×10^{-6}.

246. THE TEMPERATURE COEFFICIENT OF QUARTZ OSCILLATORS.—H. Straubel. (*Physik. Zeitschr.*, 15th August, 1934, Vol. 35, No. 16, pp. 657–658.)

This note records an extension of work by the writer (1934 Abstracts, p. 332) in which the temperature coefficient was reduced to zero by cutting the crystal in directions differing from the usual ones. The work is here extended to a temperature interval from −180°C to +300°C. The influence of temperature on the frequency generated is found to be quite different for the two directions. Curves for the positive and negative quadrants are given. The writer has recently succeeded in making quartz plates oscillate in a simple Pierce circuit up to frequencies of 43×10^6 c/s without additional reaction.

247. OPTICAL DEMONSTRATION OF THE OVERTONES OF A PIEZO-QUARTZ CRYSTAL [by Supersonic Waves in Xylol] AND THE MARKED FLATTENING OF ITS RESONANCE CURVE BY FLUID DAMPING.—E. Hiedemann and N. Seifen. (*Zeitschr. f. Physik*, No. 5/6, Vol. 91, 1934, pp. 413–417.)

For other work on this subject by Debye and Sears; Lucas and Biquard; Bergmann; Bachem, Hiedemann, Asbach, Hoesch, *see* Abstracts, 1932, p. 576; 1933, p. 150; 1934, p. 332; 1934, pp. 329, 505, and 567; also 1934, p. 567 (Wyss).

248. NEW DIFFRACTION PHENOMENA WITH OSCILLATING CRYSTALS.—Schaeffer and Bergmann. (*See* 194.)

249. NEW INTERFERENCE PHENOMENA IN OSCILLATING PIEZO-QUARTZ [Nodal Planes forming Space Lattice Structure revealed by Optical Diffraction and dependent on Crystal Symmetry].—C. Schaeffer and L. Bergmann. (*Physik. Ber.*, 1st Sept. 1934, Vol. 15, No. 17, p. 1401.)

250. AN X-RAY STUDY OF A LONG X-CUT QUARTZ CRYSTAL VIBRATING UNDER THE TRANSVERSE PIEZOELECTRIC EFFECT.—M. Y. Colby and S. Harris. (*Phys. Review*, 15th Sept. 1934, Series 2, Vol. 46, No. 6, pp. 445–450.)

251. LAWS OF THE DISENGAGEMENT OF ELECTRICITY BY TORSION IN QUARTZ (STREPHO-ELECTRICITY).—E. P. Tawil. (*Comptes Rendus*, 12th Nov. 1934, Vol. 199, No. 20, pp. 1025–1026.)

Further development of the work dealt with in Abstracts, 1929, p. 159. A formula is arrived at for the absolute value of the quantity of electricity set free: $Q = K.CL/\pi(R^2 - r^2)$, where K is a constant, L the cylinder length, and C the moment of the couple; the denominator represents the surface of the annular section. For a couple of 1 kg/cm and unity length and surface, K is found equal to 0.12 e.s.u. Ny Tsi Zé and Tsien Ling Chao have confirmed the writer's previous discovery (1934, p. 332); their result that the charges are larger at the ends than at the mid-point of the cylinder is here explained: it is due to these measurements being taken on a solid cylinder instead of a hollow one.

252. VARIATION OF THE DIELECTRIC CONSTANT OF ROCHELLE SALT CRYSTALS WITH FREQUENCY AND APPLIED FIELD STRENGTH.—A. Zeleny and J. Valasek. (*Phys. Review*, 15th Sept. 1934, Series 2, Vol. 46, No. 6, pp. 450–453.)

The frequency range employed was 30 to 30×10^6 c/s. The dielectric constant declined uniformly from 62 000 at 30 c/s to 220 at 10^7 c/s and then dropped abruptly to negative values (inductive reactance) at 14×10^7 c/s. Previous values by other workers have all been too low because of the marked action of the slightest film of modified crystal or binding material between crystal and electrodes—here nearly eliminated by mercury-salt solution electrodes. The effect only exists in crystals cut perpendicularly to the *a* axis.

253. INVERSE PIEZOELECTRIC PROPERTIES OF ROCHELLE SALT.—Vigness. (*See* 168.)

254. BRIDGES FOR THE MEASUREMENT OF FREQUENCY [and a New Bridge operated by Varying only a Resistance].—G. Sacerdote. (*Alta Frequenza*, August, 1934, Vol. 3, No. 4, pp. 437–443.)

255. STUDY OF A PRECISION WAVEMETER TO CONFORM WITH THE MADRID AGREEMENT ON THE ACCURACY OF STATION FREQUENCIES.—E. Divoire. (*Rev. Gén. de l'Élec.*, 17th Nov. 1934, Vol. 36, No. 20, pp. 701–702: summary only.)

256. NEW METHOD OF TRANSMITTING CALIBRATED FREQUENCIES FOR THE PERIODICAL CONTROL OF THE VARIOUS FREQUENCY-METERS IN REGIONAL RADIO STATIONS.—A. Vainberg. (*Rev. Gén. de l'Élec.*, 15th Sept. 1934, Vol. 36, No. 11, p. 388: long summary only.)

257. STUDY OF THE PROCESSES OF SYNCHRONISATION OF CLOCKS AND OTHER MECHANICAL OSCILLATORS.—M. Lavet. (*Rev. Gén. de L'Élec.*, 27th Oct. and 3rd Nov. 1934, Vol. 36, Nos. 17 and 18, pp. 563–575 and 607–623.)

258. THE ESTABLISHMENT OF A PRECISION HIGH-FREQUENCY STANDARD CAPABLE OF DELIVERING CONSIDERABLE POWER [up to 500 Watts: Wavelength 50 to 10 m].—F. G. Dunnington. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 331: abstract only.)

259. A HETERODYNE GENERATOR STABILISED BY AN IRON/HYDROGEN LAMP [Iron Barretter connected in Oscillating Circuit keeps Oscillatory Current constant and satisfies Conditions for Frequency Stability: Possible Combination with Quartz Control for Added Precision].—G. Longo. (*L'Onde Élec.*, Aug./Sept. 1934, Vol. 13, No. 152/153, pp. 377–380.)

260. ALL-WAVE SIGNAL GENERATOR FOR PRODUCTION TESTS.—R. F. Shea. (*Electronics*, August, 1934, pp. 244–246.)

261. AN OSCILLATOR SYNCHRONISED BY A FREQUENCY DOUBLE OF ITS OWN [Two-Valve Circuit giving a Very Stable First Subharmonic of a Given Frequency].—G. Longo. (*L'Onde Élec.*, Aug./Sept. 1934, Vol. 13, No. 152/153, pp. 372–376.)

262. A GENERATOR FOR ALL FREQUENCIES [Dynatron Oscillator with Interchangeable Coils giving Frequencies from Infra-Audible to Short-Wave].—H. Keller. (*Radio, B., F. für Alle*, November, 1934, pp. 177–180.)

