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# WIRELESS ENGINEER

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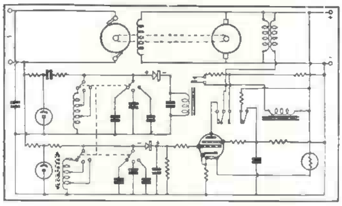
PROBLEMS WE HAVE SOLVED—NO. I

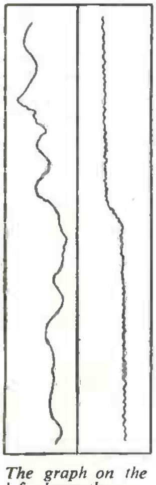
# THE ELECTRONIC GOVERNOR



*CIRCUIT OF S.E.M. ELECTRONIC GOVERNOR (Pat. No. 16640/41)*

THE usual way of controlling the speed or frequency of a rotating electrical machine is by means of a centrifugally operated governor. This method has certain inherent faults, such as, wear on moving parts and mechanical lags, which are transmitted to the machine, producing a certain amount of instability.

S.E.M. research engineers were asked to produce a governor with an accuracy of at least that of the best centrifugal governor when working under the same variation of load and supply voltage. For this purpose the Electronic Governor was developed. The circuit essentially comprises a resonant circuit tuned to a frequency corresponding to the normal speed of the machine. The alternating current from the resonant circuit is applied through a rectifier to the grid of an amplifying valve, the output from this valve being fed to the control field of the motor.



*The graph on the left shows the normal frequency variations obtained with a centrifugal governor. On the right is shown a frequency curve produced where an electronic governor is used.*

The control current produced by the governor is applied to an auxiliary field coil on the motor from which the main speed control is obtained. Energization of this coil varies with the speed of the motor, so that any change is immediately compensated by the Electronic Governor.

The governor gives a speed control of less than 0.5%, and the intermittent variation or hunting is less than 10% of that experienced with centrifugal governors. The governor can be fixed at any distance from the rotating machine, and is fitted with a control giving speeds of plus and minus 3% of the nominal speed.

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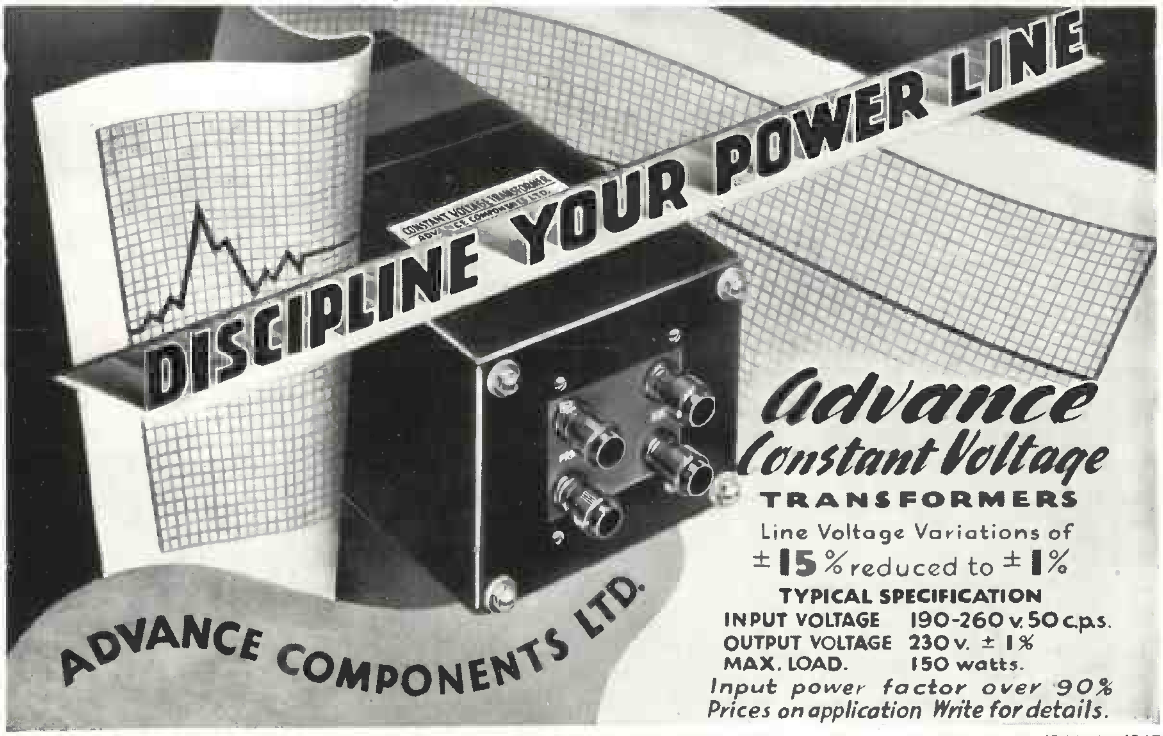


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A DEVELOPMENT OF THE MULLARD LABORATORIES

# WIRELESS ENGINEER

Editor HUGH S. POCOCK, M.I.E.E. Technical Editor Prof. G. W. O. HOWE, D.Sc., M.I.E.E.

VOL. XXII MAY, 1945 No. 260


## EDITORIAL

## The Radial Field in a Spherical Electromagnetic Wave

IN the April Editorial we showed how, starting from a simple consideration of a decelerated electric charge, it is possible by easy stages, involving very little mathematics, to establish the radiation resistance of a dipole or of any other simple type of aerial. We mentioned that, since in the dipole equal positive and negative charges are involved, there will be no radial field except in the immediate neighbourhood of the dipole. A student would be quite justified, however, in pointing out that, except in the equatorial plane, there is a radial component in the electric field, that seems to be unaccounted for. That there must be such a radial field is obvious, for as one proceeds from the equatorial plane towards the pole the tangential field decreases, that is, the number of lines of force per square centimetre decreases and also the available cross-section decreases. Every electric line of force that crosses the equatorial plane has to leave the spherical shell and enter the adjacent one before it reaches the pole and to do this it must become radial. The strength of the radial field can be calculated from this consideration. If in Fig. 1 $\mathcal{E}_t$ is the strengthof the tangential field at the point of maximum field strength in the equatorial plane, its mean value over the quarter wavelength will be $2\mathcal{E}_t/\pi$. At an angle $\theta$ to the vertical this will be reduced to $(2/\pi)\ \mathcal{E}_t \sin\theta$ and the area of cross-section will be $2\pi r \sin\theta \times \lambda/4$. Denoting by $\psi$ the total number of electric lines crossing this radial zone of width $\lambda/4$ we have $\psi = r\lambda\mathcal{E}_t \sin^2\theta$, and therefore

$$d\psi/d\theta = r\lambda\mathcal{E}_t\, 2 \sin\theta \cos\theta.$$

Now this change in the number of tangential lines must be equal to the number of radial lines crossing the zonal strip of width $rd\theta$, that is, to $\mathcal{E}_r \times 2\pi r \sin\theta \times rd\theta = 2\pi r^2 \mathcal{E}_r \sin\theta\, d\theta$. Hence $\mathcal{E}_r = \mathcal{E}_t\,(\lambda/\pi r) \cos\theta$.

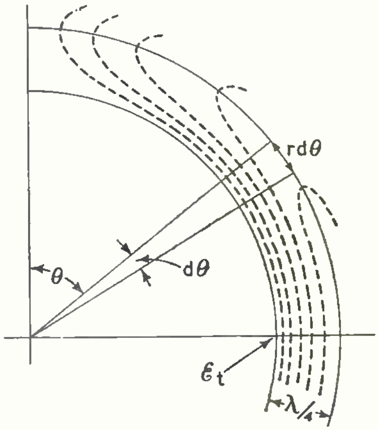


Fig. 1.

It is zero at the equator, a maximum at the poles and, as one would expect, it varies inversely as the square of the distance $r$. It is, of course, only of academic interest.

In the case of two equal and opposite charges $+q$ and $-q$ oscillating over a path of length $l$ we saw that $\mathcal{E}_t = q\omega^2 l/c^2 r$. In this case, therefore,

$$\mathcal{E}_r = \left(\frac{q\omega^2 l}{c^2 r} \times \frac{\lambda}{\pi r}\right) \cos\theta = \frac{2q\omega l}{cr^2} \cos\theta.$$

There is, however, another way of regarding the radial field, which brings out more clearly how it is produced. Fig. 2 shows a dipole

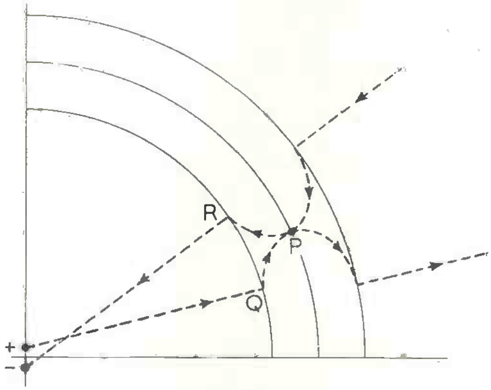


Fig 2.

with its charges at rest at their maximum displacement. They were previously in the reverse positions, but at a certain moment they executed a semi-oscillation, starting towards the centre with an acceleration which decreased harmonically as they approached it, passing through it at their maximum velocity and then decelerating and coming to rest in the positions shown. The resulting pulse is shown travelling outwards along a single line of electric force from each charge. It is evident that there is no appreciable resultant field outside the pulse and that within it the tangential components due to the two charges are in the same direction. Within the pulse, however, there is a radial component, except in the equatorial plane, due to the fact that the electric flux through a zone 1 cm. wide drawn around the sphere through the point $P$ is the resultant of the two opposing fluxes passing through zones at $Q$ and $R$. Now the zone at $Q$ has a bigger diameter and a greater width and therefore a larger area than that at $R$, and since the radial flux per square centimetre is the same for each, the total electric flux through the former is greater than that through the latter, with the result that the electric field within the pulse has a radial component which can be shown to be equal to $(2q\omega l/cr^2) \cos\theta$ at any point such as $P$ on the surface in which the tangential component is zero.

G. W. O. H.

# Proposed Raising of the Frequency Band for Frequency-Modulated Broadcasting in America

A GREAT fight is going on in the United States over the band of frequencies to be allocated to frequency-modulated broadcasting. The Federal Communications Commission has proposed to raise the frequency range from the present 42–50 Mc/s to 84–102 Mc/s. This proposal led to an enquiry at which many witnesses were heard for and against the suggested change.

The Commission maintain that such a change would "raise F-M above sky-wave interference," but there has been an outcry against it on the grounds that it would paralyse a new industry for two years after the war and discriminate against it in the highly competitive post-war radio market. The Commission is alleged to have rejected the opinions of qualified experts and given undue weight to its own witnesses.

The frequency-modulation industrial group maintain that during the last five years they have developed resources and facilities to meet an expected demand for five million radio sets in the first year after the war, and that the proposed change of frequency would paralyse these facilities.

Major E. H. Armstrong gave evidence before the Commission and urged that the band 48 to 66 Mc/s should be allocated to frequency-modulated broadcasting, frequencies below 48 Mc/s to amateurs and the higher frequencies to television. The 48 to 66 band would provide eight channels, the same number as the proposed 84 to 102 band.

The Commission has been largely influenced by K. A. Norton, a member of its staff, but his calculations and predictions have been called unsound by Armstrong, who has the support of H. H. Beverage, of the Radio Corporation of America, and C. H. Burrows, the Chairman of the Radio-wave Propagation Committee of the National Defence Research Committee. The latter maintain that their views are in accordance with those of Dr. Dellinger of the Bureau of Standards and of the Radio Technical Planning Board.

Norton's point is that at the peak of the sunspot cycle, which is expected to occur about 1948, there would be serious *F* layer interference at the frequency suggested by Armstrong and his associates, which would be eliminated by raising the frequency as suggested by the Commission. On March 1st the Commission decided, in view of the seriousness of the position, to hold a secret session under military supervision as soon as possible, at which experts will attend and give information that for security reasons cannot be made public.

The industry itself seems to be divided on the matter, for the suggested change was opposed by representatives of the Yankee Network and the General Electric Co., but approved by representatives of Cowles Broadcasting Co. and the American Broadcasting Co. They were also divided as to the effect of the proposed change on the prices of receivers, one representative giving the increase as 15 to 30 dollars, whereas another maintained that it need not exceed 4 dollars. It will be interesting to see what effect, if any, K. A. Norton's secret data has on his opponents.

G. W. O. H.

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# The Late Sir Ambrose Fleming

*Pioneer of the Thermionic Valve*

It is with regret we record that Sir Ambrose Fleming, D.Sc., Hon.D.Eng. (Liverpool), F.R.S., died at Sidmouth on April 18th at the age of 95.

John Ambrose Fleming was educated at the University College, Gower Street, London, and at the Royal College of Chemistry. In order to have the opportunity of studying under Clerk Maxwell he left his first appointment as science master at Cheltenham College to go to the Cavendish Laboratory, Cambridge, in 1877. He held professorships of mathematics and physics at University College, Nottingham, and of electrical engineering at University College, London—the latter post from 1885 to 1926.

As electrical adviser to Marconi's Wireless Telegraph Company he assisted in solving the technical problem of equipping the station at Poldhu used for the first transatlantic transmissions in 1901.

Fleming's name will always be associated with the two-electrode thermionic valve. Writing in 1934 in his book "Memories of a Scientific Life" of the introduction by de Forest of the third electrode in the valve, Sir Ambrose adds "but, sad to say, it did not occur to me to place the metal plate and the zigging wire in the same bulb and use an electron charge of positive or negative on the wire to control the electron current to the plate."

Sir Ambrose received many awards and honours for his work in electrical physics. In 1892 he was elected a Fellow of the Royal Society and in 1910 was awarded the Society's Hughes Medal. In 1921 he received the Albert Medal (R.S.A.), in 1928 the Faraday Medal (I.E.E.), in 1931 the Duddell Medal (Physical Society), and in 1935 the Kelvin and Franklin Medals. He was knighted in 1929.

His best known literary works are "Fifty Years of Electricity," which, published from the offices of *Wireless World* in 1921, outlined in simple language the history of applied electricity from 1870, and "The Thermionic Valve" (1919), which dealt with the developments of the valve in radio-telegraphy and telephony. His first scientific paper on "The Contact Theory of the Galvanic Cell" was presented at the inaugural meeting of the Physical Society in 1874.

# SPACE CHARGE EFFECTS—

## Between a Positive Grid and Anode of a Beam Tetrode

*By G. B. Walker, M.A.*

(*Continued from page* 169, *April* 1945 *issue.*)

## PART II

### Introduction

IN Part I we investigated the formation of a potential minimum between the screen and anode of the beam tetrode for the particular case that all electrons are just able to cross to the anode. This state of affairs occurs when the potential minimum has the value $V_T$ where we defined $V_T$ as that potential at which electrons which receive the greatest deflection on crossing the screen lose their forward velocity component. This is perhaps the most important case in the normal usage of the valve, for it determines the anode voltage below which a marked drop in anode current occurs, but if we are properly to understand the behaviour of space charge in the valve, and other effects arising therefrom, it is necessary to develop the analysis to include all the possible potential distributions which can arise.

### General Account of Space Charge in the Screen-Anode Region

When small currents are passed the situation is without interest. The presence of charge causes a slight reduction of the potential in the field and nothing of greater moment happens until the current has a sufficiently high value for a potential minimum to be formed between the screen and anode. The existence of a potential minimum is a fundamental feature in the distribution of space charge, and in the former low current case perhaps the simplest way to determine the potential between the screen and the anode is to assume that a virtual potential minimum exists either before the screen or beyond the anode. In this way the problem becomes of the same type whether a real minimum exists or not and we shall proceed accordingly.

We shall take as data the effective potential at the screen grid and the current which enters the screen-anode region in the anode direction. It might seem reasonable to take the anode voltage as given also, leaving only the value of the anode current and the potential distribution in the valve to be found, but, as we shall see, for a given value of anode voltage, there can be more than one possible distribution of space charge and potential in the valve, whereas for a given value of the potential minimum the anode current and anode voltage are uniquely determined. It is more convenient, therefore, to carry out the analysis with the value of the potential minimum included in the data.

### The Potential Minimum.—Case I

Let $V_m$ specify the value of the potential minimum and consider first the case in which $V_m > V_T$.

As will be understood from what has been written previously there are only forward moving electrons in this case and equations (12) and (13) apply.

To evaluate the integration constant in (13) we have now $dV/dx = 0$ when $V = V_m$.

Proceeding as before we shall write:

$$\int_{V_m}^{V} \frac{dV}{\sqrt{\dfrac{V^{3/2} - (V - V_T)^{3/2} - [V_m^{3/2} - (V_m - V_T)^{3/2}]}{V_T}}} = \sqrt{\frac{32}{3}} \cdot \pi \cdot \sqrt{\frac{m}{2e}} \cdot i \cdot x \quad \quad (31)$$

where $x$ is again measured from the potential minimum.