263. "THE NEGATIVE RESISTANCES OF ELECTRONIC TUBES, AND THEIR MEASUREMENT": SOME OBSERVATIONS.—G. Dilda: Pinciroli. (*Alta Frequenza*, August, 1934, Vol. 3, No. 4, pp. 474–476.) For Pinciroli's paper *see* 1934 Abstracts, p. 384.

264. PORTABLE ALTERNATING-CURRENT OPERATED HETERODYNE BEAT APPARATUS OF UNUSUAL FREQUENCY STABILITY [particularly for Very Small Capacity-Change Measurements].—J. D. Stranathan. (*Review Scient. Instr.*, September, 1934, Vol. 5, No. 9, pp. 334–336.)

The apparatus consists of a fixed 545 kc/s frequency quartz-controlled oscillator; an electron-coupled oscillator (whose frequency is determined by the capacity in the circuit) entirely enclosed, except for the air condensers, in a lagged container temperature-controlled to within less than 0.1°C; a detector and amplifier for the beat note; and an auxiliary 1 000 c/s tuning-fork generator with whose help the frequency of the second oscillator can be adjusted to the same value within less than one cycle. If the room temperature is kept constant "the frequency never varies by more than one cycle from a constant value."

265. NOTE ON A PRECISION VARIABLE CONDENSER [Linear Variation up to 14.2 $\mu\mu$F] FOR DIRECT MEASUREMENT OF EXTREMELY SMALL CAPACITY CHANGES.—J. D. Stranathan. (*Review Scient. Instr.*, September, 1934, Vol. 5, No. 9, p. 315.)

266. A SIMPLE METHOD OF MEASURING CAPACITY WITH GREAT ACCURACY.—M. Marketu. (*Physik. Zeitschr.*, 15th Aug. 1934, Vol. 35, No. 16, pp. 629–632.)

The method described is a modification of Niemeyer's arrangement (1930 Abstracts, p. 461), in which the capacity to be measured is included in the oscillating circuit of a valve emitter; the change in the anode-circuit current gives the change in capacity. Niemeyer's method is here modified to measure large capacities with the accuracy necessary for the measurement of dipole moments (0.5%): suitable valves are chosen, and a mirror galvanometer is used as the measuring instrument. No auxiliary condenser is needed to regulate the sensitivity.

267. DETERMINATION OF THE RESISTANCE OF CARBORUNDUM [and other Polycrystalline Substances, and Liquids] BY THE METHOD OF EDDY-CURRENT HEATING.—L. Rousinow. (*Russian Journ. of Tech. Phys.*, No. 2, Vol. 4, 1934, pp. 319–327.)

268. THE MEASUREMENT OF VERY LARGE LIQUID RESISTANCES [Adaptation of Barretter Method].—M. Wien. (*Physik. Zeitschr.*, 15th Aug. 1934, Vol. 35, No. 16, p. 652.)

269. METHODS OF MEASURING ELECTROLYTIC CONDUCTIVITIES WITHOUT ELECTRODES AND AT HIGH FREQUENCY.—E. Denina. (*Rev. Gén. de l'Élec.*, 13th Oct. 1934, Vol. 36, No. 15, p. 510: summary only.)

270. PAPERS ON THE MEASUREMENT OF ELECTRICAL CONSTANTS OF SOIL.—Smith-Rose and McPetrie: McPetrie. (*See* 17 and 16.)

271. THE MUTUAL ACTION BETWEEN A COIL OF CIRCULAR SECTION AND A THIN-WALLED COAXIAL HOLLOW METAL SPHERE, AT HIGH FREQUENCIES.—Buchholz. (*See* 286.)

272. THE A.C.-FED COIL OF FINITE LENGTH, *and* THE DISTRIBUTION OF TEMPERATURE INSIDE A CURRENT-CARRYING COIL OF RECTANGULAR CROSS SECTION: CORRECTIONS.—H. Buchholz. (*Arch. f. Elektrot.*, 15th Sept. 1934, Vol. 28, No. 9, p. 577.) Corrections to typographical errors in the papers referred to in 1934 Abstracts, pp. 218 and 281.

273. THE MUTUAL INDUCTANCE BETWEEN EQUAL CIRCUITS IN PARALLEL PLANES [with Equi-Mutual-Inductance Lines in Diagram with Axial Displacement as Abscissae and Spacing as Ordinates].—K. Potthoff. (*Arch. f. Elektrot.*, 15th Sept. 1934, Vol. 28, No. 9, pp. 578–580.) Extension of the writer's treatment of coaxial circuits referred to in 1933 Abstracts, p. 633, r-h column.

274. THE MEASUREMENT OF IMPEDANCE: DISCUSSION.—Astbury: Clark: Lamb. (*Journ. I.E.E.*, October, 1934, Vol. 75, No. 454, p. 542.) *See* 1934 Abstracts, p. 508.

275. AN ELECTROSTATIC VOLTMETER FOR VERY HIGH FREQUENCIES [up to 10 Mc/s, with Straight Line Calibration].—B. A. Sharpe. (*Journ. Scient. Instr.*, September, 1934, Vol. 11, No. 9, pp. 284–287.)

276. PNEUMATIC ADJUSTMENT OF ZERO IN MIRROR GALVANOMETERS, PARTICULARLY THOSE WITH PHOTOCELL MAGNIFICATION OF DEFLECTION.—R. Sewig. (*Physik. Ber.*, 1st Sept. 1934, Vol. 15, No. 17, p. 1398.)

277. THE MAGNIFICATION OF GALVANOMETER DEFLECTIONS BY PHOTOCELLS. (*See* various past Abstracts, under "Miscellaneous.")

278. Copper-Oxide Rectifiers in Ammeters and Voltmeters [and the Various Errors liable to arise: Effective Values within 10%, however Distorted the Wave-Form, by use of Linear-Characteristic Instruments: etc.].—E. Hughes. (*Journ. I.E.E.*, October, 1934, Vol. 75, No. 454, pp. 453–462: Discussion pp. 469–480.)

279. A Direct-Reading Form-Factor Meter [incorporating Copper-Oxide Rectifier].—R. S. J. Spilsbury. (*Ibid.*, pp. 463–469: Discussion pp. 469–480.)

280. Fundamental Principles in the Design of High-Sensitivity Electro-Magnetic Measuring Instruments [and the Improvement of Sensitivity without Undue Increase in Size].—J. S. Averbuh. (*Izvestia Elektroprom. Slab. Toka*, March, 1934, No. 2, pp. 57–67.)

281. The Variation of the Dielectric Constant of a Viscous Dielectric [Tung Oil] with Temperature and with Frequency.—A. A. Bless. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 340: abstract only.)

282. Determination of the Dielectric Constant of Some Dilute Aqueous Solutions of Electrolytes, using Rapid Electrical Oscillations [Wavelength 15 m: Agreement with Debye-Falkenhagen Theory].—F. P. Henninger. (*Ann. der Physik*, No. 4, Vol. 20, Series 5, 1934, pp. 413–440.)