By means of the substitutions $V = V_T \cdot \gamma$ and $V_m = \alpha \cdot V_T$, (31) can be written:

$$\int_{\alpha}^{V/V_T} \frac{V_T^{3/4} \cdot d\gamma}{\sqrt{\gamma^{3/2} - (\gamma - 1)^{3/2} - [\alpha^{3/2} - (\alpha - 1)^{3/2}]}} = \sqrt{\frac{32}{3}} \cdot \pi \cdot \sqrt{\frac{m}{2e}} \cdot i \cdot x \quad \quad (32)$$

It is convenient to introduce the function $f\left(\frac{V}{V_T}, \alpha\right)$ defined for values of $\alpha \geqslant 1$ as follows:

$$f\left(\frac{V}{V_T}, \alpha\right) = \int_{\alpha}^{V/V_T} \frac{d\gamma}{\sqrt{\gamma^{3/2} - (\gamma - 1)^{3/2} - [\alpha^{3/2} - (\alpha - 1)^{3/2}]}} \quad .. \quad .. \quad (33)$$

whence:

$$x = 0.0444 \cdot \frac{V_T^{3/4}}{\sqrt{i}} \cdot f\left(\frac{V}{V_T}, \alpha\right) \quad .. \quad (34)$$

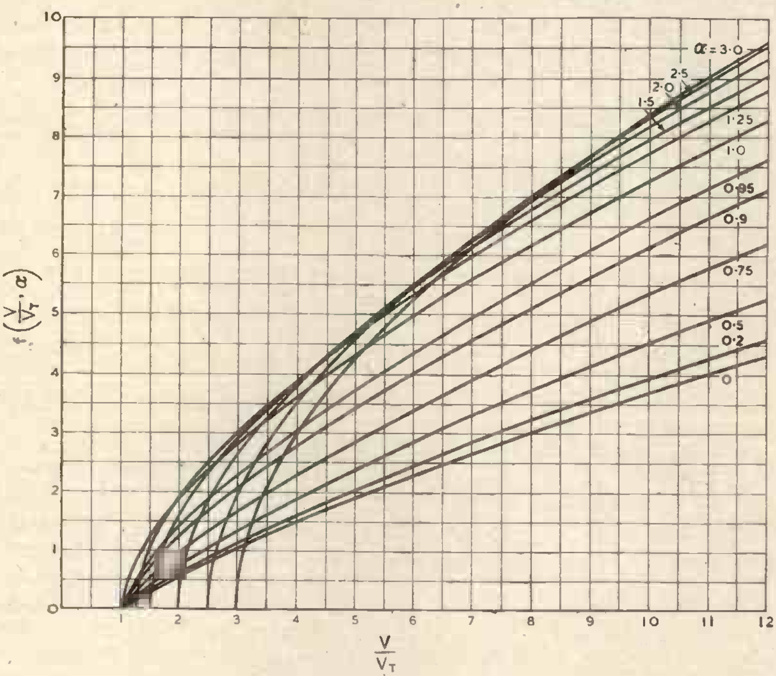


Fig. 6. *Graphs of the function $f\left(\frac{V}{V_T}, \alpha\right)$ for a set of values of α which is treated as a parameter.*

The function $f\left(\frac{V}{V_T}, \alpha\right)$ has been evaluated for a set of values of $\alpha$ and graphed in Fig. 6. It is to be noted that when $\alpha = 1$, $f\left(\frac{V}{V_T}, \alpha\right)$ and the function $f\left(\frac{V}{V_T}\right)$, which was encountered earlier, are identical.

For a given value of $\alpha$ the appropriate value of $V_a$ may be found by a similar method to that for calculating the anode voltage at the knee, for :—

$$f\left(\frac{V_a}{V_T}, \alpha\right) = \frac{x_{2a} - x_g}{0.0444 \times \frac{V_T^{3/4}}{\sqrt{i}}} = \frac{x_{2a} \cdot \sqrt{i}}{0.0444 \times V_T^{3/4}} - f\left(\frac{V_g}{V_T}, \alpha\right) \quad .. \quad .. \quad .. \quad .. \quad (35)$$

and since all the quantities in the extreme right of these equations are known the value of $f\left(\frac{V_a}{V_T}, \alpha\right)$ may be found and hence $V_a$ is uniquely determined.

To illustrate the relation between $\alpha$ (that is $V_m/V_T$) and $V_a$ the curves in Fig. 7 were prepared making use of the dimensions of the valve described in Table 2. Three current values were chosen and it will be seen that the $V_a$ curve has a minimum, the significance of which will be described later.

**The Virtual Potential Minimum**

The case of the virtual potential minimum follows at once from the foregoing.

The graphs in Fig. 7 can be extended until $\alpha = V_g/V_T$, that is, we can plot $V_a$ against $V_m$ until $V_m = V_g$ when the potential minimum coincides with the screen. If higher anode voltage values are required we may assume the existence of a virtual potential minimum behind the screen at a value less than $V_g$. The screen and anode now lie on the same side of the potential minimum and it is necessary to change the sign of the second term on the right-hand side of (35). Thus the equation relating

$V_m$ and $V_a$ is now:

$$f\left(\frac{V_a}{V_T}, \alpha\right) = \frac{x_{2a} \cdot \sqrt{i}}{0.0444 \times V_T^{3/4}} + f\left(\frac{V_g}{V_T}, \alpha\right) \quad \ldots \quad (36)$$

For a given value of anode voltage it is possible by interpolation to find the corresponding value of the virtual potential minimum and likewise its position, thus enabling us by the aid of (34) to estimate the potential at any point in the field.

At very low current densities, and values of anode voltage less than the screen, it may be necessary to consider a virtual minimum beyond the anode, but this case need not be discussed here.

For the linear tangential velocity distribution law we may proceed as above, but $f\left(\frac{V}{V_T}, \alpha\right)$ must be replaced by the function $\phi\left(\frac{V}{V_T}, \alpha\right)$ where:

$$\phi\left(\frac{V}{V_T}, \alpha\right) = \frac{2}{\sqrt{3}} \int_1^{V/V_T} \frac{d\gamma}{\sqrt{\left(\gamma \sin^{-1}\sqrt{\frac{1}{\gamma}} + \sqrt{\gamma - 1}\right) - \left(\alpha \sin^{-1}\sqrt{\frac{1}{\alpha}} + \sqrt{\alpha - 1}\right)}} \quad \ldots \quad (33a)$$

The function $\phi\left(\frac{V}{V_T}, \alpha\right)$ has been graphed for a set of values of $\alpha$ in Fig. 6(a) and the dotted curves in Fig. 7 show the relation between $V_a$ and $\alpha$ for this law.

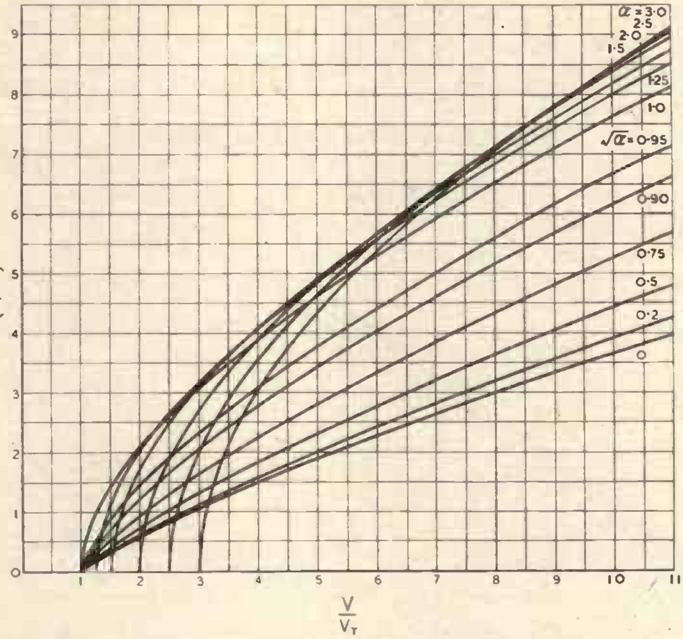


Fig. 6 (a). *Graphs of the function* $\phi\left(\frac{V}{V_T}, \alpha\right)$ *for a set of values of* $\alpha$. *For convenience when* $\alpha < 1$ *values of* $\sqrt{\alpha}$ *instead of* $\alpha$ *are given.*

## The Potential Minimum.—Case II

When $V_m < V_T$ the problem is more complex since electrons which receive large tangential velocity components at the screen fail to reach the anode, and, in consequence, over part of the field there are electrons moving against the main stream. We shall assume as before that the electron beam is broad and that the potential is constant over any section parallel to the anode. This being so it follows that the tangential velocity component of an electron which crosses the screen and is reflected back to it remains constant throughout the entire motion in the screen anode region. We shall also assume that reflected electrons remain within the main beam and contribute to the space charge density therein.

Consider first the fraction of the current which would cross a plane at potential $V_m$ and hence reach the anode.

If $v_t'$ is the tangential velocity acquired by an electron at the screen, then that electron will reach the anode provided $\frac{1}{2}mv_t'^2 < eV_m$ (this may be seen from the fact that the total speed of the electron at the plane $V_m$ is $\sqrt{\frac{2e}{m}.V_m}$, and if the tangential velocity component is less than this the electron must still possess forward motion).

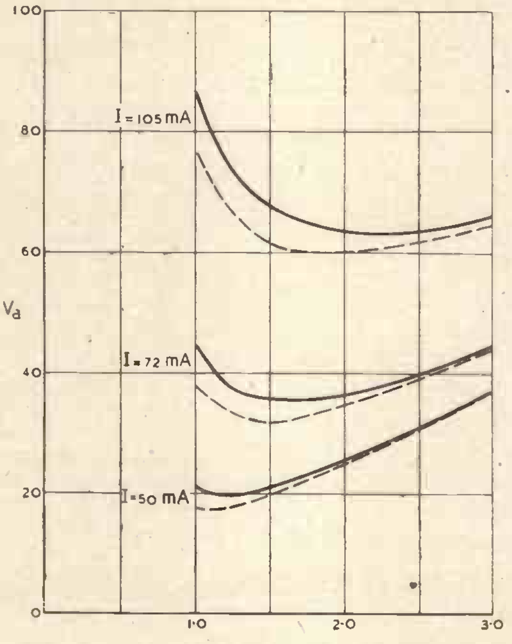


Fig. 7. *Curves relating $V_a$ and $\alpha$ (= $V_M/V_T$) for three values of current. The heavy lines refer to the "square" distribution law and the dotted lines to the "linear."*

Now according to the first distribution law, it is equally likely that the square of the tangential velocity of an electron lies anywhere between zero and $\frac{2e}{m}.V_T$, thus the fraction of the current consisting of electrons with tangential velocity squared less than $\frac{2e}{m}.V_m$ is simply $V_m/V_T$. Thus if $I$ is the current crossing the screen in the anode direction, the part reaching the anode is: $I_a = \frac{Vm}{V_T}.I$.

It can be shown by a similar argument that for the second tangential velocity distribution law: $I_a = \sqrt{\frac{V_m}{V_T}}.I$.

Thus for a given value of $V_m$ the current reaching the anode may at once be determined.

We shall now proceed to calculate $V_a$ given $I$ and $V_m$.

In Fig. 8, a rough sketch is given of the potential distribution between the screen and the anode. It will assist to treat the three regions separately.

In region 1 electrons whose normal velocity at any plane at potential $V$ lies between $\sqrt{\frac{2e}{m}.V}$ and $\sqrt{\frac{2e}{m}.(V - V_m)}$ appear once only, since they succeed in reaching the anode, whereas those electrons with normal velocity between $\sqrt{\frac{2e}{m}.(V - V_m)}$ and $\sqrt{\frac{2e}{m}.(V - V_T)}$ appear twice since they will be reflected in region 2.

The space charge density $\rho$ at this plane is therefore:

$$\rho = \int_0^{V_m/V_T} \frac{i\,.\,dx}{\sqrt{\frac{2e}{m}}\sqrt{V - xV_T}} + 2\int_{V_m/V_T}^{1} \frac{i\,.\,dx}{\sqrt{\frac{2e}{m}}\sqrt{V - xV_T}}$$

$$= 2\sqrt{\frac{m}{2e}}.\frac{I}{A}.\left[\frac{\sqrt{V}+\sqrt{V-V_m}-2\sqrt{V-V_T}}{V_T}\right] \quad \ldots \quad \ldots \quad (39)$$

In region 2 let us concentrate on a plane

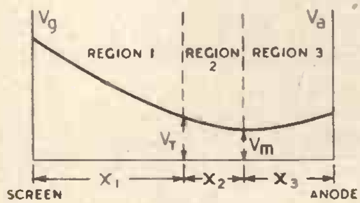


Fig. 8.

at potential $V$. As before, electrons whose normal velocity lies between $\sqrt{\frac{2e}{m}.V}$ and $\sqrt{\frac{2e}{m}.(V - V_m)}$ cross only once, those with normal velocity between $\sqrt{\frac{2e}{m}.(V - V_m)}$ and zero cross twice, and the remainder of the current crossing the screen fails to reach the plane. Consequently, we may express the space charge density at the plane $V$ as follows :

$$\rho = \int_0^{V_m/V_T} \frac{i\,.\,dx}{\sqrt{\frac{2e}{m}}\sqrt{V - xV_T}} + 2\int_{V_m/V_T}^{V/V_T} \frac{i\,.\,dx}{\sqrt{\frac{2e}{m}}\sqrt{V - xV_T}} = 2\sqrt{\frac{m}{2e}}\cdot\frac{I}{A}\cdot\left[\frac{\sqrt{V} + \sqrt{V - V_m}}{V_T}\right] \quad (40)$$

In region 3, there are only forward moving electrons, consequently :

$$\rho = \int_0^{V_m/V_T} \frac{i\,.\,dx}{\sqrt{\frac{2e}{m}}\sqrt{V - xV_T}} = 2\sqrt{\frac{m}{2e}}\cdot\frac{I}{A}\cdot\left[\frac{\sqrt{V} - \sqrt{V - V_m}}{V_T}\right] \quad \ldots \quad (41)$$

Poisson's equation in the three regions takes the forms :—

$$\text{Region 1 :} \quad \frac{d^2V}{dx^2} = 4\pi\,.\sqrt{\frac{m}{2e}}\cdot\frac{I}{A}\cdot 2\left[\frac{\sqrt{V} + \sqrt{V - V_m} - 2\sqrt{V - V_T}}{V_T}\right] \quad \ldots \quad (42)$$

$$\text{Region 2 :} \quad \frac{d^2V}{dx^2} = 4\pi\,.\sqrt{\frac{m}{2e}}\cdot\frac{I}{A}\cdot 2\left[\frac{\sqrt{V} + \sqrt{V - V_m}}{V_T}\right] \quad \ldots \quad (43)$$

$$\text{Region 3 :} \quad \frac{d^2V}{dx^2} = 4\pi\,.\sqrt{\frac{m}{2e}}\cdot\frac{I}{A}\cdot 2\left[\frac{\sqrt{V} - \sqrt{V - V_m}}{V_T}\right] \quad \ldots \quad (44)$$

Integrating each equation once, we have

$$\text{Region 1 :} \quad \tfrac{1}{2}\left(\frac{dV}{dx}\right)^2 = 4\pi\,.\sqrt{\frac{m}{2e}}\cdot\frac{I}{A}\cdot\frac{4}{3}\cdot\left[\frac{V^{3/2} + (V - V_m)^{3/2} - 2(V - V_T)^{3/2} + K_1}{V_T}\right] \quad (45)$$

$$\text{Region 2 :} \quad \tfrac{1}{2}\left(\frac{dV}{dx}\right)^2 = 4\pi\,.\sqrt{\frac{m}{2e}}\cdot\frac{I}{A}\cdot\frac{4}{3}\cdot\left[\frac{V^{3/2} + (V - V_m)^{3/2} + K_2}{V_T}\right] \quad \ldots \quad (46)$$

$$\text{Region 3 :} \quad \tfrac{1}{2}\left(\frac{dV}{dx}\right)^2 = 4\pi\,.\sqrt{\frac{m}{2e}}\cdot\frac{I}{A}\cdot\frac{4}{3}\cdot\left[\frac{V^{3/2} - (V - V_m)^{3/2} + K_3}{V_T}\right] \quad \ldots \quad (47)$$

To determine the integration constants $K_1$, $K_2$ and $K_3$ we may make use of the following facts :

1. That $dV/dx$ is continuous at the boundary between any two regions.
2. That $dV/dx = 0$ when $V = V_m$

Whence : $K_1 = K_2 = K_3 = -V_m{}^{3/2}$

Rearranging the equations and integrating, we get :

$$\int_{V_T}^{V_g} \frac{dV}{\sqrt{\dfrac{V^{3/2} + (V - V_m)^{3/2} - 2(V - V_T)^{3/2} - V_m{}^{3/2}}{V_T}}} = \sqrt{\frac{32}{3}\,.\,\pi\,.\sqrt{\frac{m}{2e}}\cdot\frac{I}{A}}\cdot x_1 \quad \ldots \quad (48)$$

$$\int_{V_m}^{V_T} \frac{dV}{\sqrt{\dfrac{V^{3/2} + (V - V_m)^{3/2} - V_m{}^{3/2}}{V_T}}} = \sqrt{\frac{32}{3}\,.\,\pi\,.\sqrt{\frac{m}{2e}}\cdot\frac{I}{A}}\cdot x_2 \quad \ldots \quad (49)$$

$$\int_{V_m}^{V_a} \frac{dV}{\sqrt{\dfrac{V^{3/2} - (V - V_m)^{3/2} - V_m{}^{3/2}}{V_T}}} = \sqrt{\frac{32}{3}\,.\,\pi\,.\sqrt{\frac{m}{2e}}\cdot\frac{I}{A}}\cdot x_3 \quad \ldots \quad (50)$$

where: $x_1$ is the extent of region 1.
$x_2$ is the extent of region 2.
$x_3$ is the extent of region 3.

Equation (50) may be rewritten:

$$V_T^{1/2} . V_m^{1/4} . f\left(\frac{V_a}{V_m}\right) = \sqrt{\frac{32}{3}} . \pi . \sqrt{\frac{m}{2e}} . \frac{I}{A} . x_3 \qquad .. \quad .. \quad (51)$$

where $f\left(\frac{V_a}{V_m}\right)$ is the function already defined in Part I.

Equation (49) may be rewritten

$$V_T^{3/4} . f_1\left(\frac{V_m}{V_T}\right) = \sqrt{\frac{32}{3}} . \pi . \sqrt{\frac{m}{2e}} . \frac{I}{A} . \quad x_2$$

Where: .. .. (52)

$$f_1\left(\frac{V_m}{V_T}\right) = \left(\frac{V_m}{V_T}\right)^{1/4} \int_{V_m/V_T}^{1} \frac{d\gamma}{\gamma^{5/4}\sqrt{1 + (1-\gamma)^{3/2} - \gamma^{3/2}}} \qquad .. \quad .. \quad (53)$$

This function has been graphed in Fig. 9.

The integral to the left of (54) may be used to define the function $f\left(\frac{V_g}{V_T}, \alpha\right)$ for values of $\alpha < 1$. It has been evaluated for a set of values of $\alpha$ [see lower curves Fig. 6].

It follows therefore that:

$$x_1 = 0.0444 . \sqrt{\frac{A}{I}} . V_T^{3/4} . f\left(\frac{V_g}{V_T}, \alpha\right) \qquad (55)$$

$$x_2 = 0.0444 . \sqrt{\frac{A}{I}} . V_T^{3/4} . f_1\left(\frac{V_m}{V_T}\right) \qquad (56)$$

$$x_3 = 0.0444 . \sqrt{\frac{A}{I}} . V_T^{3/4} . \alpha^{1/4} . f\left(\frac{V_a}{V_m}\right) \qquad (57)$$

where: distances $x_1$, $x_2$, $x_3$ are in mm.,
currents are in mA,
potentials are in volts.

These equations together with the relation:

$$I_a = \frac{V_m}{V_T} . I \qquad .. \quad .. \quad .. \quad (37)$$

are enough to determine the anode current

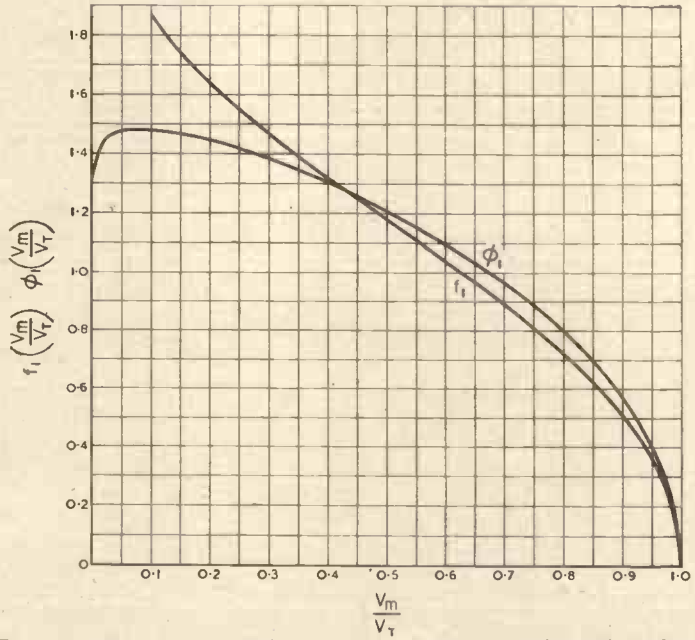


Fig. 9. *Graphs of the functions $f_1 (V_M/V_T)$ and $\phi_1 (V_M/V_T)$.*

The integral in equation (48) is more difficult to deal with. Making the substitution $\gamma = V/V_T$, there results:

$$V_T^{3/4} \int_1^{V_g/V_T} \frac{d\gamma}{\sqrt{\gamma^{3/2} + (\gamma-\alpha)^{3/2} - 2(\gamma-1)^{3/2} - \alpha^{3/2}}}$$

$$= \sqrt{\frac{32}{3}} . \pi . \sqrt{\frac{m}{2e}} . \frac{I}{A} . \quad x_1 \qquad (54)$$

and anode voltage corresponding to values of $V_m$ less than $V_T$.

$x_1$ and $x_2$ may be determined from (55) and (56) (obtaining the appropriate values of $f\left(\frac{V_g}{V_T}, \alpha\right)$ and $f_1\left(\frac{V_m}{V_T}\right)$ from the graphs).

From the relation $x_{2a} = x_1 + x_2 + x_3$ the distance $x_3$ may be found, and hence by (57) the value of $f\left(\frac{V_a}{V_m}\right)$. From the graph of this function the ratio $V_a/V_m$ may be determined and hence $V_a$.

A curve has been drawn (Fig. 10) relating $\alpha$ and $V_a$ on the assumption that, throughout, the current crossing the screen was constant. Since $I_a$ is proportional to $\alpha$ this curve also gives the relation between $I_a$ and $V_a$.

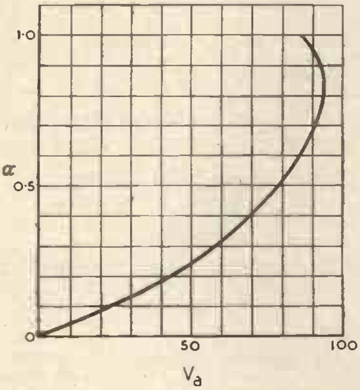


Fig. 10.

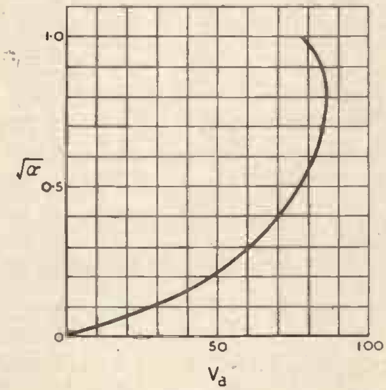


Fig. 10(a).

*Fig. 10. Curves relating $V_a$ and $\alpha$ for the "square" law when $\alpha < 1$. Throughout it is assumed that the current crossing the screen in the anode direction is fixed at 105 mA. The curve also gives the relation between $I_a$ and $V_a$ since here $I_a$ is proportional to $\alpha$.*

*Fig. 10(a). Curve relating $V_a$ and $\sqrt{\alpha}$ for the linear law when $I \times 105$ mA. In this case $I_a$ is proportional to $\sqrt{\alpha}$.*

A similar chain of reasoning may be gone through for the linear tangential velocity distribution law.

In place of equations (39), (40) and (41) we now have:

$$\rho_1 = \int_0^{\sqrt{V_m/V_T}} \frac{i \,.\, dx}{\sqrt{\frac{2e}{m}\left(V - x^2 V_T\right)}} + 2\int_{\sqrt{V_m/V_T}}^{1} \frac{i \,.\, dx}{\sqrt{\frac{2e}{m}\left(V - x^2 V_T\right)}} = \frac{I}{A}\cdot\sqrt{\frac{m}{2e}}\cdot\frac{1}{\sqrt{V_T}}\cdot\left[2\sin^{-1}\sqrt{\frac{V_T}{V}} - \sin^{-1}\sqrt{\frac{V_m}{V}}\right] \quad \text{(39a)}$$

$$\rho_2 = \int_0^{\sqrt{V_m/V_T}} \frac{i \,.\, dx}{\sqrt{\frac{2e}{m}\left(V - x^2 V_T\right)}} + 2\int_{\sqrt{V_m/V_T}}^{\sqrt{V/V_T}} \frac{i \,.\, dx}{\sqrt{\frac{2e}{m}\left(V - x^2 V_T\right)}} = \frac{I}{A}\cdot\sqrt{\frac{m}{2e}}\cdot\frac{1}{\sqrt{V_T}}\cdot\left[\pi - \sin^{-1}\sqrt{\frac{V_m}{V}}\right] \quad \text{(40a)}$$

$$\rho_3 = \int_0^{\sqrt{V_m/V_T}} \frac{i \,.\, dx}{\sqrt{\frac{2e}{m}\left(V - x^2 V_T\right)}} = \frac{I}{A}\cdot\sqrt{\frac{m}{2e}}\cdot\frac{1}{\sqrt{V_T}}\cdot\sin^{-1}\sqrt{\frac{V_m}{V}} \quad \text{(41a)}$$

Poisson's equation now takes the forms:

$$\text{Region 1:}\quad \frac{d^2V}{dx^2} = 4\pi\cdot\frac{I}{A}\cdot\sqrt{\frac{m}{2e}}\cdot\frac{1}{\sqrt{V_T}}\cdot\left[2\sin^{-1}\sqrt{\frac{V_T}{V}} - \sin^{-1}\sqrt{\frac{V_m}{V}}\right] \quad \text{(42a)}$$

$$\text{Region 2:}\quad \frac{d^2V}{dx^2} = 4\pi\cdot\frac{I}{A}\cdot\sqrt{\frac{m}{2e}}\cdot\frac{1}{\sqrt{V_T}}\cdot\left[\pi - \sin^{-1}\sqrt{\frac{V_m}{V}}\right] \quad \text{(43a)}$$

$$\text{Region 3:}\quad \frac{d^2V}{dx^2} = 4\pi\cdot\frac{I}{A}\cdot\sqrt{\frac{m}{2e}}\cdot\frac{1}{\sqrt{V_T}}\cdot\left[\sin^{-1}\sqrt{\frac{V_m}{V}}\right] \quad \text{(44a)}$$

By integrating (42a), (43a) and (44a), and noting that:

$$\int \sin^{-1}\sqrt{\frac{V_T}{V}}\,.\,dV = V\cdot\left[\sin^{-1}\sqrt{\frac{V_T}{V}} + \sqrt{\frac{V_T}{V}}\sqrt{1 - \frac{V_T}{V}}\right]$$

expressions similar to (45), (46) and (47) may be obtained and integration constants defined as before. A further rearrangement and integration provides the results :

$$\frac{2}{\sqrt{3}}\int_{V_T}^{V_g} \frac{V_T^{1/4}\,.\,dV}{V^{1/2}\sqrt{2\left(\sin^{-1}\sqrt{\frac{V_T}{V}}+\sqrt{\frac{V_T}{V}}\sqrt{1-\frac{V_T}{V}}\right)-\left(\sin^{-1}\sqrt{\frac{V_m}{V}}+\sqrt{\frac{V_m}{V}}\sqrt{1-\frac{V_m}{V}}\right)-\frac{\pi}{2}\,.\,\frac{V_m}{V}}}$$

$$=\sqrt{\frac{32}{3}\,.\,\pi\,.\,\sqrt{\frac{m}{2e}}\,.\,\frac{I}{A}}\,.\;x_1 \quad \ldots \quad (48a)$$

$$\frac{2}{\sqrt{3}}\int_{V_m}^{V_T} \frac{V_T^{1/4}\,.\,dV}{V^{1/2}\sqrt{\pi-\left(\sin^{-1}\sqrt{\frac{V_m}{V}}+\sqrt{\frac{V_m}{V}}\sqrt{1-\frac{V_m}{V}}\right)-\frac{\pi}{2}\,.\,\frac{V_m}{V}}}=\sqrt{\frac{32}{3}\,.\,\pi\,.\,\sqrt{\frac{m}{2e}}\,.\,\frac{I}{A}}\,.\;x_2 \quad \ldots \quad (49a)$$

$$\frac{2}{\sqrt{3}}\int_{V_m}^{V_a} \frac{V_T^{1/4}\,.\,dV}{V^{1/2}\sqrt{\sin^{-1}\sqrt{\frac{V_m}{V}}+\sqrt{\frac{V_m}{V}}\sqrt{1-\frac{V_m}{V}}-\frac{\pi}{2}\,.\,\frac{V_m}{V}}}=\sqrt{\frac{32}{3}\,.\,\pi\,.\,\sqrt{\frac{m}{2e}}\,.\,\frac{I}{A}}\,.\;x_3 \quad \ldots \quad (50a)$$

Equation (50a) may be rewritten : $V_T^{1/4}\,.\,V_m^{1/2}\,.\,\phi\left(\frac{V_a}{V_m}\right)=\sqrt{\frac{32}{3}\,.\,\pi\,.\,\sqrt{\frac{m}{2e}}\,.\,\frac{I}{A}}\,.\;x_3$ (51a)

where $\phi\left(\frac{V_a}{V_m}\right)$ is the function already met in Part I.

Equation (49a) may be rewritten

$$V_T^{3/4}\,.\,\phi_1\left(\frac{V_m}{V_T}\right)=\sqrt{\frac{32}{3}\,.\,\pi\,.\,\sqrt{\frac{m}{2e}}\,.\,\frac{I}{A}}\,.\;x_2 \quad \ldots \quad (52a)$$

where :

$$\phi_1\left(\frac{V_m}{V_T}\right)=\frac{4}{\sqrt{3}}\left(\frac{V_m}{V_T}\right)^{1/2}\int_{\sqrt{V_m/V_T}}^{1}\frac{d\gamma}{\gamma^2\sqrt{\pi-\sin^{-1}\gamma-\gamma\sqrt{1-\gamma^2}-\frac{\pi}{2}\,.\gamma^2}} \quad \ldots \quad (53a)$$

This function has been graphed in Fig. 9.

The integral in (48a) has been dealt with in the same fashion as the integral

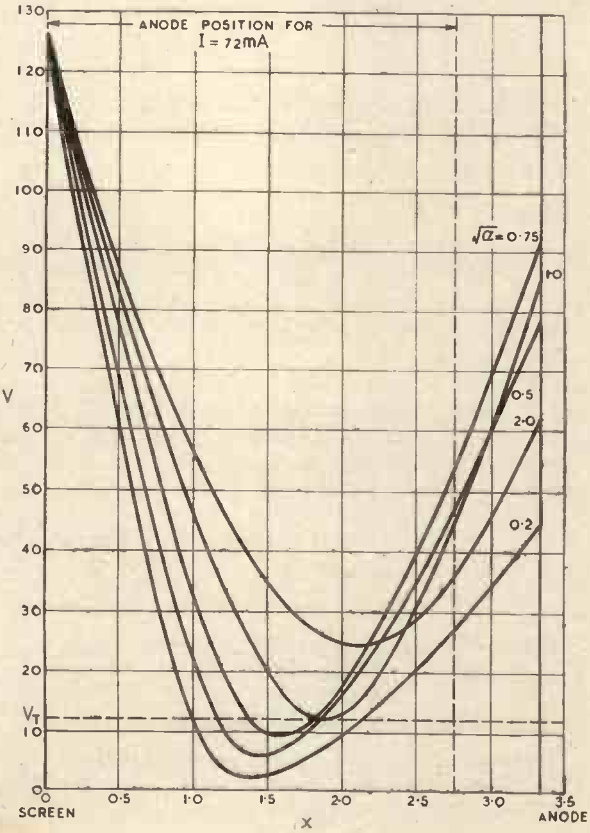


Fig. 11. *Potential distributions between the screen and anode for the "square" velocity distribution law.*

in (48), so that (48a) may be rewritten :

$$V_T^{3/4} \cdot \phi\left(\frac{V_g}{V_T}, \alpha\right) = \sqrt{\frac{32}{3}} \cdot \pi \cdot \sqrt{\frac{m}{2e}} \cdot \frac{I}{A} \cdot x_1 \qquad (54a)$$

where :

$$\phi\left(\frac{V_g}{V_T}, \alpha\right) = \frac{2}{\sqrt{3}} \int_1^{\sqrt{V_g/V_T}} \frac{d\gamma}{\sqrt{2\left(\gamma \cdot \sin^{-1}\sqrt{\frac{1}{\gamma}} + \sqrt{\gamma - 1}\right) - \left(\gamma \sin^{-1}\sqrt{\frac{\alpha}{\gamma}} + \sqrt{\alpha(\gamma - \alpha)}\right) - \frac{\pi}{2} \cdot \alpha}}$$

This defines $\phi\left(\frac{V_g}{V_T}, \alpha\right)$ for values of $\alpha < 1$. The function has been evaluated for a set of values of $\sqrt{\alpha}$ (*see* graphs Fig. 6(a)). This is more convenient, since the anode current is now proportional to $\sqrt{\alpha}$.

Thus, to correspond with equations (55), (56) and (57) we now have :

$$x_1 = 0.0444 \cdot \sqrt{\frac{A}{I}} \cdot V_T^{3/4} \cdot \phi\left(\frac{V_g}{V_T}, \alpha\right) \quad \ldots \quad (55a)$$

$$x_2 = 0.0444 \cdot \sqrt{\frac{A}{I}} \cdot V_T^{3/4} \cdot \phi_1\left(\frac{V_m}{V_T}\right) \quad (56a)$$

$$x_3 = 0.0444 \cdot \sqrt{\frac{A}{I}} \cdot V_T^{3/4} \cdot \alpha^{1/2} \cdot \phi\left(\frac{V_a}{V_m}\right) \quad \ldots \quad (57a)$$

It should be noted that the $\phi$ functions play the same rôle as the $f$ functions, the only difference in the sets of equations (55), (56) & (57) and (55a), (56a), & (57a) being in equation (57a) where $\alpha$ now appears to the power $\frac{1}{2}$ instead of to the power $\frac{1}{4}$. Since $I_a = \sqrt{\frac{V_m}{V_T}} \cdot I$, we give the relation between $\sqrt{\frac{V_m}{V_T}}$ and $V_a$ in Fig. 10(a), since in terms of anode current this curve has the same significance as the one in Fig. 10.

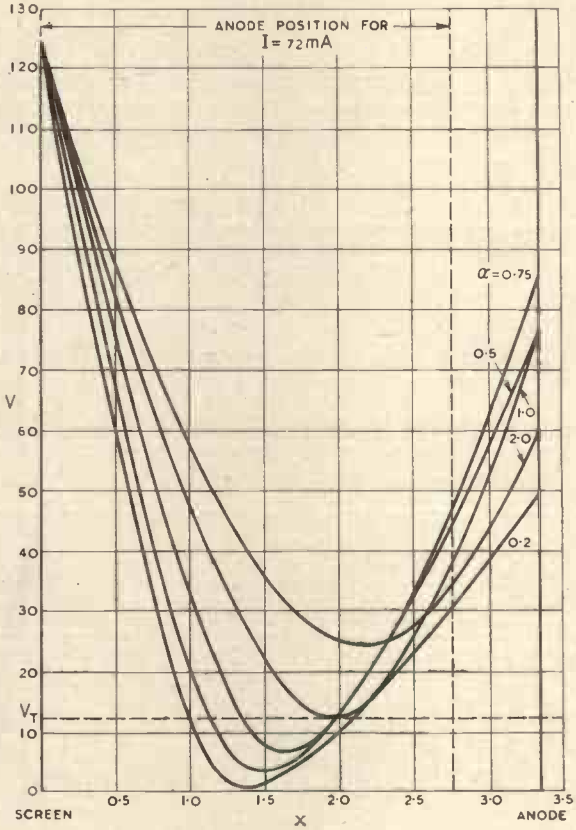


Fig. 11(a). *Potential distributions between the screen and anode for the "linear" velocity distribution law.*

## The Potential Distribution

A few curves showing the potential distribution between the screen and anode for different values of the potential minimum are drawn in Figs. 11 and 11(a). In the former the "square" tangential velocity distribution law is used and in the latter the linear. Both figures refer to valve (2) and throughout it is assumed that the current crossing the screen in the anode direction is 105 mA.

The horizontal dotted line marks the potential value $V_T$ and the second highest curve which touches this line illustrates the potential distribution for the critical case in which the potential minimum has the value $V_T$. To prepare this curve we first find the position of the potential minimum from equation (20) and then make use of (18).

For the highest curve, representing a

potential minimum greater than $V_T$ an identical procedure is adopted, this time using equation (34).

The lower curves which are not symmetrical about the potential minimum are a little more difficult, for it is necessary to treat separately the three regions referred to earlier. The extents of the regions are given in equations (55) (56) and (57) by which we can find $x_1$, $x_2$ and $x_3$ as before.