283. Measurements of Absorption in Liquids [Butyl Alcohols] in the Region of Short Electrical Waves. III.—J. Malsch. (*Ann. der Physik*, 1934, Series 5, Vol. 20, No. 1, pp. 33–56.)

For Parts I and II *see* 1934 Abstracts, p. 393. The present paper deals with a wavelength of 180 cm and describes a development of the Lecher wire method of measurement of the electromagnetic constants of liquids. The writer finds that Debye's dipole theory gives a satisfactory qualitative explanation of the observed phenomena, and that no special natural vibrations of the liquid molecules need be invoked.

284. Anomalous Absorption and Dispersion of the Primary Alcohols in the Ultra-Short-Wave Region.—K. Krause. (*Physik. Zeitschr.*, 1st Sept. 1934, Vol. 35, No. 17, pp. 684–691.)

285. The Application of Newton's Law of Cooling to the Measurement of Very Small Thermal Effects.—Swietoslawski and Salcewicz. (*Comptes Rendus*, 5th Nov. 1934, Vol. 199, No. 19, pp. 935–937.)

SUBSIDIARY APPARATUS AND MATERIALS

286. The Mutual Action between a Coil of Circular Section and a Thin-Walled Coaxial Hollow Metal Sphere, at High Frequencies [with reference to Screening Cans].—H. Buchholz. (*Arch. f. Elektrot.*, 15th Sept. 1934, Vol. 28, No. 9, pp. 556–577.)

Kaden's investigations (Abstracts, 1932, p. 654, and 1933, pp. 576–577) represent the coil as a magnetic dipole. The present treatment is more general, the dipole being replaced by a current ring whose only spatial limitation is that its axis passes through the centre of the sphere: the ring may lie outside or inside the sphere. The quasi-stationary treatment is adequate up to frequencies of 100 Mc/s. The wall thickness is taken as not greater than about 1 mm, so that the outside and inside diameters of the shell can be treated as equal. Various expressions (equations 5α, β, γ and δ) are derived for the primary vector potential of the current ring, and with their help the solution is obtained for the total vector potential taking into account the influence of the spherical shell: first as an infinite series (12) and then transformed into the more convenient integral (14). The validity of this is confirmed by taking certain limiting cases, namely a current ring parallel to a conducting plane, a single linear conductor similarly placed, a magnetic dipole, and a hollow sphere in a homogeneous alternating magnetic field.

From this general solution for the vector potential the expression is obtained, by the Poynting law of energy flow, for the external impedance of the current ring (20, 20a and b). For high frequencies and large distances between ring and shell (when equation 24′ is fulfilled) the numerically useful relations 23a and b can be derived from these. When the distance is small, so that 24′ is not fulfilled, a different treatment is necessary to avoid the mathematical complications: for this case equations 31a and b are derived for R and ωL, on the assumption that the ring lies in an equatorial plane of the sphere.

Finally the damping action of the shell on the magnetic field produced by the current ring is investigated by calculation of the field strengths at points on the coil axis.

The results of the above work can be applied to an actual coil of N current rings. If these rings, in spite of their insulation, lie so close together that the whole bunch has only a small cross section, it is merely necessary to introduce the factor N into the vector-potential equations. If the coil takes rather the form of a single-layer cylindrical coil the application is not so simple but can be accomplished without difficulty, at any rate for short, wide coils.

287.—The Polar Form of the ker and kei Functions, with Applications to Eddy-Current Heating [Theory of Losses in Radio-Frequency Coils or Screens].—N. W. McLachlan and A. L. Meyers. (*Phil. Mag.*, October, 1934, Series 7, Vol. 18, No. 120, pp. 610–624.) The ker and kei functions being defined by the relationship

$$i^{-\nu}K_\nu(zi^{\frac{1}{2}}) = \mathrm{ker}_\nu z + i\,\mathrm{kei}_\nu z.$$

288. The Mutual Action of Electron Beams [Calculation of the Repulsion of Two Beams in High Vacuum, and Experimental Investigation of Gas-Concentrated Beams: in connection with Multiple-Ray Cathode-Ray Oscillographs].—G. Wendt. (*Arch. f. Elektrot.*, 15th Sept. 1934, Vol. 28, No. 9, pp. 529–534.)

It is shown that high-vacuum multiple-ray tubes can be built, with dimensions and ray currents similar to those of ordinary tubes, "for voltages down to 100 v without any appreciable deviation" of the rays. This value is given in the summary: the actual example given in the text of the paper is a 50 cm-long ray of 10 μA: if a deviation of 0.5 mm on the screen is considered admissible, the voltage can be as low as 350 v. The experimental investigation of gas-concentrated rays shows that these are also free from noticeable mutual action for voltages down to 500–800 v.

289. DOUBLE CATHODE-RAY OSCILLOGRAPH.—V. I. Feoktistov. (*Russian Journ. of Tech. Phys.*, No. 2, Vol. 4, 1934, pp. 332–336.)

A combination of two oscillographs projecting cathode rays on opposite sides of a moving photographic film sensitised on both sides, thus avoiding interaction between the rays but allowing two records to be made simultaneously on the same film.

290. ELECTRICAL [Electrostatic] LENSES FOR COLD-CATHODE CATHODE-RAY OSCILLOGRAPHS WITH SINGLE VACUUM.—F. Malsch and F. A. Becker. (*Arch. f. Elektrot.*, 15th Sept. 1934, Vol. 28, No. 9, pp. 580–586.)

Authors' summary :—" For sealed-off tubes, electrostatic lenses have certain advantages over magnetic [lighter weight and greater convenience for transport]. In cold-cathode tubes with a single vacuum the ordinary types of electrostatic lens, however, introduce difficulties in the shape of unwanted discharges between the lens electrodes, owing to the comparatively low vacuum necessary. Forms of lens are here described with which these discharges do not occur. Further, a new type of lens due to Rogowski is described in which the counter-electrode can be put at the cathode potential, so that only a single h.t. source is required for discharge-tube and lens. An oscillogram shows the practicability of the principle both for pre- and main concentration."

The writer points out that the cold-cathode oscillograph has had a new field of application opened for it by Rogowski's development of the electrostatic retarding lens (Abstracts, 1933, p. 635: *see* also p. 402), thanks to which the electrons can be brought down to low speeds so as to give great sensitivity. The practicability of the principle has already been shown for tubes with a two-stage vacuum (Malsch and Westermann, 1934, p. 219), but wide application can only be attained if sealed-off, single-vacuum tubes can be used, and it is here that the inter-electrode discharge difficulty arises. Sub-division of the lens system into several pairs of electrodes is inconvenient for various reasons: lowering the gas pressure means increasing the dimensions of the discharge tube, particularly its diameter. The new Rogowski lens is of tubular type: Fig. 5a shows the arrangement for a concentrating lens without electron-retardation. The field of the middle electrode penetrates through the gap l into the inner tube, and the penetration coefficient can be varied by altering either l or the diameter d_2. Fig. 5b shows a simple lens with electron retardation. Fig. 8 shows an experimental tube with double concentration: the ray passes the first stop (3 mm aperture) and enters the pre-concentrating lens. The middle electrode of this (at cathode potential) is centred exactly with regard to the inner tube (at anode potential) by amber rings, so that the second stop, on which the ray is now concentrated, can have a very small aperture (0.3 mm). The ray is then concentrated on to the screen by the main concentrating lens.