To relate potential and distance throughout these regions we may write :

$$\text{Region I}: \quad x = x_1 - 0.0444 \cdot \sqrt{\frac{A}{I}} \cdot V_T^{3/4} \cdot f\left(\frac{V}{V_T}, \alpha\right) \quad \ldots \quad (58)$$

$$\text{Region II}: \quad x = x_1 + x_2 - 0.0444 \cdot \sqrt{\frac{A}{I}} \cdot V_T^{3/4} \cdot \left(\frac{V}{V_T}\right)^{1/4} \cdot f_1\left(\frac{V_m}{V}\right) \quad \ldots \quad (59)$$

$$\text{Region III}: \quad x = x_1 + x_2 + 0.0444 \cdot \sqrt{\frac{A}{I}} \cdot V_T^{3/4} \cdot \alpha^{1/4} \cdot f\left(\frac{V}{V_m}\right) \quad \ldots \quad (60)$$

with corresponding relations for the linear law.

(*Note.*—In the above form all distances are measured from the screen.)

As was mentioned above, all the curves are drawn on the assumption that $I$, the current passing the screen in the anode direction, is 105 mA, and that the distance from anode to screen is 3.34 mm., but from the fact that all distances are proportional to $1/\sqrt{I}$ it follows that we may use those curves to illustrate potential distributions at different values of $I$ merely by changing the distance scale by the ratio $\sqrt{\frac{I_1}{I}}$ where $I_1$ is the new current value. Pictorially the curves remain unchanged and the anode is moved to the left or right according to a decrease or increase in $I$. The vertical dotted line marks the anode position when $I = 72$ mA. The method breaks down for values of $I$ so small that the anode lies on the screen side of the potential minimum $V_T$. A change in the

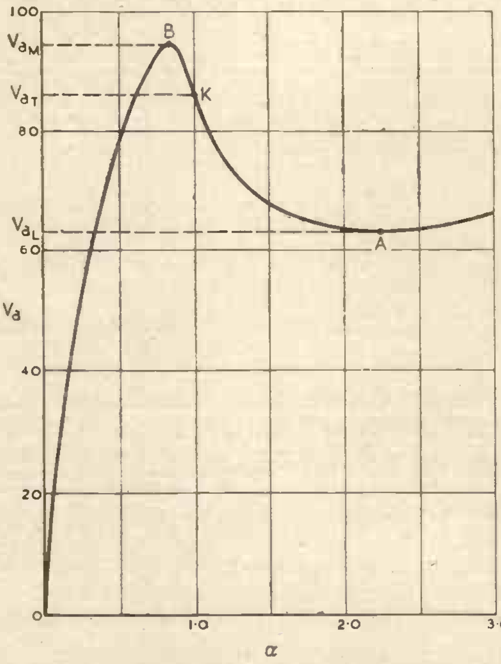


Fig. 12. *Relation between $V_a$ and $\alpha$ for the "square" velocity distribution law, when $I = 105\,mA$.*

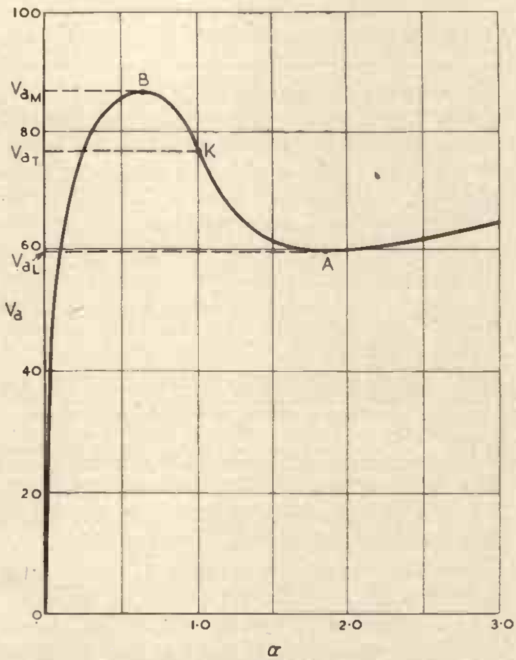


Fig. 12(a). *Relation between $V_a$ and $\alpha$ for the "linear" velocity distribution law when $I = 105\,mA$.*

actual spacing from screen to anode can be appreciated on the graph without a change of the $x$ scale.

### The Instability Phenomenon

Let us combine in one graph the relation between $V_a$ and $V_m$ for $V_m > V_T$ and $V_m < V_T$. For valve (2) with $I$ held at 105 mA there results the curve in Fig. 12, where the "square" tangential velocity distribution law has been assumed.

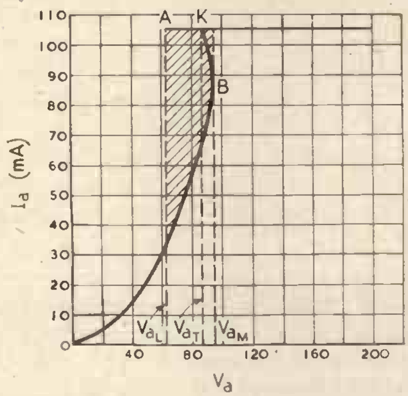


Fig. 13. *The relation between $V_a$ and $I_a$ for the "square" velocity distribution law deduced from Fig. 12. The shaded part marks the region in which the valve is unstable.*

The point $K$ marks the value of $V_a$ and $V_m$ at which a reflection of electrons back to the grid commences.

For all values of $V_m$ to the right of $K$ the anode current has the fixed value $I$, that is, all electrons which cross the screen reach the anode. To the left of $K$ the anode current is given by the relation :

$$I_a = \frac{V_m}{V_T} . I$$

and so we are able to plot the relation between $V_a$ and $I_a$. This has been done in Fig. 13. In both Figs. 12 and 13, $V_{a_T}$ is the anode voltage at which the potential minimum is $V_T$.

$V_{a_L}$ is the lowest anode voltage at which the total current $I$ can reach the anode.

$V_{a_M}$ is the greatest anode voltage at which electrons can be returned to the screen.

For values of $V_a$ between $V_{a_L}$ and $V_{a_T}$ there are three possible potential distributions in the screen anode region. In two of these the potential minimum has a value greater than $V_T$, whereas in the third the potential minimum is less than $V_T$. A change between the first two distributions would have no effect on the anode current, but a change to the third would be accompanied by a return of electrons to the screen.

When $V_a$ lies between $V_{a_T}$ and $V_{a_M}$ there are again three possible potential distributions, but this time two are with $V_m < V_T$ involving different values of anode current, and in the third $V_m$ is greater than $V_T$.

In this we have an explanation for the well-known discontinuity which is sometimes to be observed at the knee in the $I_a - V_a$ characteristic curve of a beam tetrode when the curve is traced on a cathode-ray tube by the method referred to earlier.

For an anode voltage less than $V_{a_L}$ or greater than $V_{a_M}$ there is a unique value for the anode current, but in the intervening region a sudden vertical jump can occur.

The shaded region in Fig. 13 is, therefore, to be regarded as unstable. Corresponding curves for the "linear" tangential velocity distribution law are given in Figs. 12 (a) and 13 (a). It is clear that the effects referred to are not peculiar to any particular velocity distribution.

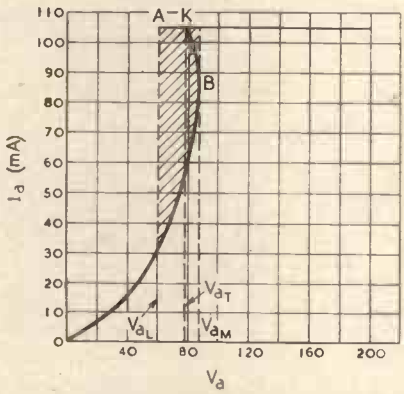


Fig. 13(a). *The instability effect as decuced from "linear" velocity distribution law.*

It might be argued (*cf.* George Jaffe, "On the Current Carried by Electrons of Uniform Initial Velocity," *Physical Review*, February 1944, Vol. 55, Nos. 3 and 4, Page 91), that the distribution in which the potential in the field is highest is the most stable in that work must be done in changing to a lower potential distribution, but a satisfactory answer to this question can only be obtained by studying time variations in the field which is beyond the scope of this paper.

(*To be concluded*).

# A SQUARE-WAVE ANALYSER*

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## 1. Introduction

IT is well known that a linear network is completely defined by its response to a Heaviside unit step (Fig. 1) and that a sufficient approximation to the step response can in many cases be conveniently obtained experimentally by the use of a square wave of suitable frequency.

The experimental procedure for testing a network is to interpose it between a source of square waves and a cathode-ray tube oscillograph, and to observe or photograph the resulting waveform. Up to this point the procedure is simple and convenient, but it is no more possible to express the result merely by a record of the trace, than it is to describe the physical appearance of an object merely by a photograph. All the information necessary is contained in the photograph, but for descriptive purposes certain measurements must be made, which can specify the object in the absence of the photograph. For the sake of compactness the number of these measurements must be kept small, but naturally at the cost of exactness.

The reduction of a complicated affair to a few descriptive numbers is, of course, very familiar; thus for the purpose of buying a shirt the size of a man is the diameter of his neck and, sometimes, the length of his arms. No doubt a better fit would result if more figures were used, but the number of sizes that would have to be made and stocked would be enormously increased. It is the same with the matter in hand: the number of figures must be kept small, or in subsequent handling they will become quite unmanageable.

For the purpose of obtaining such descriptive numbers the experimental procedure outlined above is not at all convenient or accurate: it is difficult to make direct measurements on the screen of a cathode-ray tube, and it takes a long time to take photographs or tracings, and measure them. It therefore seems logical to look for an instrument that will give directly the descriptive numbers, as a substitute for, or as a supplement to, the oscillograph. In effect this means some type of voltmeter, and several considerations suggest the peak voltmeter. It is the most convenient form of voltmeter at high frequencies, and its readings will be associated with definite points on the waveform.

Now, with the peak voltmeter in mind, consider the probable shape of the waveform to be analysed. The application of a unit step could theoretically result in any shape, however irregular, if the network is quite unspecified, but the practical interest is normally in networks and amplifiers whose response is a recognisable approximation to a unit step. In such networks it is usually possible to distinguish between two types of distortion associated respectively with the steep rise and the long flat. In the whole of this discussion only the distortion of the rise is considered; the network is assumed to be capable of "holding" the long flat indefinitely. Taking the response of Fig. 2 as typical, the most important number should give a measure of the time taken to pass from the initial to the final state. This might be taken as the time from, say, 5 per cent. to 95 per cent. of the final value. Such a definition is not, however, very satisfactory for our purpose: the percentages to be used are open to argument, and the definition does not fit easily with either measurement or calculation. A better definition is the time from the initial to the final state, supposing that the slope were constant and equal to the maximum slope of the actual curve. This is the time "$t_1$" shown in Fig. 2. There is some hope of calculating this time for simple networks, and it clearly fits in with the peak voltmeter for measurement if a differentiating network is interposed.

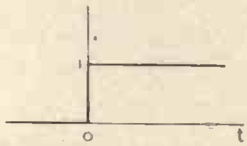



Fig. 1.
*Heaviside unit step.*

For the actual descriptive figure it is

* MS. accepted by the Editor, January, 1945.

more convenient to take the reciprocal of $t_1$, and in what follows this figure is referred to as the speed of the network and is designated by the symbol $s$. This term is not, however, entirely satisfactory, as speed suggests distance divided by time, and our figure is simply the reciprocal of a time.

It is practicable to allow a second descriptive figure, but most inadvisable to have more than two. This second figure could be used to measure the time before the response becomes appreciable—the delay time which has a physical significance in transmission lines in the time of transmission. However, for a large class of practical cases this delay time has no interest, and can be neglected.

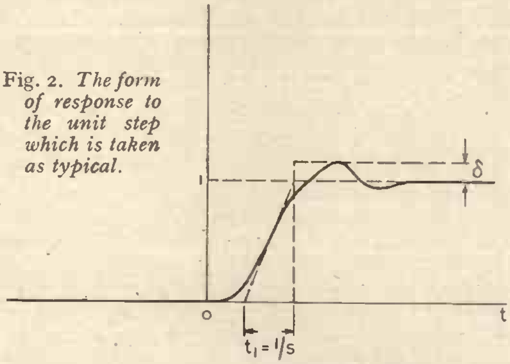



Fig. 2. *The form of response to the unit step which is taken as typical.*

A point of greater practical interest is that superimposed on a fairly smooth transition between the initial and final values is some form of damped oscillation. The second descriptive figure should give a measure of this oscillation. Strictly speaking, at least three figures are required for this purpose, to describe the amplitude frequency and decay of the oscillation, but that is two figures more than we are permitting ourselves. It seems reasonable to allocate the figure to the amplitude of the oscillation, and inspecting the curve, a convenient measure is the amount by which the curve rises above the final value. This is the distance " δ " indicated on Fig. 2, and in the following is referred to as the overshoot and measured as a percentage of the final value. It is readily measured by the peak voltmeter.

The discussion so far has led to the response of the network being defined by two descriptive figures, the speed and the overshoot. These particular figures happen to have the merit of being directly measurable, but apart from that, with only two figures permitted, they are the ones that would probably be chosen.

Before proceeding to describe an instrument for measuring these figures, it is as well to consider their use when obtained. Consider as an example the problem of designing a video-frequency amplifier. This might consist of a number of pentode valves with resistive loads. Then the speed as defined above will be limited by the inevitable capacitances across the loads, but there will be no overshoot. It is well known that the speed can be increased by various artifices which at the same time introduce in general an overshoot. It is unusual to find such an amplifier without this " compensation," and the practical design problem centres round it. It is, therefore, necessary to have a working criterion to compare different methods of compensation, and decide on the choice, as well as to be able to summarise the final performance. This example shows clearly the necessity of limiting the number of descriptive figures. For instance, two amplifiers might have equal gain and equal overshoot ; then the one with the higher speed is the better. If, however, more descriptive figures were used, in general only one figure could be made the same for each amplifier, and to come to a decision it would be necessary to assign a relative importance to the remaining unequal figures. A similar state of affairs is found in the rating of distortion in power valves. The distortion can be given as " total harmonic content," a single figure, or it can be expressed as so much second harmonic, third harmonic, etc. If the latter method is used, then no comparison is possible unless the relative importance of the various harmonics is known, which is a matter for an artist rather than an engineer.

While only networks energised by a unit step have been discussed, it is clear that the whole argument also applies to a chain containing a detector, where the input is sinusoidal and the envelopes of the input and output waveforms are taken in place of the waveforms considered.

## 2. General Principles of the Analyser

The general principles of an instrument to measure the speed and overshoot are quite simple. Thus consider a valve whose anode resistance is much higher than the load impedance and whose grid is energised with the waveform of Fig. 2. In the anode can be switched one of three impedances, resistance $R$ with parallel capacitance $C$, resistance

$R$, or inductance $L$ (Fig. 3). The anode current will be a replica of the input voltage. With the switch in position 1, if $C$ is very large, it is clear that the reading of the peak voltmeter is proportional to $R$ times the final input voltage. In position 2 the reading is proportional to $R$ times the greatest input voltage. In position 3, the reading is proportional to $L$ times the greatest slope of the input voltage. The speed and overshoot are thus determined by the three readings and the values of $L$ and $R$ in a simple way.

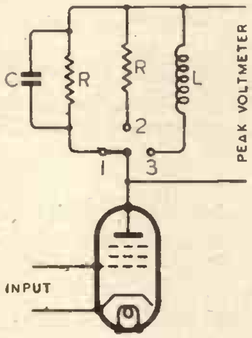



Fig. 3.
*The analysing circuit.*

Now consider the case where the waveform to be analysed is repetitive, and is of the form of the input waveform of Fig. 4. This waveform is balanced about the reference line. The voltages delivered to the peak voltmeter in switch positions 1, 2, 3 will then be approximately as shown in Fig. 4, balanced about their reference lines. The peak voltmeter (assumed perfect) will measure the greatest excursion from the reference lines, and will thus measure the voltages indicated on Fig. 4, i.e. $V_1$ in switch position 1, $V_2$ in switch position 2, and $V_3$ in switch position 3.

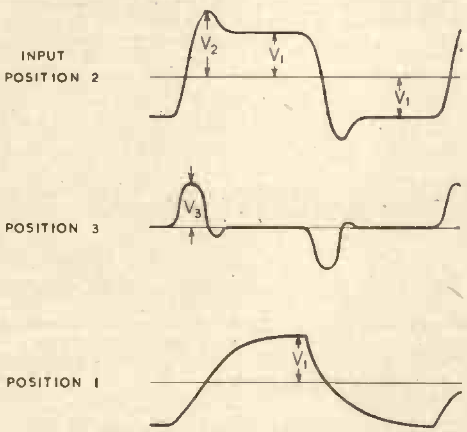



Fig. 4. *The waveform at various parts of the analysing circuit.*

The horizontal reference axis of Fig. 4 is shifted compared to the reference axis of Fig. 2, and as the speed and overshoot have been defined on the basis of Fig. 2, a factor 2 will appear in the equations for speed and overshoot in terms of $V_1$, $V_2$, $V_3$.

Thus comparing Figs. 2 and 4 (position 2):

$$1 + \delta = \frac{V_1 + V_2}{2V_1}$$

$$\text{i.e. overshoot} = \delta = \tfrac{1}{2}\,\frac{V_2 - V_1}{V_1} \qquad \ldots \quad (1)$$

$$\text{Also} \qquad \frac{V_1}{R} = \frac{V_3}{L.2/t_1}$$

$$\text{i.e.} \qquad \text{speed} = 1/t_1 = \tfrac{1}{2}\,\frac{R}{L}\,\frac{V_3}{V_1} \qquad (2)$$

If an amplitude control is introduced to bring $V_1$ to a standard reading, $V_3$ and $V_2$ give the speed and overshoot. Thus a direct reading instrument is obtained, and various speed ranges are covered by switching in appropriate values of inductance.

In the instrument to be described the valve mentioned is a ten-watt pentode followed by a conventional peak voltmeter consisting of a diode followed by a D.C. amplifier. Gain control is by a variable feed-back resistance in the cathode of the pentode. Before going into details it is as well to discuss whether such practical circuits can approximate sufficiently closely to the foregoing simple calculations.

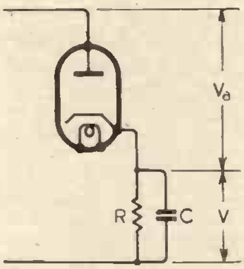



Fig. 5.
*The diode circuit.*

There are two main possibilities of error. The first is in the "leakage error" of the peak voltmeter which is required to measure the amplitude of pulses whose duration is short compared with the period time. The second is in the differentiating circuit, since there must be stray capacitance across the inductance. These two effects will be considered in the next two sections.

## 3. Errors in the Peak Voltmeter

In this section the voltmeter is taken as a diode connected as in Fig. 5. Consider first the input waveform shown in Fig. 6, an idealisation appropriate for the speed measurement. The diode can be represented accurately for low currents by the equation.

$$i_a = Ae^{aV_a} \qquad \ldots \quad \ldots \quad \ldots \quad (3)$$

This well known result was checked for the diodes used, and was accurate for currents up to 100$\mu$A, a typical experimental curve being shown in Fig. 10. The value of the exponent $a$ is 10.

Assume that $C$ is so large that the variation of $V$ over a cycle is very small compared to $V$.

When there is no applied voltage, $V$ will have a quiescent value $V_0$.

Define the efficiency as $\eta = \frac{V - V_0}{E}$

and write $\eta = 1 - d$.

The steady state condition is that the integral of the current flowing into the capacitance $C$ over the period shall be zero.

That is $\int \left(i_a - \frac{V}{R}\right) dt = 0$

Now it is justifiable to neglect the contribution of the $i_a$ term in this integral except during the time $t_1$.

Thus $t_1 \, . \, Ae^{a(E-V)} = (t_1 + t_2)\frac{V}{R}$

or $$Ve^{aV} = AR\frac{t_1}{t_1 + t_2}e^{aE} \quad .. \quad (4)$$

And $V_0$ is given by

$$V_0 e^{aV_0} = AR$$

Dividing the last two equations :—

$$\frac{V}{V_0} = \frac{t_1}{t_1 + t_2}e^{a(E - V + V_0)} \quad .. \quad .. \quad (5)$$

Equation (5) can be solved for $V$ approximately in an explicit form, if the efficiency is nearly unity, i.e., $d$ is small.

Making the substitutions

$$E - V + V_0 = dE$$

$$\frac{V}{V_0} = 1 + \frac{E}{V_0}(1 - d)$$

equation (5) becomes

$$adE = ln\frac{t_1 + t_2}{t_1} + ln\left[1 + \frac{E}{V_0}(1 - d)\right]$$

$$= ln\frac{t_1 + t_2}{t_1} + ln\left(1 + \frac{E}{V_0}\right)\left(1 - \frac{dE}{E + V_0}\right)$$

$$= ln\frac{t_1 + t_2}{t_1} + ln\left(1 + \frac{E}{V_0}\right) - \frac{dE}{E + V_0}$$

approximately, since this last term is small, $d$ being small.

Thus
$$dE = \frac{ln\frac{t_1 + t_2}{t_1} + ln\left(1 + \frac{E}{V_0}\right)}{a + \frac{1}{E + V_0}} \quad .. \quad (6)$$

For $\frac{t_2}{t_1} \gg 1$ and $\gg \frac{E}{V_0}$, and $E$ greater than a few volts, ($V_0$ is of the order of 1 volt), equation (6) is very approximately

$$dE = \frac{1}{a} ln\frac{t_2}{t_1} \quad .. \quad .. \quad .. \quad (7)$$

Now $dE$ is the amount by which the voltmeter indication fails to reach the peak $E$. Equation (7) shows that very approximately this difference depends only on $\frac{t_2}{t_1}$ and is independent of $E$.

It is often convenient to calibrate voltmeters with a sinusoidal waveform, so the efficiency with a sinusoidal input waveform will now be calculated.

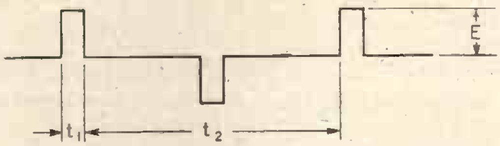



Fig. 6. *Idealised waveform for the calculation of voltmeter errors in the speed measurement.*

Taking the input as $E \sin \omega t$, the integral equation is now

$$\int_0^{\frac{2\pi}{\omega}} \left[Ae^{a(E \sin \omega t - V)} - \frac{V}{R}\right] dt = 0$$

$$\frac{2\pi}{\omega} \cdot \frac{V}{R} = Ae^{-aV}\int_0^{\frac{2\pi}{\omega}} e^{aE \sin \omega t} \, dt$$

$$= Ae^{-aV} \cdot \frac{2\pi}{\omega} \cdot I_0(aE)$$

where $I_0(x) \equiv J_0(jx)$, and $J_0\ (z)$ is the Bessel function of the first kind of zero order.

Since $I_0(x) \sim \frac{e^x}{\sqrt{2\pi x}}$ for large $x$, an appropriate approximation for $E$ greater than a few volts, $a$ being, say, 10, the above equation simplifies to

$$Ve^{aV} = AR\frac{e^{aE}}{\sqrt{2\pi aE}}$$

or $$\frac{V}{V_0} = \frac{e^{a(E - V + V_0)}}{\sqrt{2\pi aE}} \quad .. \quad .. \quad (8)$$

Equation (8) is identical with (5) if $\sqrt{2\pi aE}$ is substituted for $\frac{t_1 + t_2}{t_1}$. The counterpart to equation (6) can therefore be written down ($d_s$ being written for $d$)

$$d_s . E = \frac{ln\sqrt{2\pi aE} + ln\left(1 + \frac{E}{V_0}\right)}{a + \frac{1}{E + V_0}} \qquad (9)$$

Fig. 8 shows the calculated efficiency for

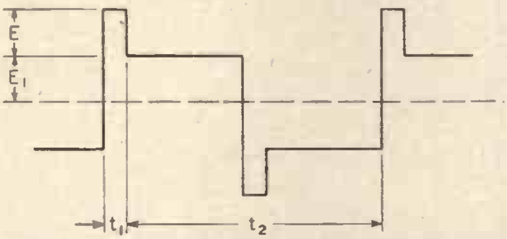



Fig. 7. *Idealised waveform for the calculation of voltmeter errors in the overshoot measurement.*

the numerical conditions relevant to the instrument described in the next section, for two values of $E$ . $V_0$ is taken as 1.0 volt, corresponding to $R = 40$ megohms for the diode characteristic of Fig. 10 and $a = 10$. It was verified that over the range drawn the diode was not driven beyond the accurately exponential portion of its characteristic. On the same figure is shown the efficiency for a sinusoidal input.

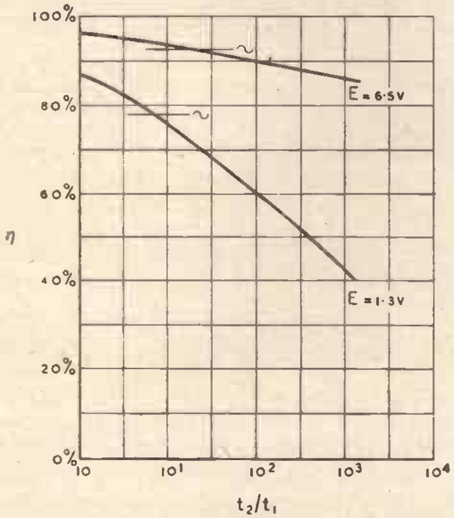



Fig. 8. *The voltmeter efficiency for an input of the form of Fig. 6. The short horizontal lines marked ~ show the efficiency for a sinusoidal input having the same peak voltage.* ($a = 10$, $V_0 = 1$ *volt.*)

Now consider the waveform shown in Fig. 7: this is an idealisation appropriate for the overshoot measurement. The length of the pulses is again taken as $t_1$.

Suppose that in the absence of the pulses, i.e., with a square wave of amplitude $E_1$, the voltage across the condenser is $V_1$; and that with the pulses it is $(V_1 + V)$. $V_1$ can, of course, be found from the previous analysis.

To find $V$ the procedure is the same as before. Taking $t_2 \gg t_1$ and neglecting the parts of Fig. 7 below the centre line, the integral equation is :—

$$At_1 e^{a(E+E_1-V-V_1)} + \tfrac{1}{2} At_2 . e^{a(E_1-V-V_1)} = \frac{V+V_1}{R} . t_2$$

or

$$(V + V_1)e^{aV} = \tfrac{1}{2}AR\, e^{a(E_1-V_1)}\left[\frac{2t_1}{t_2} e^{aE} + 1\right]$$

And $V_1$ is given by equation (4), putting $t_2 = t_1$ :—

$$V_1 e^{aV_1} = \tfrac{1}{2}AR\, e^{aE_1}$$

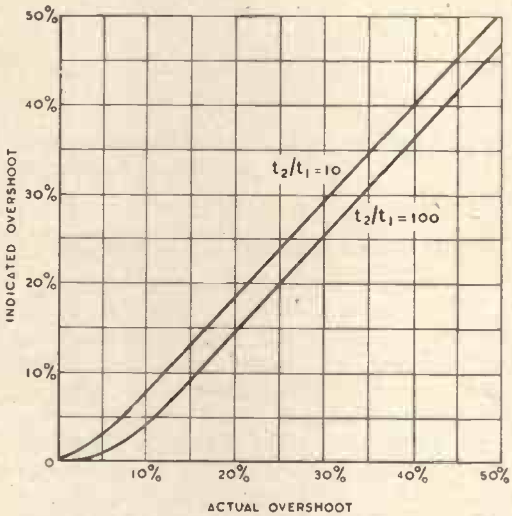



Fig. 9. *The indicated overshoot for an actual overshoot of the form of Fig. 7* ($E_1 = 3.25$ *volts*, $a = 10$, $V_0 = 1$ *volt*).

Dividing these last two equations :—

$$\left(1 + \frac{V}{V_1}\right)e^{aV} = 1 + \frac{2t_1}{t_2} e^{aE} \qquad .. \quad (10)$$

For given numerical values of $V_1$, $E$, $t_2/t_1$, equation (10) is easily solved by trial and error, and with certain conditions an approximate solution can be obtained similar to equations (6) and (9).

A numerical case has been calculated which is relevant to the problem in hand. Take $E_1 = 3.25$ volts. Then using the values $a = 10$ and $V_0 = 1$ volt as before,

$V_1$ is found to be 4 volts. If $E = 3.25$ volts, then the actual overshoot is 50 per cent. For this value of $E$, $V$ is calculated from equation (10) for a certain $t_2/t_1$. The indicated overshoot is then :

$$\frac{1}{2}\frac{V}{V_1 - V_0} = \frac{1}{2}\frac{V}{V_1 - 1}$$

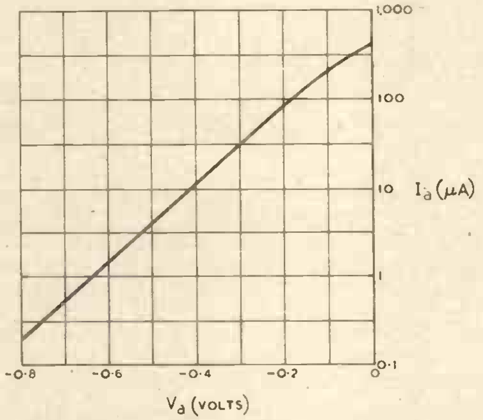


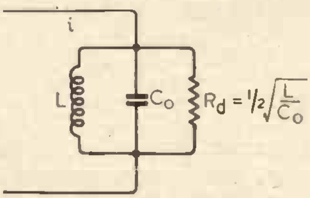

Fig. 10. *Typical characteristic of the diodes used. (Mullard EA50.)*

Fig. 9 shows the indicated overshoot against the actual overshoot for two values of $t_2/t_1$.

## 4. Errors in the Differentiating Network

The problem considered in this section is to decide how nearly $V_m$, the maximum value of the voltage across the differentiating circuit of Fig. 11, measures the maximum slope (i.e. the speed) of $i$, the current into the combination. In Fig. 11 $L$ is the same inductance as is shown in Fig. 3, but $C_0$ represents the stray capacitance due to the valve, etc., and $R_d$ is a damping resistance which will be adjusted to a critical value as explained later. It is to be expected that $V_m$ will be proportional to the speed for

Fig. 11. *The differentiating network* $\left(\alpha = \frac{1}{\sqrt{LC_0}}\right)$




low speeds, but will reach a limiting value as the speed is increased, due to the presence of the stray capacitance $C_0$.

The waveform chosen for $i$ is shown in Fig. 12. It has a speed $s$ and no other parameter, and is therefore the logical choice for the purpose.

If $Z$ is the impedance of $L$, $C_0$, $R_d$, then $V = iZ$. The next step is to write $i$ and $Z$ as operators ; the Heaviside notation is used.

$$i = \frac{s}{p}\mathbf{1} - \frac{s}{p}\mathbf{1}_{(1/s)} \quad .. \quad .. \quad (11)$$

where the suffix $(1/s)$ indicates a time delay $1/s$. It is easily verified that equation (11) represents Fig. 12.

Also $$\frac{1}{Z} = \frac{1}{R_d} + C_0 p + \frac{1}{Lp}$$

or $$Z = \frac{Lp}{1 + \frac{L}{R_d}p + LC_0p^2}$$

Now make the combination "critically damped," i.e., put $\frac{L}{R_d} = 2\sqrt{LC_0}$. Writing $\sqrt{LC_0} = 1/\alpha$,

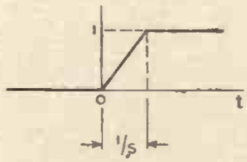
$$Z = \frac{L\alpha^2 p}{(p+\alpha)^2} \quad .. \quad .. \quad .. \quad (12)$$

Combining equations (11) and (12) :—

$$V = iZ = \frac{Ls\alpha^2}{(p+\alpha)^2}\mathbf{1} - \frac{Ls\alpha^2}{(p+\alpha)^2}\mathbf{1}_{(1/s)}$$

Now $\frac{1}{(p+\alpha)^2}\mathbf{1}$ is a simple and well known operational formula, given for instance in the text-book "Operational Circuit Analysis"

Fig. 12. *Idealised input waveform used for the calculation of the error in the differentiating network.*




by Bush, Appendix $C$, equation (7). The solution for $V$ can thus be written down :—

$$V = Ls\left[1 - e^{-\alpha t}(1 + \alpha t)\right] - Ls\left[1 - e^{-\alpha(t-1/s)}\{1 + \alpha(t - 1/s)\}\right] \quad .. \quad .. \quad (13)$$

The first term is to be taken as zero for $t < 0$, and the second term zero for $t < 1/s$.

$V_m$, the greatest value of $V$, is required next. The first term has no maximum up to the time $t = 1/s$. For $t > 1/s$, both terms are to be used. Thus :—

$$\frac{dV}{dt} = Ls\alpha^2\left[te^{-\alpha t} - (t - 1/s)\,e^{-\alpha(t-1/s)}\right]$$

$$= 0 \text{ for } t = \tau = \frac{e^{\alpha/s}}{s(e^{\alpha/s} - 1)}$$

Now write $\alpha/s = 2K$, giving

$$\frac{\alpha\tau}{K} = \frac{2\,e^{2K}}{e^{2K} - 1}$$

$$\frac{\alpha\tau - K}{K} = \frac{e^{K} + e^{-K}}{e^{K} - e^{-K}} = \coth K$$

$$\alpha\tau = K(1 + \coth K) \qquad \ldots \quad (14)$$

Now substitute $t = \tau$ in equation (13) to obtain $V_m$.

$$\frac{V_m}{Ls} = (1 - K + K\coth K)\,e^{K - K\coth K} - (1 + K + K\coth K)\,e^{-K - K\coth K}$$

$$= e^{-K\coth K}\Big[(1 + K\coth K)(e^{K} - e^{-K}) - K(e^{K} + e^{-K})\Big]$$

$$= 2e^{-K\coth K}\Big[(1 + K\coth K)\sinh K - K\cosh K\Big]$$

$$= 2\sinh K\,e^{-K\coth K}$$

When $K$ is very large, i.e. $s$ is small compared to $\alpha$, this expression tends to 1. Thus writing $V_m = \eta Ls$, $\eta$ is the efficiency of the differentiator, unity at low input speeds, and falling to zero at very high input speeds.

$$\eta = 2\sinh K\,e^{-K\coth K} \qquad \ldots \qquad \ldots \quad (15)$$

The relation between $\eta$ and $K$ is shown in Fig. 13 from which the error in assuming $s = \dfrac{V_m}{L}$ can be obtained for any particular $L,C_0$. This will be looked into more closely in the next section.

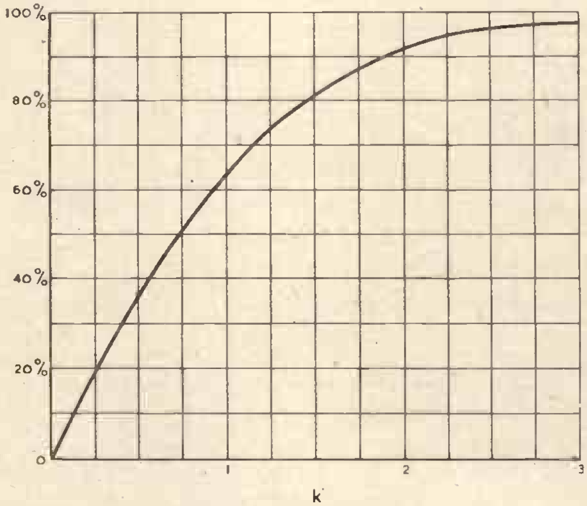



Fig. 13. *The efficiency of the differentiating network with an input of the form of Fig. 11.* $\left(K = \dfrac{\alpha}{2s}\right)$

If instead of the waveform of Fig. 12 a different shape had been assumed (with the same speed), a different relation between $\eta$ and $K$ would have resulted, again rising from 0 at $K = 0$ and tending to 1 for large $K$, but with different values of $\eta$ at a finite value of $K$.

Thus equation (15) and Fig. 13 are only indicative of the efficiency for waveforms approximating to Fig. 12. For different waveforms the error would probably be greater.

In this calculation the circuit has been assumed critically damped. But the calculation has been for a single wavefront, whereas the application will be for a repetitive wave. Some damping is, therefore, essential to ensure that $V$ has become zero by the time that the next wavefront arrives. Critical damping removes $R$ from the equations and greatly simplifies the calculations.

## 5. An Experimental Analyser

An experimental instrument has been made on the lines discussed and is illustrated; the circuit is shown schematically in Fig. 14.

The waveform to be analysed is applied to the grid of $V_1$, to whose cathode is connected a variable carbon resistance permitting a small range of gain control, and to whose anode various impedances can be switched. The switches $S_1$ and $S_1'$ are ganged. For position 0 the load is zero; this is convenient for adjusting the zero of the indicating meter. For position 1 the load is 200 ohms, shunted by a capacitance which can be chosen by switch $S_2$. For position 2 the load is 200 ohms. For position 3 the load is 8 $\mu$H shunted by 280 ohms, this resistance providing the critical damping referred to in Section 4. Positions 4 and 5 are similar to position 3, the loads being 40 $\mu$H, 630 ohms and 200 $\mu$H, 1,410 ohms. The voltage across the load is applied to a peak voltmeter of conventional design, consisting of the diode $V_2$ and D.C. amplifier $V_3$. The current through the meter is adjusted to zero for zero input by varying the bias of $V_3$ by the potentiometer at the right of Fig. 14.