291. THE THEORETICAL AND PRACTICAL SENSITIVITIES OF GAS-FOCUSED CATHODE-RAY OSCILLOGRAPHS, AND THE EFFECTS OF THE GAS ON THEIR PERFORMANCE.—MacGregor-Morris and Henley. (*See* 203.)

292.—CATHODE-RAY OSCILLOGRAPHIC STUDIES OF SURGE PHENOMENA.—Allibone, Hawley and Perry. (*See* 42.)

293. A LOW-VOLTAGE CATHODE-RAY OSCILLOGRAPH WITH FLUORESCENT VIEWING SCREEN. —H. P. Kuehni. (*Gen. Elec. Review*, September, 1934, Vol. 37, No. 9, pp. 429–432.) Embodying the tube described by Metcalf (1932 Abstracts, p. 475).

294.—THE NEW DUFOUR CATHODE-RAY OSCILLOGRAPH [Internal and External Recording Types].—Gondet and Beaudouin. (*Rev. Gén. de l'Élec.*, 1st Sept. 1934, Vol. 36, No. 9, pp. 291–301.)

295. ACHROMATIC ELECTRIC ELECTRON LENSES [Theoretical Investigation].—W. Henneberg. (*Zeitschr. f. Physik*, No. 11/12, Vol. 90, 1934, pp. 742–747.)

Author's summary :—The theoretical work in this paper shows that there are no short electric single or immersion lenses which are chromatically corrected. It is however possible, in principle, to construct an achromatic condensing lens out of two stops. The potential lines for such a lens are given, though it is thought that it will be of little practical importance.

296. THE ELECTRICAL IMMERSION OBJECTIVE AS A SYSTEM FOR THE BRAUN [Cathode-Ray] TUBE [Magnification Formula of System].—H. Johannson. (*Zeitschr. f. Physik*, No. 11/12, Vol. 90, 1934, pp. 748–753.)

For previous papers on this subject *see* 1934 Abstracts, p. 51; also p. 336, von Ardenne.

297. SOME PROBLEMS IN HIGH-TENSION TECHNIQUE: (1) THE INFLUENCE OF ELECTRODE SHAPE IN THE H.T. ELECTROMETER: (2) HIGH-VELOCITY CATHODE RAYS, WITH SPECIAL ATTENTION TO ELECTRON-OPTICAL IMAGE FORMATION.—H. Zate. (*Aachen Dissertation*, 1933, 17 pp.: *Physik. Ber.*, No. 13, Vol. 15, 1934, p. 1079.)

298. ELECTRON MICROSCOPY OF BIOLOGICAL OBJECTS [Specimen Microphotographs and Methods of Destruction Prevention].—L. Márton. (*Phys. Review*, 15th Sept. 1934, Series 2, Vol. 46, No. 6, pp. 527–528.) For previous work *see* 1934 Abstracts, p. 451.

299. THE COMBINED OPTICAL AND ELECTRON MICROSCOPE, ITS PROPERTIES AND USE.—W. Knecht. (*Ann. der Physik*, No. 2, Vol. 20 Series 5, 1934, pp. 161–182.)

Combining an optical microscope with known electron microscopes in the same tube, so that the images of an emitting surface formed by the different microscopes can be directly compared. The immersion objective of Johannson (Abstracts, 1934, p. 51) and the magnetic coils of Ruska and Knoll (1931, p. 625) were used for the electron microscopes. It was found that there was no fundamental difference between the images formed by the electric and magnetic microscopes, but details of the images formed by the electron and the optical microscopes frequently differ. The electron microscopes give better images of phenomena in the intermediate layer between the metal base and the paste surface of an oxide cathode, and of phenomena in very thin barium films.

300. A Time-Base Circuit and Electron Relay for Use with a Cathode-Ray Oscillograph.—A. M. Cassie. (*Proc. Phys. Soc.*, 1st Sept. 1934, Vol. 46, No. 256, pp. 721–732.)

Author's abstract :—The ordinary sealed-off type of cathode-ray oscillograph is adapted to form a relay capable of picking out accurately points on a current or voltage wave to be investigated by means of a second cathode-ray oscillograph. A time-base circuit and the amplifier for the relay are described also.

301. The Split-Sphere Spark Gap as a Switching Organ [in Cathode-Ray Oscillograph Circuits, Short-Time Measurements, etc.].—R. Strigel. (*Arch. f. Elektrot.*, 15th Sept. 1934, Vol. 28, No. 9, pp. 586–593.)

The split-electrode spark gap is a sphere gap in which one sphere is divided into two segments by a wedge-shaped gap tapering towards the main gap. A spark between the two segments triggers the main spark. The present investigations show that the over-all delay time is made up of τ_1, due to the building-up of the necessary break-down voltage on the segments and depending only on the steepness of the incoming wave front ; τ_2, the delay between the attainment of this breakdown voltage and the formation of the spark, which can be reduced to about 10^{-7} sec. by rounding the split electrodes (with a radius of about 2 mm) so as to give an approximately homogeneous field in the gap, and by the use of strong mercury-vapour irradiation ; and τ_3, the building-up time of the main discharge, which by similar irradiation can be reduced to a few 10^{-8}ths of a second. The influence of the sphere material is also investigated.

302. The "Negative Glow" Oscilloscope [with Applications to Visual Observation ; Photographic Recording, including Sound-Film Work ; as Milliammeter or Microammeter ; as Voltmeter ; etc.].—M. Abadie. (*Rev. Gén. de l'Élec.*, 15th Sept. 1934, Vol. 36, No. 11, pp. 363–367.)

303. A Method of Measuring Low Pressures [Variation of Ionisation Manometer Principle].—G. Spiwak and A. S. Ignatow. (*Physik. Zeitschr. der Sowietunion*, No. 1/2, Vol. 6, 1934, pp. 53–68 : in German.) Based on the indication not of ionic current but of change of electronic current due to dissipation of negative space charge by the positive ions.

304. An Automatic Device for Maintaining Constant Pressure [around 1 mm of Hg]. C. Chandrasekhariah. (*Current Science*, Bangalore, September, 1934, Vol. 3, No. 3, pp. 112–113.)

305. Metals for Fusing in Glass [Importance of Coefficient of Expansion, Adhesion to Glass, Thermal Conductivity, Low Gas Content : Suitability of Fe-Cr with 25% Cr].—W. F. Brandsma. (*Physik. Ber.*, 15th Aug. 1934, Vol. 15, No. 16, p. 1268.)

306. Electrodeposition of Rubber.—D. F. Twiss. (*Journ. I.E.E.*, October, 1934, Vol. 75, No. 454, pp. 481–486.)

307. New Dielectric has Superior Properties ["Laytex" reduces Weight and Bulk of Wire and Wire Coils].—(*Elec. World*, 13th Oct. 1934, Vol. 104, No. 12, p. 82.)