The damping resistances are calculated on a basis of a capacitance of 25$\mu\mu$F, this being the measured stray capacitance.

In use the procedure is effectively as follows. The switch $S_1$ is put to position 0, and the zero adjusted. Then with $S_1$ in position 1, and the "smoothing" capacitance set by $S_2$ to remove the overshoot, the meter reading is adjusted by the gain control to half scale. Putting $S_1$ to position 2 removes the "smoothing" capacitance, and the meter reading increases to indicate the overshoot, if any, on a direct scale on the meter. Position 3 (or 4 or 5) gives the speed, read directly on the meter.

The direct scales, calculated according to equations (1) and (2), are 0–50 per cent. overshoot, and speeds of 0.2M to 1M, 1M to 5M, 5M to 25M. (M is written for $10^6$). The calibration of the meter was made with a sinusoidal input.

So far we have proceeded as though the errors discussed in Sections 3 and 4 were absent. The magnitude of these errors will now be discussed, dealing first with errors due to the peak voltmeter.

The speed ranges are spaced 5 : 1, so that it is not necessary to use less than one-fifth of full scale of the meter. The corresponding voltages to the diode are 6.5 volts and 1.3 volts peak. Reference to Fig. 8 shows that for $t_2/t_1$ about 10, the errors are negligible at either end of the scale; for $t_2/t_1$ about 100 the errors are appreciable at the bottom of the scale, but negligible at the top of the scale. Thus errors in the speed measurement will be negligible as long as the input frequency is chosen high, and there is more latitude in the choice if the reading happens to come at the top of the scale. Remembering that $t_1 = 1/s$, and $t_2 = 1/f$, $f$ being the input frequency, it is clear that the input frequency should be about one-tenth the speed.

Reference to Fig. 9 shows that for $t_2/t_1 = 10$, the overshoot measurement is fairly accurate, even for small overshoots, and that for $t_2/t_1 = 100$ the error is not excessive for large overshoots. Thus again the frequency must be kept high, particularly if the overshoot happens to be small. Now the $t_1$ used for Fig. 7 is not necessarily the same in practice as the $t_1$ used for Fig, 6, but the two times are usually of the same order. Thus it seems fair to say that if the frequency is chosen about one-tenth the speed, the errors in both speed and overshoot measurements can be neglected.

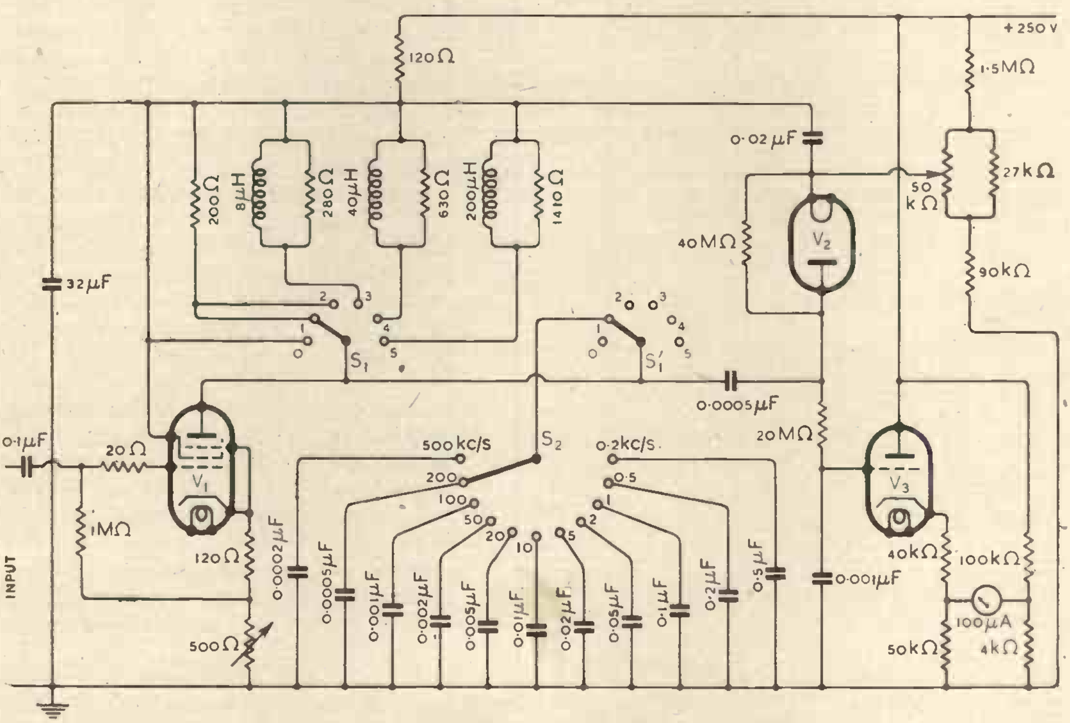
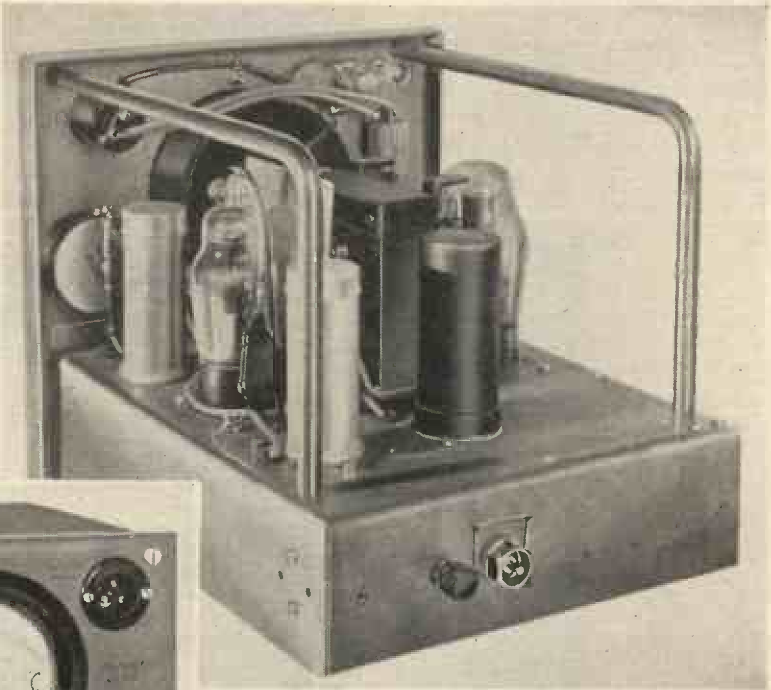



Fig. 14. *Schematic diagram of an experimental analyser.*

The point now arises, is it possible to choose a value of smoothing capacitance large enough to remove the overshoot, and yet not so large as appreciably to reduce the peak voltage of a square wave without overshoot, when the frequency is as high as one-tenth the speed? The answer provided by experiment is that it is not possible for overshoots of 50 per cent., but that it can just about be done



*Chassis of the experimental analyser withdrawn from its case. The complete instrument is shown below.*

for, say, a 10 per cent. overshoot. If the input frequency is 1/100 the speed there is no difficulty, even for 50 per cent. overshoot, but then, of course, the voltmeter error can be appreciable in some cases. Fortunately there is a way out, and it is to use two values of input frequency, of equal amplitude. (Square-wave generators generally use saturated valves, so that the amplitude does not change with change of frequency). The lower frequency, say 1/100 the speed, is used for the setting operation ($S_1$ at position 1), and the higher frequency for the overshoot and speed measurements. To facilitate setting up, the switch $S_2$ is marked in frequency rather than capacitance. This shows the greatest frequency that can be used at that capacitance setting, for a reduction in reading of about ½ per cent.

Since the readings decrease slowly with reduced input frequency, the trial and error process of finding suitable input frequencies is rapid. Incidentally an input frequency of one-tenth the speed is very convenient for viewing on an oscillograph. The double frequency method is not always essential: it is often practicable to work with a single frequency and allow for the errors.

Turning now to the errors in the differentiating network, these can be calculated by equation (15) or obtained from Fig. 13, knowing that $\alpha = \dfrac{1}{\sqrt{LC_0}}$ for each speed range. As stated already, $C_0 = 25\mu\mu$F. The errors are summarised in the following table:—

| Range | $\alpha$ | Input Speed (s) | $K\left(=\frac{\alpha}{2S}\right)$ | Efficiency |
|---|---|---|---|---|
| | | | | Per cent. |
| 0.2 to 1M | 14.1 | 1M | 7 | 100 |
| 1M to 5M | 31.6 | 5M | 3.2 | 98 |
| 5M to 25M | 70.8 | 5M | 7.1 | 100 |
| ,, | ,, | 10M | 3.54 | 99 |
| ,, | ,, | 15M | 2.36 | 95 |
| ,, | ,, | 20M | 1.77 | 88 |
| ,, | ,, | 25M | 1.41 | 79 |

Thus the errors are only appreciable for speeds in excess of 15M. Since such high speeds are likely to be rare, the scale for the top range has not been corrected.

The general construction is shown in the accompanying photographs. The valves $V_1$ and $V_2$ and associated components are placed in the compartment to the rear of the chassis, and the input is at the back; this was done because in most oscillographs the input is at the back. The inductances are of dust-core type for convenience of adjustment, and care was taken with the wiring to keep down stray inductance and capacitance.

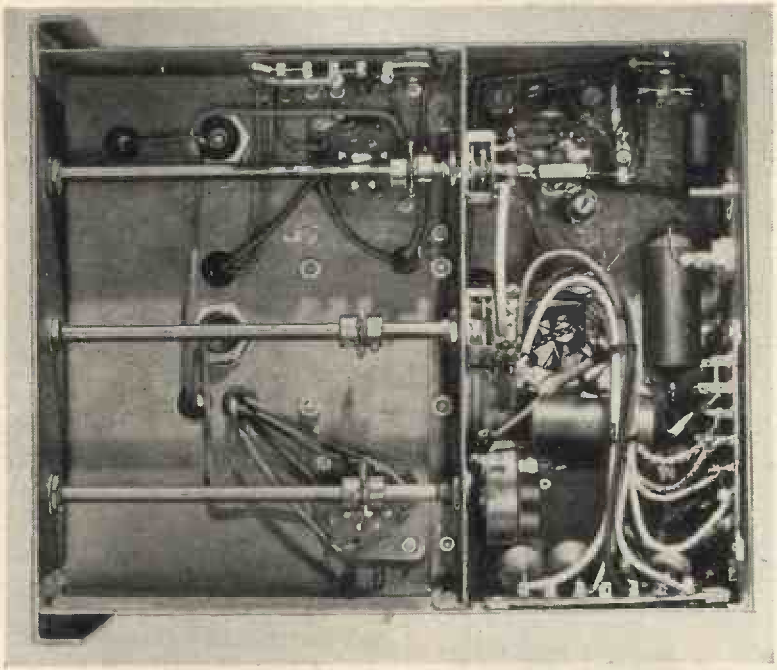
To test the analyser a three-stage video amplifier was made, with variable cathode compensation and variable capacitance loading. Thus a wide range of speed and overshoot was easily obtained. A series of tests, partly against an oscillograph and partly by internal cross-checks, showed that the behaviour of the instrument is adequately represented by the analysis given, and a fair conclusion seems to be that the instrument will give reliable results with multi-stage networks.

For the instrument described,

Input capacitance = 25 $\mu\mu$F.

Required input voltage = 4 volts peak (maximum gain).

15 volts peak (minimum gain).



*Underside view of the chassis of the experimental instrument.*

## 6. Acknowledgments

The author wishes to acknowledge his debt to Mr. C. G. Clayton, who has done all the experimental work in connection with the instrument described; to Mr. D. P. Dalzell for much discussion (but not for the author's own choice of mathematical methods); and finally to the Mullard Radio Valve Company for permission to publish this article.

# WIRELESS PATENTS

## A Summary of Recently Accepted Specifications

*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.*

### AERIALS AND AERIAL SYSTEMS

565 526.—Short-wave aerial, particularly for use on mobile craft, in which tuning is effected mechanically by winding or unwinding a flexible conductor.

*Standard Telephones and Cables Ltd. and E. O. Willoughby. Application date 8th May, 1943.*

### DIRECTIONAL WIRELESS

565 351.—Direction-finding or course-navigating instrument comprising two magnetic circuits and a common element rotating on the earth's magnetic field.

*Aga-Baltic Akt. Convention date (Sweden) 21st April, 1942.*

565 379.—Blind-landing beacon in which two lobes of side-band energy are radiated on each side of a median zone which is filled with carrier and side-band energy.

*Standard Telephones and Cables Ltd. (assignees of A. G. Kandoian). Convention date (U.S.A.) 11th May, 1942.*

565 896.—Radio navigational system in which provision is made to enable a mobile receiver to give automatic indications of predetermined point-to-point positions along its route.

*Standard Telephones and Cables Ltd. (communicated by International Standard Electric Corporation). Application date 4th June, 1943.*

566 026.—Radio navigational system in which the bearings of two transmitters are shown simultaneously on a cathode-ray indicator against two time bases, one synchronised with a rotating aerial and the other with a cyclic tuning device.

*H. Jefferson. Application date 20th March, 1942.*

### RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

565 519.—Shock-proof casing for thermionic amplifiers or repeaters, particularly for undersea cable installations.

*Western Electric Co., Inc. Convention date (U.S.A.), 21st April, 1942.*

565 764.—Automatic tuning control system for frequency-modulated signals wherein the derived biasing voltage is of the same polarity for both directions of mistuning.

*Marconi's W.T. Co. Ltd. (assignees of W. R. Koch). Convention date (U.S.A.) 1st May, 1942.*

565 794.—Receiver in which the tuning condenser gives a lower rate of capacitance change, and the indicator needle moves over a magnified scale, at selected parts of the short-wave band.

*A. F. Burgess (communicated by the Zenith Radio Corp.). Application date 21st May, 1943.*

565 795.—Cathode-ray device for indicating simultaneously the selected wave band, and the instantaneous tuning of the set, together with the incoming signal strength and the output volume.

*Philips Lamps Ltd. Convention date (U.S.A.) 25th May, 1942.*

565 870.—Push-pull amplifier comprising two or more pairs of valves and one cathode follower in each pair, the whole being fed from a common H.T. source (addition to 564 250).

*G. S. P. Scantlebury and E. L. C. White. Application date 21st April 1943.*

565 895.—Variable permeability device in which the coil windings are arranged to produce a more uniform axial field and a wider tuning range.

*Marconi's W.T. Co. Ltd. (assignees of C. Wentworth). Convention date (U.S.A.) 29th May, 1942.*

### TELEVISION CIRCUITS AND APPARATUS

FOR TRANSMISSION AND RECEPTION

565 547.—Fluorescent screen, consisting of a number of insulated strips, coated with material giving different colour responses, for a cathode-ray television receiver.

*A. C. Cossor Ltd.; D. A. Bell; and H. Moss. Application date 4th May, 1943.*

565 703.—Balanced detector circuit for locking the saw-toothed synchronising signals used in television to the frequency of the local supply mains.

*Standard Telephones and Cables Ltd. (assignees of R. L. Campbell). Convention date (U.S.A.) 10th January, 1942.*

565 710.—Television and sound receiver wherein an automatic gain-control voltage is derived from the video carrier wave and is determined by the blanking level, irrespective of the synchronising impulses.

*Philco Radio and Television Corporation (assignees of W. E. Bradley). Convention date (U.S.A.) 13th June, 1942.*

### TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

565 403.—Phase modulator comprising a multi-vibrator with a phase-splitting circuit, suitable for motor car or like mobile transmitters.

*The Mullard Radio Valve Co. Ltd. and C. E. G. Bailey. Application date 5th February, 1943.*

565 413.—Frequency-modulating system comprising a velocity-modulation tube with one or more resonators variably tuned by the signal energy.

*N. C. Barford. Application date 5th May, 1943.*

565 521.—Multi-branch terminal connections for high-powered radio-frequency apparatus, particularly wireless transmitters.

*Dubilier Condenser Co. (1925) Ltd. (communicated* *by W. A. Dubilier). Application date 29th April, 1943.*

565 856.—High-frequency contact device in which a roller element makes a line contact which is variable laterally to reduce wear (addition to 558 169).

*Standard Telephones and Cables Ltd. and A. J. Maddock. Application date 26th May, 1943.*

## SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

565 206.—Combined transmitter and receiver for facsimile signalling, wherein one light ray is used for sending, and a double ray for reception.

*L. A. Thompson. Application date 8th December, 1941.*

565 785.—Multiplex signalling system in which the opening of a signal-channel depends upon the phase relation between a reference current and the primary signal, particularly for remote control or telecommunication switching.

*Standard Telephones and Cables Ltd. (communicated by International Standard Electric Corporation). Application date 5th March, 1943.*

## CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

565 374.—Assembly and support, to ensure rigidity of the deflection plates of a cathode-ray tube.

*Standard Telephones and Cables Ltd. (assignees of S. J. Koch and R. E. Rutherford). Convention date (U.S.A.) 8th July, 1942.*

565 486.—Construction, assembly, and sealing of the " gun " electrodes of a cathode-ray tube.

*Standard Telephones and Cables Ltd. (assignees of S. J. Koch and R. E. Rutherford). Convention date (U.S.A.) 29th May, 1942.*

565 578.—Construction and arrangement of the coated sleeves for indirectly-heated cathodes.

*Marconi's W.T. Co. Ltd. (assignees of N. R. Smith). Convention date (U.S.A.) 1st January, 1942.*

565 689.—Cathode for gas-filled discharge tube with means for preventing rapid disintegration of the active material.

*Siemens Electric Lamps and Supplies Ltd. and J. N. Aldington. Application date 11th June, 1943.*

565 694.—Arrangement for screening a cathode-ray indicator against the ultra-violet radiation used to increase the visibility of nearby meters and instruments in the dark.

*Standard Telephones and Cables Ltd. and H. Wolfson. Application date 10th May, 1940.*

565 767.—Apparatus for sealing the glass bulb of a thermionic valve or other vacuum tube.

*Standard Telephones and Cables Ltd. and W. R. Moscrip. Application date 21st May, 1943.*

565 810.—Composition and processing of a coated-metal grid wire, to minimise secondary emission, when used in a transmitting valve.

*Marconi's W.T. Co. Ltd. (assignees of E. A. Lederer and A. D. Power). Convention date (U.S.A.) 10th December, 1941.*

565 949.—Apparatus for winding hollow grid electrodes for thermionic valves.

*The Mullard Radio Valve Co. Ltd.* and *L. M. Myers. Application date 2nd April, 1943.*

565 950.—Process for making metal-to-steatite joints in the manufacture of high-voltage electron-discharge tubes.

*The Mullard Radio Valve Co. Ltd.* and *L. M. Myers. Application date 2nd April, 1943.*

## SUBSIDIARY APPARATUS AND MATERIALS

565 243.—Clamping structure for electrical condensers of the " sheet-stack " or interleaved type.

*Dubilier Condenser Co. (1925) Ltd. and P. R. Coursey. Application date 29th April, 1943.*

565 320.—Anodic or electrolytic process for applying the blocking-layer to a selenium-type rectifier.

*Standard Telephones and Cables Ltd. (assignees of A. von Hippel and J. H. Schulman). Convention date (U.S.A.) 21st November, 1942.*

565 323.—Method of treating the sensitive surface of a selenium rectifier with thallium compounds.

*O. K. Kolb. Application date 22nd November, 1943.*

565 354.—Impedance network for stabilising the A.C. output delivered by a vibrating-reed relay from a fluctuating source of D.C.

*H. M. Harmer. Application date 16th February, 1943.*

565 375.—Construction of fixed condenser housed inside a single cup-like member which serves to connect the condenser to an external circuit.

*P. A. Sporing and The Telegraph Condenser Co. Ltd. Application date 16th March, 1943.*

563 500.—Condenser in which the dielectric consists of a core of " loaded " thermoplastic with a casing of plastic applied by injection moulding.

*Standard Telephones and Cables Ltd. and J. A. Leno. Application date 12th February, 1943.*

565 609.—Direct-current amplifier in which a heat-sensitive non-linear resistance (Thermistor) forms part of the intervalve coupling.

*Standard Telephones and Cables Ltd.; P. K. Chatterjea; and C. T. Scully. Application date 14th May, 1943.*

565 638.—Frequency-dividing circuit in which successive pulses are fed through a diode to a storage condenser which is periodically discharged by a gas-filled trigger device coupled to a buffer or limiter valve.

*Standard Telephones and Cables Ltd.; L. W. Houghton; and D. M. Ambrose. Application date 12th May, 1943.*

565 691.—Means for adjusting the gap between one face of a piezo-electric crystal and its casing, so as to increase the accuracy of thermostatic control.

*The General Electric Co. Ltd. and S. K. Lewer. Application date 9th August, 1943.*

565 776.—Two-coil inductance in which the parts are mounted inside a hollow brass cylinder and spaced so as to give a predetermined positive or negative temperature coefficient.

*The Mullard Radio Valve Co. Ltd. and W. H. Morris-Airey. Application date 8th November, 1943.*

565 825.—Preparing and coating the elements of a copper-oxide rectifier to give a high and durable efficiency factor.

*Westinghouse Brake and Signal Co. Ltd. (assignees of P. H. Dowling and H. L. Taylor). Convention date (U.S.A.) 25th May, 1942.*

565 853.—Radio screening device for a sparking plug comprising a rigid element supported by the cylinder head and a flexible screening tube between the element and the plug.

*Lodge Plugs Ltd. and B. Hopps. Application date 26th May, 1943.*

565 959.—Spark-gap apparatus, combined with cold-cathode trigger-discharge tubes, for gauging or measuring small distances.

*Standard Telephones and Cables Ltd. and H. S. Bishop. Application date 1st June, 1943.*

## Literature

THE Copper Development Association has issued a 24-page booklet giving in tabular form concise data on the composition and mechanical properties of copper and the most important copper base materials. This C.D.A. Publication No. 36 (revised) is entitled "Classification of Copper and Copper Alloys," and is obtainable from the temporary address of the Association, 9, Bilton Road, Rugby, free of charge to readers giving evidence of responsible status.

A leaflet from Salford Electrical Instruments of Peel Works, Salford, Lancs, briefly summarises the properties and performance of some of the more commonly used magnetic dust cores manufactured by the company. Dimensional drawings are given of twelve Gecalloy cores, together with tabulated data of their performance at 200 kc/s, 1 Mc/s and 10 Mc/s.

Physical and electrical details of R.I. transformers and chokes that will be in production as soon as the necessary materials are made available are given in a catalogue issued by Radio Instruments (Aeronautical and General Instruments, Ltd.), Purley Way, Croydon, Surrey.

"A Study in Vibration," by R. G. Manley, of Silentbloc, Ltd., gives, in concise form, information on the fundamentals of mechanical vibration problems. Copies are available from Silentbloc, Ltd., Victoria Gardens, Ladbroke Road, Notting Hill Gate, London, W.11.

## A Ferranti Product

WITH the removal from the Secret List of the Distant Reading Compass, employed by the R.A.F. to overcome the limitations of the ordinary magnetic compass, Ferranti are able to disclose details of this instrument of which they are manufacturers.

The master unit, which is carried in the tail of the aircraft as far away as possible from electrical interference and magnetic disturbances, combines a gyroscopic direction indicator and a magnetic compass, each of which has the effect of checking the other. The D.R. compass is unaffected by vibration from heavy gunfire, abnormal changes in speed, high altitudes, etc., and indicates the difference between true and magnetic north. Probably its greatest advantage is that it allows the pilot to "weave" with impunity.

## Technical Journals

THE functions of the technical and trade journals of this country in relation to post-war industry at home and abroad and the limitations imposed on them by the exigencies of war are set out in a memorandum issued by and available from the Council of the Technical and Trade Press, Imperial House, Kingsway, W.C.2. In it the Council stresses the need for the prompt removal of the handicaps—particularly that of paper rationing—under which we are labouring. For over three years the specialised Press has been working with a basic paper ration of approximately one-fifth its pre-war consumption, moreover the quality of paper has deteriorated seriously.

The memorandum also urges the release of information "on the many new discoveries and inventions that British scientific research has evolved and British technical skill developed during the war." It is further stressed that the British inventor and manufacturer obtain "the fullest and most immediate recognition of their wartime achievements which will provide the world with a yardstick of their ability to meet peacetime needs."

## Oliver Lodge Scholarship

TO commemorate the 25th Jubilee of the I.E.E. Radio Section, a Research Scholarship, to be known as the "Oliver Lodge Scholarship," has been founded. It will have a basic annual value of £250 and will be tenable for one year, but may be extended for a second year. The scholar will be required to carry out research in a subject closely allied to radio engineering.

Further particulars and nomination forms, which must be returned by May 15th, are obtainable from the Secretary, I.E.E., Savoy Place, London, W.C.2.

## Meetings

**Institution of Electrical Engineers**

*Radio Section.*—"The Characteristics of Luminescent Materials for Cathode-Ray Tubes," discussion to be opened by C. G. A. Hill, B.Sc., May 15th.

"Non-Ferrous Contact Springs," discussion to be opened by H. G. Taylor, D.Sc. (Eng.), and L. B. Hunt, Ph.D., M.Sc., May 22nd.

The above meetings will be held at 5.30 at the I.E.E., Savoy Place, London, W.C.2.

*Cambridge Radio Group.*—"Carrier Protection on Overhead Transmission Lines," by D. H. Towns, B.Sc., at 6.0 at the Technical School, Collier Road, Cambridge, May 8th.

**Television Society**

"The Human Eye and the Photo-Cell," by W. Sommer, D.Phil., at 6.0 at the I.E.E., London, W.C.2, May 29th.

**Royal Society of Arts**

"Wire Broadcasting," by Paul Adorjan, at 1.45 at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2., May 23rd.

**Institution of Electronics**

*North-West Branch.*—"Design of Electron Guns of Radial Symmetry," by H. Moss, Ph.D., B.Sc., at 6.30, at Reynolds Hall, College of Technology, Manchester, June 1st.

# ABSTRACTS AND REFERENCES

Compiled by the Radio Research Board and published by arrangement with the Department of Scientific and Industrial Research

**Comparative Length of the Abstracts.**—*It is explained to new readers that the length of an abstract is no sign, by itself, of the importance of the work concerned. An important paper in English may be dealt with by a short abstract, or even, if it is in a journal readily obtainable, by a square-bracketed addition to the title, while a paper of similar importance in a language other than English may be given a long abstract. In addition to these questions of language and accessibility, the nature of the work has, of course, a great effect on the useful length of its abstract.*



## PROPAGATION OF WAVES

1378. COMMENTS ON BETHE'S THEORY OF DIFFRACTION OF ELECTROMAGNETIC WAVES BY SMALL HOLES [706 of March: No "Failure" of Kirchhoff's Theory, because This was always Limited to Wavelengths Small compared with Size of Aperture: Rayleigh's Solution of the Scalar Problem for Longer Wavelengths (using Method essentially the Same as Bethe's for the More Complicated Vectorial Problem): Lamb's Exposition (in his *Hydrodynamics*)].—C. L. Pekeris: Bethe. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, p. 351.)

1379. THE POLARISING ANGLE FOR REFLECTION AT THE BOUNDARY BETWEEN TWO ABSORBING MEDIA.—L. Pincherle. (*Proc. Phys. Soc.*, 1st Jan. 1945, Vol. 57, Part 1, No. 319, pp. 56–60.)

"The problem of determining theoretically under what conditions there is no reflected wave when a plane electromagnetic wave is incident upon the plane boundary between two different media is a well-known one [references are given to recent books by Stratton and Slater and to König's *Handbuch der Physik*]. However, the analogue of Brewster's formula in the case of absorbing media has not, to my knowledge, been given explicitly. It is the purpose of this paper to establish it": it is given by eqn. 8, $\cot\phi_1 \cot\psi_2 + \cot\psi_1 \cot\phi_2 = 2$: for $\eta_1 = \eta_2 = 0$ we have $\psi_1 = \phi_1$ and $\psi_2 = \phi_2$, so that eqn. 8 becomes $\cot\phi_1 \cot\phi_2 = 1$, the usual condition ($\eta = \sigma/\omega\epsilon$).

"It is possible that the theoretical results obtained may have practical applications: dielectric constants and conductivities could be determined by measuring the angles at which no reflection occurs, in the same way as refractive indices of perfect dielectrics are found by measuring the Brewster angle . . ."

"The equations (7) can be solved for given $E$, $\eta_1$, $\eta_2$, but, as with the equivalent equations given by Stratton, no simple expressions can be obtained for the angles. The solution, however, is easily obtained in limiting cases, to which we shall confine ourselves": these are $\eta_1, \eta_2 \ll 1$; $\eta_1, \eta_2 \gg 1$; medium 1 is a dielectric and medium 2 is a conductor (case treated by Stratton); $\eta_1 = \eta_2$ and of unrestricted magnitude; and $\psi_1 = \psi_2 = 0$ (impossible for the reflected wave to be absent: this is the case for the component, "criss-cross", waves in hollow tubes, when the boundary between the media is at right angles to the axis of the tube). For previous work *see* 2628 & 3248 of 1943 and 1 of January.

1380. "HIGH-FREQUENCY TRANSMISSION LINES" [Book Review].—Willis Jackson. (*Wireless Engineer*, March 1945, Vol. 22, No. 258, p. 126.) "Can be very highly commended to those interested in its important subject."

1381. VERY-HIGH-FREQUENCY AND ULTRA-HIGH-FREQUENCY SIGNAL RANGES AS LIMITED BY NOISE AND CO-CHANNEL INTERFERENCE [with Theoretical Service-Area Maps showing also Required Spacing between Co-Channel Stations, taking Tropospheric Effects into Account: etc.].—K. A. Norton & E. W. Allen, Jr. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 58: summary only.)

1382. ON THE PROPAGATION OF RADIO WAVES [Study of the Properties of the Parabolic Layer (1383, below) throughout the Long-, Medium-, and Short-Wave Regions].—O. E. H. Rydbeck. (*Terr. Mag. & Atmos. Elec.*, Dec. 1944, Vol. 49, No. 4, p. 270: author's summary, from a Chalmers University publication, 1944.)

Continuation of the work dealt with in 2055 [and *cf.* 7] of 1943. Development of suitable expansions of the wave functions (and investigation of accuracy of Eckersley's phase-integral method): general formulae for horizontal and vertical polarisations, applicable to any kind of layer whose wave functions (and their circuit-relation) have been found: bridging between long- and medium-wave cases: attenuation coefficients for long waves (on reasonable D-layer assumptions) and comparison with empirical Austin values: formation of radially standing waves between reflector and ground: influence of collisional frequency on transmission coefficients and virtual heights: transmission properties of extremely thin layers, with special reference to discussion of nature of "abnormal" E-reflections: etc.

1383. A THEORETICAL SURVEY OF THE POSSIBILITIES OF DETERMINING THE DISTRIBUTION OF THE FREE ELECTRONS IN THE UPPER ATMOSPHERE [and the Good Approximation furnished by the Parabolic Layer].—O. E. H. Rydbeck. (*Terr. Mag. & Atmos. Elec.*, Dec. 1944, Vol. 49, No. 4, p. 275: author's summary.)

This is the Chalmers University publication referred to at the beginning of 2055 of 1943: for further development *see* 1382, above. Among the problems discussed is the calculation of the variation of the collisional frequency with height. "It is interesting to find that it can be determined from sweep-frequency reflection-coefficient measurements if the electron-density distribution is determined at the same time. So far the method has not been applied in practice . . ."

Strong support is found for "the various hypotheses of the expansion of the upper atmosphere." Finally, "the exact wave-functions for a parabolic layer are studied briefly. It is shown that the travel-time and the dispersion are finite at the critical frequency and the reflection-coefficient differs appreciably from the classical one only when the layer-thickness becomes less than about four wavelengths."

1384. COEFFICIENT OF RADIATIVE RECOMBINATION OF $N_2^+$ ($X'$) AND $e$ [Rough Approximation gives $\alpha = 7.6 \times 10^{-16}$ cm³/s, about Two Orders of Magnitude less than the Coefficient of Recombination by Three-Body Collision (*see* 1011 of April)].—J. S. Chatterji. (*Sci. & Culture* [Calcutta], Nov. 1944, Vol. 10, No. 5, pp. 214–215.)

Thus the electrons and ions will *not* disappear by this process rather than by the three-body-collision process which is the basis of Mitra's theory.

1385. AUTO-IONISATION IN DOUBLY EXCITED HELIUM AND THE $\lambda$320.4 AND $\lambda$357.5 LINES.—Ta-You Wu. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, pp. 291–294.)

1386. DAYLIGHT [with Charts of Longest Day, Earliest Sunrise, Latest Sunset: Shortest Day, Latest Sunrise, Earliest Sunset].—J. O. Perrine. (*Bell Lab. Record*, Jan. 1945, Vol. 23, No. 1, pp. 11–12.)

1387. IONOSPHERIC DETERMINATION OF THE ULTRA-VIOLET INTENSITIES OF THE SOLAR RADIATION IN THE REGION 700–900 AU.—W. Waldmeier. (*Terr. Mag. & Atmos. Elec.*, Dec. 1944, Vol. 49, No. 4, pp. 275–276: author's summary, in German, from *Helvet. Phys. Acta*, 1944, p. 168 onwards.)

"It is shown that the expression $f_0^n/\cos \chi$ ($f_0$= limiting frequency of the E-layer, $\chi$ = zenith distance of the sun) is proportional to the extra-terrestrial intensity of the radiation producing the E-layer ionisation. Empirical determination of the exponent gave $n = 3$ (in contrast to the value $n = 4$ hitherto assumed). The calculated intensities show a yearly course with a well-defined maximum in December/January and a flat minimum in late summer: this course is attributed to the seasonal variation of the ionospheric temperature. The extra-terrestrial intensities $S_0$ of the E-radiation, obtained after the elimination of the yearly period, show in their monthly mean values a very close correlation with the solar activity as expressed by the relative sunspot figure $R$.

"The relation between $S_0$ and $R$ is linear; at a time of maximum solar activity $S_0$ is about twice as large as at a time of minimum activity. It is shown that the E-radiation, which probably lies in the 700–900 AU region, agrees in its statistical properties (amplitude, linearity, correlation) with those of the $W$-radiation deduced by Bartels [*see* 743 of 1944] from the solar-activity-dependent variation of the terrestrial magnetism. It therefore follows that these variations are to be traced exclusively to the E-ionisation; that is, to a current system at a height of about 110 km."

1388. A TABLE OF SECULAR VARIATIONS OF THE SOLAR CYCLE.—W. Gleissberg. (*Terr. Mag. & Atmos. Elec.*, Dec. 1944, Vol. 49, No. 4, pp. 243–244.)

"Recent investigations have led to the conclusion that—as the course of spot-frequency during each spot-cycle is disturbed by short variations of an accidental character—the cycles themselves seem to be disturbed also by accidental variations. It must, therefore, be possible to reveal the essential behaviour of the sunspot-cycles by smoothing them adequately." This is done in Table 1. "To avoid any confusion with the smoothed relative sunspot-numbers as computed by the Zürich astronomers I propose to call this new kind of smoothing 'secular smoothing' . . . In Table 1 the secular variations of the solar cycle show themselves by systematic fluctuations of the intervals between two minima, between two maxima, from minimum to maximum, or from maximum to minimum, and of the quantities $r$ and $R$ which characterise the depths of secularly smoothed minima and the heights of secularly smoothed maxima. The quantities $r$ and $R$ are known, however, only for the more recent cycles. It would be of interest to learn whether the secular variations of the solar cycle are reproduced also in terrestrial phenomena." For previous work *see* 1121/2 of 1944 and 408 of February.

1389. SOLAR ACTIVITY AND GEOMAGNETIC PERTURBATIONS [and the Importance of the "Impulse Conception" of Solar Activity].—A. J. Ol. (*Terr. Mag. & Atmos. Elec.*, Dec. 1944, Vol. 49, No. 4, p. 269: author's summary, from *Bull. de l'Acad. des Sci. de l'URSS*, Série Géographique et Géophysique, No. 6, 1943.)

For some other papers published in this journal *see* 1018 of April. "Until recently the relation between the disturbances of the magnetic field of the Earth and solar activity was established for mean characteristics only. When individual phenomena were compared . . . the results were conflicting. While some investigators stated the existence of a definite relation, others refuted it. This discrepancy cannot be done away with unless viewed in the light of the impulse nature of solar activity. In comparing magnetic perturbations with the active region of the Sun, the phase of the impulse evolving in the active region needs to be taken into consideration. Geomagnetically active is mainly a distant positive phase of a geoactive impulse, and less so its zero-phase. This conclusion can be of importance for forecasting magnetic perturbations. And it also indicates the direction for further work in this field.