308. Papers on New Insulating Materials suitable for Heating-Element Carriers.—Krebs and others. (*Elektrowärme*, Vol. 4, 1934, No. 6, pp. 129–132 : No. 2, pp. 25–29 and 38–41.)

309. The Dielectric Properties of Varnished Cloth at High Voltage-Gradients.—L. Hartshorn and E. Rushton. (*Journ. I.E.E.*, November, 1934, Vol. 75, No. 455, pp. 631–642.)

310. New Developments in the Testing of Insulating Moulding Materials [particularly the "Dynstat" Instrument for Static and Dynamic Bending Strength Measurement].—(*E.T.Z.*, 28th June, 1934, Vol. 55, No. 26, pp. 646–647.)

311. The Effective Capacity of Insulators for Short-Time Surge Processes, investigated with the Cathode-Ray Oscillograph.—G. Meyer. (*Dresden Dissertation*, 1933, 31 pp : *Physik. Ber.*, 15th July, 1934, Vol. 15, No. 14, p. 1172.)

312. A Method for Investigating Electrical Breakdown Processes [using Wilson Expansion Chamber].—L. B. Snoddy and C. D. Bradley. (*Phys. Review*, No. 6, Vol. 45, 1934, p. 432.)

313. A Formula for the Variation of Breakdown Voltage with Size of Electrodes and Inhomogeneity of the Dielectric, in Homogeneous Electrical Fields.—A. I. Goldstein. (*Russian Journ. of Tech. Phys.*, No. 2, Vol. 4, 1934, pp. 292–298.)

314. Note on a Precision Variable Condenser [Linear Variation up to 14.2 $\mu\mu$F] for Direct Measurement of Extremely Small Capacity Changes.—J. D. Stranathan. (*Review Scient. Instr.*, September, 1934, Vol. 5, No. 9, p. 315.)

315. Further Development of High-Frequency Resistances.—P. Wenk. (*Physik. Zeitschr.*, 15th Aug. 1934, Vol. 35, No. 16, pp. 653–654.)

These resistances were referred to in 1934 Abstracts, p. 281. They are made by cathode-spraying of two metal components, *e.g.* silver and platinum ;

the further development described here consists in heating them for a short time to a temperature of 600°–700°, in an oxygen-free atmosphere. The constancy of the resistances is thereby much improved.

316. Non-Metallic Conducting Films [Suspensions of Carbon in Phenol Formaldehyde Resin Solutions: used for High-Resistance Elements].—S. Bloomenthal. (*Physics*, September, 1934, Vol. 5, No. 9, pp. 225–232.)

317. The Capacity of Electrolytic Resistances.—M. Jeżewski. (*Physik. Zeitschr.*, 15th Sept. 1934, Vo. 35, No. 18, pp. 748–749.)

This paper discusses the papers by Jeżewski (Abstracts, 1933, p. 207) and Graffunder (1934, p. 395) and describes more fully the experimental method used by the former.

318. A Rheostat with Coarse and Continuous Fine Adjustment.—F. A. Cunnold and M. Milford. (*Journ. Scient. Instr.*, August, 1934, Vol. 11, No. 8, pp. 265–266.)

319. Chart for Simple Attenuator Design.—W. W. Waltz. (*Electronics*, August, 1934, p. 247.)

320. Barretter Arrangement for Medium and Low Frequencies [use of Wollaston Wires instead of Valve or Lamp Filaments].—J. Schiele. (*Physik. Zeitschr.*, 15th Aug. 1934, Vol. 35, No. 16, pp. 632–633.)

321. Researches on Iron-Hydrogen Barretter Resistances [with and without a Series Uranium-Dioxide Resistance: Stabilising Effectiveness: Life Tests].—W. Kleinschmidt. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 15, 1934, pp. 385–386.) *See* also Meyer, 1933 Abstracts, p. 284.

322. Tests on the Performance of Alkali Accumulators at Low Temperatures [Reduced Discharge Capacity at Temperatures below Freezing Point avoided by Increased Concentration of Electrolyte].—E. Schmidt and W. Piening. (*E.T.Z.*, 6th Sept. 1934, Vol. 55, No. 36, pp. 878–881.)

323. Tin Dry Accumulator: Promising Development for Small Radio Batteries.—Féry. (*Electrician*, 10th Aug. 1934, Vol. 113, No. 2932, p. 189.) *See* also 1934 Abstracts, p. 395.

324. Primary Batteries [chiefly Dry], according to Recent Patents.—Jumau. (*Rev. Gén. de l'Élec.*, 3rd Nov. 1934, Vol. 36, No. 18, pp. 625–633.) For a previous paper *see* 1932 Abstracts, p. 538.

325. Temporal Phenomena and the Spread of Magnetisation for Large Sudden Changes.—F. Hülster. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 15, 1934, pp. 387–391.)

326. Researches on the Structural Demagnetising Field of Ferromagnetic Materials.—Th. Kahan. (*Journ. de Phys. et le Rad.*, September, 1934, Series 7, Vol .5, No. 9, pp. 463–470.)

327. The Hot-Cathode Thyratron [Design, Characteristics, and Use as Highly Sensitive Relays, as Rectifiers, and as Regulable Current Converters].—R. Petit. (*Rev. Gén. de l'Élec.*, 20th Oct. 1934, Vol. 36, No. 16, pp. 533–538.

328. An Ionised-Gas Rectifier for Medium-Frequency Alternating Currents, using a Magnetic Field.—Th. Jonescu and I. Cerkez. (*Comptes Rendus*, 8th Oct. 1934, Vol. 199, No. 15, pp. 664–666.)

Based on the work dealt with in 1934 Abstracts, p. 378. If two coaxial cylinders 5 cm long and of diameters between 0.5 and 5 cm are enclosed in hydrogen at low pressure, a potential difference of 350 v will produce a discharge. If the outer cylinder is negative compared with the inner, and a magnetic field of about 30 gauss is applied parallel to the axis, the current increases from 5 to 250 mA. If the external cylinder is positive, the current keeps at a constant value of 2.5 mA until the magnetic field exceeds 50 gauss. Such a device can obviously be used as a rectifier in various connections. The diagram shows a symmetrical arrangement of two units L_1, L_2, combined with the coils B_1, B_2 and the condensers C_1, C_2. Other coils B_1', B_2', through which some of the rectified current passes, provide the required magnetic field. The tables show that the efficiency ranges from about 0.1 to 0.53; without a magnetic field, from 0.03 to 0.14 only.

329. Thermionic Pentode Controlled Constant-Voltage Rectifiers.—R. D. Evans. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 324: abstract only.)

330. The Application of a Gas-Cooled Arc to Current Conversion, with Special Reference to the Marx-Type Rectifier.—W. G. Thompson: Marx. (*Journ. I.E.E.*, November, 1934, Vol. 75, No. 455, pp. 603–630.) For the Marx arc-in-air rectifier *see* 1934 Abstracts, p. 220, r.-h column, and below.

331. The Arc-in-Air Rectifier [New Developments].—E. Marx and H. Buchwald. (*E.T.Z.*, 30th Aug. 1934, Vol. 55, No. 35, pp. 861–863.) *See* also above.

332. On the Control of [Electric] Currents in Air at Atmospheric Pressure [Bunsen Flame and Nernst Lamp Experiments: Rectifying Action: Control by Grid: etc.].—W. Hucke. (*Arch. f. Elektrot.*, 15th Sept. 1934, Vol. 28, No. 9, pp. 593–596.)

In the experiments with grid control of Bunsen flame currents (Fig. 4) characteristic curves resembling those of an ordinary valve were obtained. At the steepest parts the slopes were about 0.018 mA/v, which is greater than those obtained by Gemant (3.4 mA/kv) with his corona discharge device (1933 Abstracts, pp. 401–402).

333. A Mechanical Rectifier for the Measurement of Small, Commercial-Frequency, Alternating Potentials [giving Steady Deflections with High-Sensitivity Galvanometer].—C. C. Steffens and R. C. Tolman. (*Review Scient. Instr.*, September, 1934, Vol. 5, No. 9, pp. 312–314.)

334. Reversal of Rectified [Crystal] Detector Current at Ultra-High Frequencies.—Kopilowitsch and Tschernez. (See 107.)

335. Rectification and Photoelectric Effect with the Silicon Carbide Detector.—P. Specht. (*Zeitschr. f. Physik*, No. 3/4, Vol. 90, 1934, pp. 145–165.)

Experiments on the valve action in the silicon carbide detector show that there are two fundamental components of the action. One is localised in the barrier layer of silicon dioxide and is only effective when the load on the rectifier is small. The rectification is good and depends on the electrode material. The second is situated in the bulk of the crystal and is the cause of the valve action at higher current strengths, though its rectifying action is less marked than the first and is practically independent of the electrode material. The directions of the actions of these two components are opposite; the change from one to the other occurs continuously or discontinuously according to the dimensions of the boundary layer.

The photoelectric effect is similar to the rectification action as regards dependence on the electrode material. Photoelectric voltages up to 2 volts on open circuit were obtained; the corresponding currents were from 10^{-9} to 10^{-12} amp. Good barrier-layer valve action was always found for sensitive photoelectric points. Curves are given showing the influence of the intensity of the light, the angle of incidence and the temperature on the photoelectric e.m.f. The theory of the effect and similar phenomena in other materials are also considered.

336. Voltaic Voltage and Thermo-Voltage of Cuprous Oxide.—G. Mönch. (*Zeitschr. f. Physik*, No. 1/2, Vol. 91, 1934, pp. 124–130.)

337. The Electrolytic Valve Effect in Fused Salts [Formation of Barrier Layers of Oxide on Tantalum and Aluminium in Fused, Water-Free Salts].—G. Grünert. (*Zeitschr. f. Physik*, No. 1/2, Vol. 91, 1934, pp. 46–69.)

338. The Flow of Electron Currents in Insulators at Extreme Field Strengths [Mechanism of Current Flow through Electrolytic Oxide Layers on Various Metals: Empirical Current/Voltage Curves for Low and High Voltages].—A. Güntherschulze and H. Betz. (*Zeitschr. f. Physik*, No. 1/2, Vol. 91, 1934, pp. 70–96.)

339. The Departure of Semi-Conductors from Ohm's Law in Strong Electrical Fields.—L. Landau and A. Kompanejez. (*Physik. Zeitschr. der Sowietunion*, No. 1/2, Vol. 6, 1934, pp. 163–169: in German.)

340. Contribution to the Study of the Properties of Semi-Conducting Substances.—G. Déchêne. (*Ann. de Physique*, October, 1934, Series 11, Vol. 2, pp. 241–345.)

341. Contacts Suitable for Instruments [Investigations by Research Section of British P.O.].—H. Williams. (*Journ. Scient. Instr.*, September, 1934, Vol. 11, No. 9, pp. 273–279.)

342. Investigations on Relays [Exact Mechanical Contacts and Use of Mechanical Amplification].—H. Martin. (*Physik. Zeitschr.*, 15th Aug. 1934, Vol. 35, No. 16, pp. 658–661.)

343. Adjustable and Fixed-Setting [Bimetallic Element] Thermostat Controls.—GEC. (*Journ. Scient. Instr.*, September, 1934, Vol. 11, No. 9, pp. 299–301.)

344. High-Speed Relay.—Siemens Brothers & Company. (*Journ. Scient. Instr.*, September, 1934, Vol. 11, No. 9, pp. 295–297.)

345. The Design and Construction of Thermo-electric Cells.—R. V. Jones. (*Journ. Scient. Instr.*, August, 1934, Vol. 11, No. 8, pp. 247–257.)

346. New Method of Spectrum Analysis of Aperiodic Curves [by Representing the Curve by a Variable-Density Optical Record].—M. Lévy. (*Comptes Rendus*, 12th Nov. 1934, Vol. 199, No. 20, pp. 1031–1033.)

347. Improvements to the "Scale of Two" Thyratron Counter.—W. B. Lewis. (*Proc. Camb. Phil. Soc.*, October, 1934, Vol. 30, Part 4, pp. 543–548.)

This paper describes slight modifications of the circuit and reduction of the resolving time of the counter devised by Wynn-Williams (1932 Abstracts, p. 535).

348. A New Pulse Counter [for Rapid Pulses, *e.g.* Cosmic Rays].—H. Alfvén and P. Ohlin. (*Zeitschr. f. Physik*, No. 5/6, Vol. 90, 1934, pp. 416–420.)

The writers have previously described (1934 Abstracts, p. 564) how a thyration may be replaced by oscillating triodes in electrical counters. In this paper they discuss an apparatus based on the discharge of a condenser in discrete steps, which passes on every tenth pulse to a mechanical relay.

349. Discharge Forms in a Cylindrical Counter [for Detection of Single Photoelectron or Cosmic Ray].—S. Werner. (*Zeitschr. f. Physik*, No. 5/6, Vol. 90, 1934, pp. 384–402.)

350. An Amplifier and Recording Apparatus for Alpha-Particles, High-Speed Protons and Neutrons.—M. C. Henderson. (*Phys. Review*, 15th Aug. 1934, Series 2, Vol. 46, No. 4, p. 324: abstract only.)

351. An Arrangement for measuring Weak Ionisation Currents [Light Beam from Electrometer controls Amplifier *via* Photocells].—J. C. Jacobsen. (*Zeitschr. f. Physik*, No. 3/4, Vol. 91, 1934, pp. 167–168.)

352. New Type of Telegraph Repeater employing Carrier Currents [of Frequency 5 kc/s].—S. P. Chakravarti. (*Nature*, 6th Oct. 1934, Vol. 134, p. 537.)

STATIONS, DESIGN AND OPERATION

353. Present Costs of Broadcasting Stations.—(*Electronics*, August, 1934, pp. 254–255.)

354. The "Fatigue" of Wireless Stations: Erratum. (In 1934 Abstracts, p. 631, r-h column, read "Weaker Signals.")

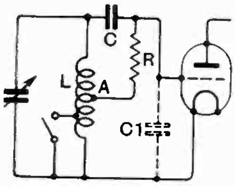
Some Recent Patents

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.

SHORT-WAVE AMPLIFIERS

Convention date (Holland), 8th May, 1933. *No.* 412532

In order to increase the selectivity of a high-frequency amplifier, when handling short waves, a part of the tuning coil L shown in the figure is short-circuited by a switch for short-wave reception, and the " leak " resistance R, instead of being connected directly to the cathode, is taken to a point A on the inductance L such that the ratio between the impedance of the upper and lower parts of the coil still in circuit is equal to the ratio between the coupling-condenser C and the inherent capacity C_1 (indicated in dotted lines) between the grid and the filament. This gives a balanced-bridge arrangement which prevents the passage of current through the resistance R, and so eliminates any damping effect due to that cause.



No. 412532.

Patent issued to N. V. Philips Gloeilampenfabrieken.

SELENIUM CELLS

Application date, 2nd February, 1933. *No.* 412665

In order to insure good electrical contact, the electrodes consist of parallel wires or strips of metal fused into an intermediate glass support so that they partly project. Selenium or thallium sulphide is then deposited in the ridges so formed. The electrode wires may be made of platinum, or of a cheaper iron-nickel alloy coated with copper and copper borate.

Patent issued to The British Thomson-Houston Co., Ltd.; H. R. Ruff; and J. Scott.

TELEVISION SCANNING

Convention date (Germany), 8th November, 1932. *No.* 412833

Relaxation oscillations of the saw-toothed type, as used for controlling the scanning electrodes in a cathode-ray television receiver, are generated by charging a condenser through a resistance and discharging it rapidly through a gas-filled valve. The input circuit of the valve is shunted by an iron-cored choke which is saturated during most of the period of the applied control frequency, though a sharp impulse is sent to the grid as the current passes through the zero point. This renders the valve conductive, and discharges the condenser at a rapid rate so as to impart the necessary quick-return motion to the cathode-ray as it passes from the end of one scanning traverse to the beginning of the next.

Patent issued to Telefunken Ges. fur Drahtlose Telegraphie m.b.h.

VARIABLE INDUCTANCES

Application date, 9th January, 1933. *No.* 412642

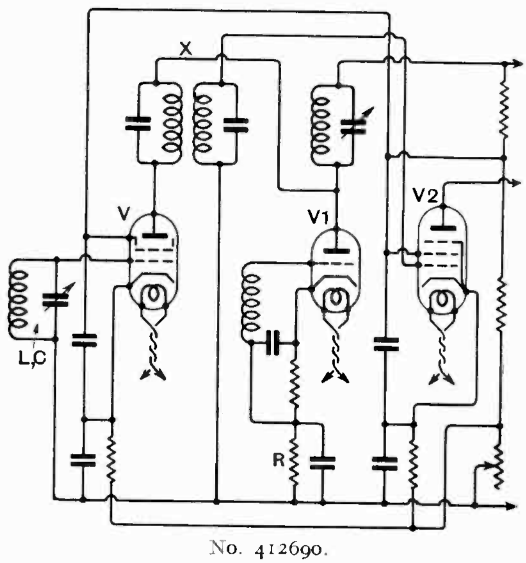
A high-frequency unit comprises a coil wound on a hollow former made to accommodate a powdered-iron core, which is moved in or out to vary the tuning. The movable core is sickle-shaped and is fulcrummed about the centre of a magnetic casing, which encloses both the winding and the core. This outer casing forms a return path for the magnetic flux from the coil, and also serves to screen the latter. Several such coils may be ganged together to form a variable-permeability unit for tuning a wireless receiver.

Patent issued to The General Electric Co., Ltd.; H. C. Turner; and G. R. Polgreen.

SUPERHET RECEIVERS

Application date, 21st February, 1933. *No.* 412690

Signals applied to the input circuit L, C are amplified by the valve V and mixed with oscillations from a generator V_1, which is coupled to the first valve by a conducting lead X. The resulting intermediate frequency is fed to the input circuit of a pentode valve V_2. According to the invention the amplitude of the output from the local oscillator is controlled by a resistance R which is inserted



No. 412690.

on the cathode side of that valve, instead of in the anode circuit proper, so that voltage fluctuations acros it do not affect the anode voltage of the detector valve V.

Patent issued to A. C. Cossor, Ltd., and D. F. S. Marshall.

RADIOGRAMS

Application dates, 4th May and 9th November, 1933. *No.* 412743

The output from a gramophone pick-up is applied to modulate the frequency of a valve oscillator forming a part of the chain of amplification in a radio receiver. Fig. 1 shows the scheme as

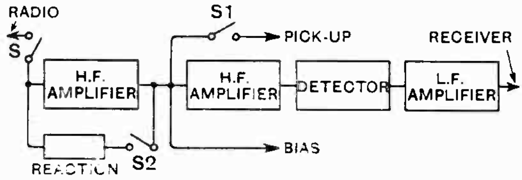


Fig. 1.

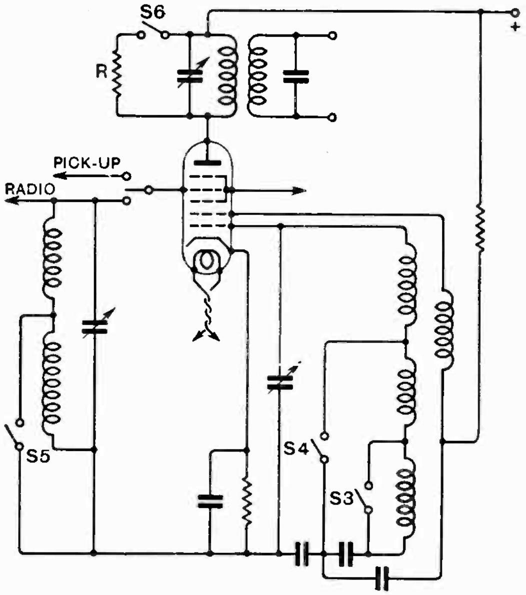


Fig. 1a
No. 412743

applied to a "straight" circuit. A switch *S* is opened to cut off the radio input, and a switch *S*1 closed to bring the pick-up into circuit. At the same time a switch *S*2 inserts a back-coupling branch which throws the H.F. amplifier into self-oscillation. The modulated gramophone voltage is then passed through the subsequent stages of the set. As applied to a superhet set, Fig. 1a, the pick-up voltage is fed to one of the grids of a penta-grid valve, and the switch *S*3 is opened to cause the valve to generate oscillations at intermediate frequency. *S*4 and *S*5 are wave-band switches. A damping resistance *R* is introduced at *S*6 to prevent the set from being overloaded during gramophone operation.

Patent issued to General Electric Co., Ltd., and C. N. Smyth.

AUTOMATIC VOLUME CONTROL

Application date, 4th January, 1933. *No.* 412944

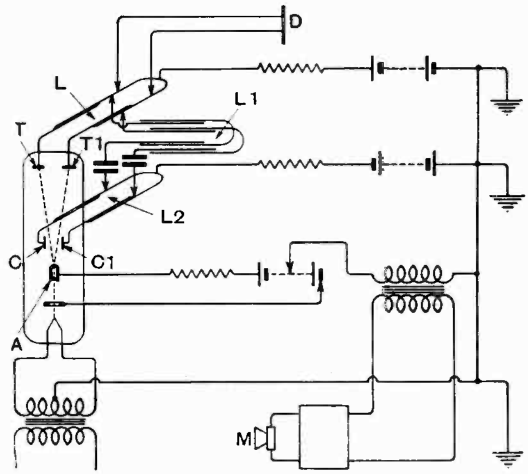
A rectifier of the dry-contact type is connected in series with the usual by-pass condenser across the output circuit of the detector valve in a wireless set, and the potential so derived is used for A.V.C. The use of the dry-contact rectifier in this position simplifies the application of A.V.C. to an existing receiver, all that is necessary being to cut the wire connecting the by-pass condenser to the cathode of the detector valve and to join the rectifier across the two ends. One terminal of the by-pass condenser is then connected through a resistance to the grid of the valve to be controlled. If required, four dry-contact units can be arranged in bridge formation to give full-wave rectification.

Patent issued to S. A. Stevens and the Westinghouse Brake and Saxby Signal Co., Ltd.

SHORT-WAVE GENERATORS

Convention date (U.S.A.), 14th January, 1933. *No.* 413335

Ultra-short waves are produced by causing the electron stream in a cathode-ray tube to oscillate to and fro between two separated anodes, which are back-coupled through tuned Lecher-wire circuits to a pair of control electrodes. As shown, the electron stream, after passing through a cylindrical anode *A*, is deflected by control electrodes *C*, *C*1 so as to impinge alternately against a pair of "target" anodes *T*, *T*1. A tuned Lecher-wire output circuit *L* is branched across the targets, and supplies short-wave oscillations to a dipole aerial *D*. "Trombone" Lecher wires *L*1 feed back part of the energy through a similar circuit *L*2 to the control electrodes *C*, *C*1 in correct phase



No. 413335

to maintain the oscillations. Speech signals are applied to the generated carrier-wave through a microphone *M*.

Patent issued to Marconi's Wireless Telegraph Co., Ltd.

PORTABLE AERIALS

Convention dates, 8th and 22nd February, 1932.
No. 412966

A portable aerial of the directional or reflector type is made collapsible so as to be readily packed for transport. The reflecting surface consists of wire-gauze embedded in fabric, or of fabric with a metallic coating. In one arrangement the fabric is stretched over a framework of poles driven into the ground to form a parabolic screen, the structure being held in position by guy-ropes. In a modified form the reflecting fabric is secured by rods which can be extended or collapsed in umbrella-fashion about a centre pole.

Patent issued to C. Lorenz Akt.

VARIABLE-MU VALVES

Convention date (Germany), 30th January, 1932.
No. 413390

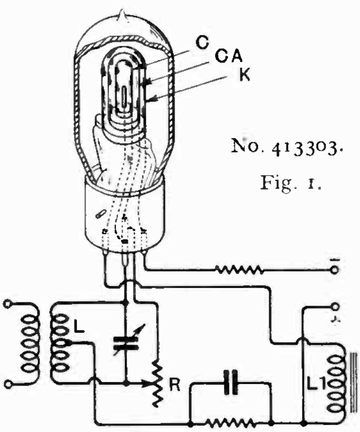
In known types of variable-mu valves, the characteristic curve flattens out as it approaches the abscissa. The result is that distortion is much more in evidence at certain points on the curve than at others. According to the invention, the "pitch" or spacing of the control grid is varied in accordance with a given formula, so that the form of the characteristic approximates to a negative logarithmic curve, i.e., it is convex relatively to the abscissa, over a grid-bias range of at least 20 volts.

Patent issued to Telefunken Ges. fur Drahtlose Telegraphie m.b.h.

COLD-CATHODE AMPLIFIERS

Convention date (U.S.A.), 14th April, 1932.
No. 413303

A gas-filled valve, operating as a cold-cathode amplifier, consists of a series of electrodes all mounted coaxially on an insulated support, so that the inter-electrode spaces are completely separated from each other in the sense that electrons can only



No. 413303.
Fig. 1.

pass from one space to the next through the electrodes. Fig. 1 shows the actual construction of the device, whilst Fig. 2 is a diagram explanatory of the method of working. In Fig. 1 a simple rod forms the anode. It is surrounded in succession by a control electrode *C* and a "cathanode" *CA*, both of helical or open meshwork wire, and a cathode *K* which may be either solid or perforated. The tube is filled with

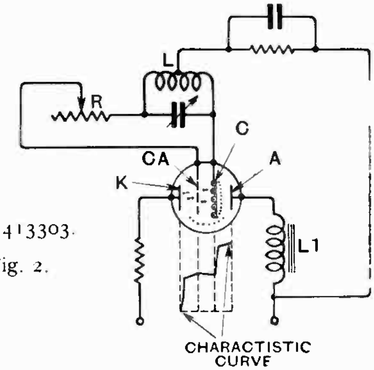


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Fig. 2.

gas. Free electrons are produced by the voltage gradient between the cathode *K* and "cathanode" *CA*, and are drawn through the control electrode *C* towards the anode. The action of the control electrode *C* depends upon the neutralisation of the sheath of electrons which is formed, as shown in Fig. 2, on the anode side of that electrode. The sheath, in effect, forms a "valve" through which the electron stream passes to the output circuit *L1 via* the anode. The input signals are applied to the coil *L*. The resistance *R* adjusts the device to the correct operating point on the characteristic curve shown in the lower part of Fig. 2.

Patent issued to Radio Research Laboratories, Inc.

TELEVISION SYSTEMS

Application date, 7th February, 1933. *No.* 413401

Relates to variable-velocity scanning in which the received picture is reconstructed by varying the speed of the scanning-spot in accordance with the different light-and-shade values. This necessitates a range of scanning velocity varying, say, from thirty to one, and whilst it is an advantage of the system that detail is concentrated in the lighter positions of the picture, the effect can be unduly exaggerated. According to the invention a proper balance is restored by introducing an intensity modulation in addition to the normal velocity modulation, so that an adequate degree of contrast can be shown in the picture with a comparatively low range of scanning velocity. Incidentally, this permits a lower frequency-band to be radiated from the transmitter. The effect is secured by causing the receiver signals to generate two voltages, one being the time integral of the other. The first voltage is then used for scanning, whilst the second is used to modulate the intensity of the scanning spot.

Patent issued to W. R. Bullimore and L. H. Bedford.

Patent No. 410010. The name of H. A. Brooke as one of the inventors was inadvertently omitted from the Abstract of the patent published in the October number.