"On the other hand, the successful solution of the above discrepancies between the mean and individual characteristics of the relation of geomagnetic and solar activity points to the importance of the impulse conception of solar activity for the understanding of many problems of heliogeophysics. There is no doubt that this conception, along with the method of mapping based upon it, will later find a fruitful application to other heliogeophysical problems, as is not the case with connections between the activity of the Sun and certain phenomena taking place in the troposphere of the Earth, which have been investigated by Rubashev."

1390. GEOPHYSICAL WORK IN THE UNION OF SOVIET SOCIALIST REPUBLICS.—N. Pushkov. (*Terr. Mag. & Atmos. Elec.*, Dec. 1944, Vol. 49, No. 4, pp. 276–277.)

1391. SUMMARY OF THE YEAR'S WORK, TO JUNE 30TH, 1944, DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON.—J. A. Fleming. (*Terr. Mag. & Atmos. Elec.*, Dec. 1944, Vol. 49, No. 4, pp. 245–250.)

1392. ON THE DETERMINATION OF MAGNETIC VERTICAL INTENSITY, $Z$, BY MEANS OF SURFACE INTEGRALS [and the Separation of $Z$ into Parts $Z_e$ and $Z_i$ due to External and Internal Sources: Sequel to Vestine's Paper, 2059 of 1941].—J. H. Taylor. (*Terr. Mag. & Atmos. Elec.*, Dec. 1944, Vol. 49, No. 4, pp. 223–237.)

1393. CALCULATION OF VERTICAL COMPONENT ($Z$) FOR POTENTIAL FIELDS FROM OBSERVED VALUES OF DECLINATION ($D$) AND HORIZONTAL INTENSITY ($H$).—N. Davids. (*Terr. Mag. & Atmos. Elec.*, Dec. 1944, Vol. 49, No. 4, pp. 239–242.)

1394. FURTHER STUDIES ON THE ORIGIN OF COSMIC RAYS: HELIUM-ANNIHILATION RAYS AND THE CAUSE OF THEIR VARIABILITY WITH TIME.—R. A. Millikan, H. V. Neher, & W. H. Pickering. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, pp. 295–302.)

Authors' summary:—"We find definite evidence that a new band of rays which we interpret as helium-annihilation rays does come in vertically at about the predicted latitude. We present a discussion of the possible composite character of the so-called silicon-annihilation and of the so-called oxygen-annihilation band. We then bring forward an explanation of the cause of our large and already reported variability in the cosmic-ray intensities found in high-altitude electroscope flights at Bismarck, Omaha, and Oklahoma City. We also make a new and more accurate determination of the value of the field-sensitive and the non-field-sensitive components of the incoming cosmic rays."

1395. THE ENERGY SPECTRUM OF THE PRIMARY COSMIC RADIATION [Comparison of Experiment & Theory, leading to Suggested Energy-Distribution Curve as Possible Alternative to Discontinuous (Atom-Annihilation) Distribution].—S. Kusaka. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 56, No. 11/12, p. 354: summary only.)

1396. ATOM-ANNIHILATION COSMIC RAYS AT MEXICO CITY [Analysis of Schremp & Baños's Directional Intensity Results (with "Cosmic-Ray Telescope", 47 of 1941 and Reference "2") and Comparison with the Millikan–Neher–Pickering Atom-Annihilation Hypothesis of Origin of Cosmic Rays].—D. T. Warren. (*Phys. Review*, 1st/15th Nov. 1944, Vol. 66, No. 9/10, pp. 252–254.)

1397. SLOW MESONS IN COSMIC RADIATION [Estimation of Intensity by Bhabha's Counter-Telescope Method].—S. V. C. Aiya & R. C. Saxena. (*Phys. Review*, 1st/15th Oct. 1944, Vol. 66, No. 7/8, pp. 183–186.) For previous use of this method *see* 1849 of 1944.

1398. ON THE ORIGIN OF MESONS AND OF THE FASTEST COSMIC RAYS, *and* ON THE RESULTS OF THE COSMIC RAYS EXPEDITION, 1942 [and the Presence, at about 3000 m Height, of Many Particles with Ionising Power 2–3 Times Greater than That of High-Energy Electrons & Mesons: probably Slow Protons: the Problem of Their Production].—J. Frenkel: A. I. Alikhanov & A. I. Alikhanian. (*Journ. of Phys.* [of USSR], No. 5, Vol. 7, 1943, p. 246: summaries only, in English.) *See* also No. 1, Vol. 8, 1944, pp. 62–63.

1399. THE TRANSITION EFFECT OF PENETRATING SHOWERS: *also* THE BAROMETER EFFECT OF PENETRATING SHOWERS: *and* SOME ASPECTS OF THE PRODUCTION OF MESONS AND THE BAROMETER EFFECT OF PENETRATING SHOWERS.—L. Jánossy & G. D. Rochester: L. Jánossy. (*Proc. Roy. Soc.*, Ser. A, 30th Nov. 1944, Vol. 183, No. 993, pp. 181–185: pp. 186—190: pp. 190–202.)

1400. THE ENERGY SPECTRUM OF ELECTRONS IN THE ATMOSPHERE ARISING FROM THE DISINTEGRATION OF MESOTRONS.—H. E. Stanton. (*Phys. Review*, 1st/15th Aug. 1944, Vol. 66, No. 3/4, pp. 48–56.)

1401. PRODUCTION OF SINGLE MESOTRONS BY NON-IONISING RADIATION AT ALTITUDES OF 10 600 FT AND 14 200 FT [Mt Evans & Echo Lake Experiments indicating Photons to be the Most Probable Agent].—J. Tabin. (*Phys. Review*, 1st/15th Aug. 1944, Vol. 66, No. 3/4, pp. 86–91.)

1402. THE MESOTRON MOMENTUM SPECTRUM AT 4.35 KM ALTITUDE [and Its Sharp Maximum between 1 and $2 \times 10^8$ eV/$c$].—D. B. Hall.

(*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, pp. 321–325.)

1403. THE SPECTRUM OF THE SOFT COMPONENT IN AIR AT HIGH ENERGIES.—I. Pomeranchuk & A. Kirpichev. (*Comptes Rendus* (*Doklady*) *de l'Ac. des Sci. de l'URSS*, 10th Oct. 1943, Vol. 41, No. 1, pp. 18–20 : in English.)

1404. ON NEUTRAL PARTICLES IN COSMIC RAYS.—V. Wechsler. (*Journ. of Phys.* [of USSR], No. 1, Vol. 7, 1943, p. 48 : in English.)

The writer ends : " We may . . . conclude that the ionising component on the sea level does not carry any noticeable part of the total energy of cosmic rays. Therefore, if on the boundary of the earth's atmosphere there falls a considerable quantity of neutral particles, then we shall have to consider that they are absorbed by the atmosphere to a considerable extent."

1405. COMMITTEE ON COORDINATION OF COSMIC-RAY INVESTIGATIONS [Activities during Year ending June 30th, 1944].—J. A. Fleming. (*Terr. Mag. & Atmos. Elec.*, Dec. 1944, Vol. 49, No. 4, pp. 251–253.)

1406. SLOPES IN THE INDIAN ATMOSPHERE.—S. N. Sen & S. P. Sircar. (*Sci. & Culture* [Calcutta], Jan. 1945, Vol. 10, No. 7, pp. 305–308.)

## ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

1407. LIGHTNING CURRENTS.—G. D. McCann. (*Journ. Applied Phys.*, Jan. 1945, Vol. 16, No. 1, Supp. p. xviii : summary only, with curves.) For another summary *see* 3410 of 1944.

1408. THE EQUILIBRIUM OF SMALL IONS AND NUCLEI [Experimental Test of Equilibrium-Equation, and Determination of Coefficient *b* : Computed Values for Combination-Coefficients between Charged Nuclei & Small Ions : Possible Existence of Multiple Charged Nuclei].—P. J. Nolan & R. I. Galt. (*Terr. Mag. & Atmos. Elec.*, Dec. 1944, Vol. 49, No. 4, p. 254 : summary of *Roy. Irish Acad.* paper, 1944.)

1409. SUMMARY OF THE YEAR'S WORK, TO JUNE 30TH, 1944, DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION OF WASHINGTON.—J. A. Fleming. (*Terr. Mag. & Atmos. Elec.*, Dec. 1944, Vol. 49, No. 4, pp. 245–250.)

## PROPERTIES OF CIRCUITS

1410. THE LOADING OF A LECHER-WIRE LINE BY AN INDUCTIVELY COUPLED LOAD.—J. Gensel. (*T.F.T.*, Feb. 1944, Vol. 33, No. 2, pp. 23–31.)

From the Siemens & Halske laboratories. Author's summary :—" In u.s.w. technique a load (particularly an aerial) is often coupled to an oscillating Lecher system by means of a coupling loop, as shown diagrammatically in Fig. 1a. The question arises in what way the aerial resistance $\mathfrak{R}_A$, together with the impedance of the coupling loop, affects the properties of the Lecher-wire line, and especially how the impedance $\mathfrak{R}$ of the Lecher line is altered by the load coupled to it. It is shown that for the latter problem an equivalent circuit can be drawn, consisting of the unaltered Lecher line and a concentrated resistance, either $\mathfrak{R}'_{ers}$ at the locality of the load or $\mathfrak{R}''_{ers}$ at the end of the line (Fig. 1b). This equivalent circuit is derived [first for the general case (Fig. 5) and then, in simpler form (Fig. 6) for a coupling about in the middle of a Lecher system having a length of approximately $\lambda/2$ : a further assumption is that the " coupling length " $l$ is small compared with the total length, so that the electrical angle $\alpha l$ for the wavelength in question is small compared with $\pi$ : these assumptions are adhered to in all the subsequent work, as valid for a large number of practically important cases (for example, a Lecher line forming the oscillatory circuit of an u.s.w. generator and coupled at its current antinode —*i.e.* its mid-point—to an aerial). Eqn. 25 gives $\mathfrak{R}'_{ers}$, but since this concentrated resistance at the locality of the coupled load has no direct physical significance, it is " transformed " into the concentrated resistance $\mathfrak{R}''_{ers}$ at the end of the line, given by eqn. 26 : $\mathfrak{R}''_{ers} = (\mathfrak{R}_A + jZ_0\alpha l)/k^2(\alpha l)^2$].

" The equivalent circuit is investigated more closely for a particular case [where $l_1$, the far end of the Lecher system, beyond the " coupling length " $l$, is exactly $\lambda/4$] with the result that a noteworthy connection with transformer theory is established [since, according to the coupling-factor curves of Fig. 3, $k$ is at most 0.7, the " transformer " has a rather poor efficiency—a coupling of at most 70% or a leakage $\sigma = 1 - k^2$ of at least 50% : top of p. 28].

" Finally the question is considered of how the natural wavelength of the Lecher system is altered by the coupled load " : first for the case of a real load (" we see from eqn. 40 that the detuning of our system is always negative ; that is, the natural wavelength is always *shortened* by the coupling of a real load ; the more so, the closer the coupling " : but the shortening is always fairly small, and at most equals the ratio of the " coupling length " $l$ to the total length of the system. The detuning is shown in Fig. 11 for the case where $2\pi l/\lambda_0 = 0.1$, which for $\lambda_0 =$ 1 m means a " coupling length " $l$ of about 1.6 cm, and with $k^2_{max} = 0.5$ gives a maximum detuning of $v_0 = 1.6\%$).

Lastly the detuning due to an imaginary load is discussed. For an inductive load the curve corresponding to Fig. 11 for the real load is very similar, and again the effect on the Lecher line is quite small. On the other hand, for a capacitive load the equation for the relative detuning, eqn. 49, although similar in form to eqn. 39 for a real load, leads to the quadratic eqn. 50, so that the Lecher system with a coupled capacitance has two detunings (eqn. 51 and Fig. 15) and thus possesses two different natural wavelengths. This point is investigated further, leading to the summarising statement that if the loading capacitance is varied from small to large values, the natural wavelength first increases in comparison with the undetuned value, the detuning becoming serious as soon as the terminating capacitance approaches the value $C_A = C_S/\alpha_0^2 l^2$ (eqn. 54). " In Fig. 15 that corresponds to the point $C_A/C_S = 100$, and we see that here the detuning, after reaching its highest positive value, suddenly jumps to an equally high negative value. From here onwards the detuning is always negative, and decreases, as $C_A$ is still further increased, to the short-circuit value $v_0$". A more precise estimate of the critical value for $C_A'$ is that given by eqn. 55, which in the case considered differs from the eqn. 54 value by about 5%.

1411. PAPER ON THE DESIGN OF "BUTTERFLY" CIRCUITS FOR ULTRA-HIGH FREQUENCIES [giving Continuously Adjustable Four-to-One Tuning Ratio without Sliding Contacts: Very Compact].—General Radio. (*Gen. Rad. Experimenter*, Oct. 1944.) *See* also back cover of *Journ. Applied Phys.*, Jan. 1945, Vol. 16, No. 1.

1412. LAW-LINEARITY OF SEMICIRCULAR-PLATE VARIABLE CONDENSERS.—Griffiths. (*See* 1537.)

1413. THE PINCH EFFECT: AN ELECTROSTATIC PHENOMENON [Editorial on the Flow of Electrons constituting a Current in a Copper Wire, in reply to Query whether the "Pinch" Effect (*e.g.*, in Electric Furnaces) may occur in a Solid Conductor, and If Not, Why Not?]. — G. W. O. H. (*Wireless Engineer*, March 1945, Vol. 22, No. 258, pp. 105–106.)

1414. "COMMUNICATION CIRCUITS: SECOND EDITION" [Book Review].—L. A. Ware & H. R. Reed. (*QST*, Oct. 1944, Vol. 28, No. 10, pp. 37 and 98.)

1415. EQUIVALENT NETWORKS FOR THE THREE KINDS OF TRIODE CIRCUITS [Grounded-Cathode, Grounded-Anode (Cathode-Follower), & Grounded-Grid: Special Properties of the Last: the Double-Triode Circuit with Cathode-Intercoupling ("Interesting as a Non-Reversing One-Way Voltage & Current Amplifier with Less than Half the Transconductance and Much Less Capacitive-Feedback Coupling"].—H. A. Wheeler. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 59–60: summary only.)

1416. METHOD OF BALANCING FOR DIRECT-CURRENT AMPLIFIERS WITH TWO OR MORE STAGES [D.R.P.744 287 of 13/2/41: applicable also to Phase-Reversing Circuits].—Anon. (*T.F.T.*, June 1944, Vol. 33, No. 6, p. 127.)

"The balancing of multi-stage d.c. amplifiers is in general a matter of extreme difficulty, owing among other things to the fact that a change in one stage brings about changes in all the subsequent stages, and these have to be eliminated. This involves as a rule a great expenditure of time and trouble, if indeed it can be done successfully at all. Further, damage or destruction to the valves may occur, because for instance the output valve may receive, if unbalanced, a high positive grid bias which would lead to an intolerable overloading. In order to keep the conditions reasonably within bounds so that a rapid and certain balancing can be accomplished, the practice has been to cut down the number of valves and to use, as much as possible, only two stages. Then, however, it becomes necessary, in order to obtain sufficient amplification, to employ large external resistances: but this leads to an undesirable narrowing of the frequency-band, particularly when the phase relations between oscillations of different frequencies have to be considered, as is unavoidable in amplifiers for measuring purposes, though not in those for music or speech. A further difficulty arises in the course of regulating the amplification. If the voltage under measurement has a d.c. fundamental component, or if for special reasons the amplification control cannot take place in the first stage, then a variation of amplification by the adjustment of a potential-divider must produce a shifting of the working point which will necessitate a fresh balancing.

"According to the present invention, these difficulties are avoided if, in the d.c. amplifier of Fig. 23 (containing also $R$ and $C$ sections) a direct voltage with an inherent or added alternating component is applied. The amplifier is first adjusted (with the switches in the position shown) for alternating current: the switch 7 of the first valve is then put over and the battery-tap 12 adjusted till the same anode current is restored. The same thing is done from stage to stage. If the d.c. fundamental component of the voltage under test changes, all that is necessary is to turn the switch 7 of the first valve back to the $R, C$ position and to balance this valve anew. The same applies when the amplification is adjusted. The inclusion of the $R, C$ sections has the further advantage of providing an easy way of telling whether any unsatisfactory behaviour is due to the amplifier itself or to a change in the fundamental d.c. component of the voltage under measurement: and the fault can easily be kept within the limits of the amplifier. The principle of the invention can be applied also to phase-reversing circuits. The inventor gives also the circuit for a mains-adaptor unit for the direct-current amplifier in question."

1417. AMPLIFIER ARRANGEMENT FOR THE AMPLIFICATION OF D.C. OR LOW-FREQUENCY A.C. VOLTAGES [D.R.P.743 279 of 12/7/1936].—Anon. (*T.F.T.*, June 1944, Vol. 33, No. 6, p. 128.)

For such voltages, to make full use of the valve amplification (particularly of screen-grid valves) it is possible to use a saturated electron-discharge gap as external resistance: such a gap may take the form of a tungsten-cathode diode [*cf.* Durnford, 1039 of April] or of an illuminated photocell. Amplifications up to 600 are thus obtainable. It is also possible to use two similar pentodes, one as amplifier and the other as external resistance: "for this purpose the effective anode voltages of the two valves are to be made equal. The working point of both valves thus lies, for high anode voltages, in the region of steeper slope. Half the amplification factor of each pentode, which is around 600, is utilised." According to the present invention, however, the working point is so chosen that the ratio $S/i_a$ is a maximum. The inventor gives the mathematical derivation of this condition: an amplification of about 8000 should be attainable.

1418. CIRCUIT ARRANGEMENT WITH TWO SECONDARY-EMISSION VALVES [D.R.P.744 616 of 1/11/40].—Anon. (*T.F.T.*, June 1944, Vol. 33, No. 6, p. 127.)

"Various circuits with secondary-emission valves have already been published. The subject of the present invention is an amplifier connection whose input circuit works in push-pull and which allows the full amplification of the secondary-emission valves to be made use of. In Fig. 22 the cathodes of the two valves 1 and 1′ are denoted by 2 and 2′, the control grids by 3 and 3′, the screen grids by 4 and 4′, the anodes by 5 and 5′, and the s.e. cathodes by 6 and 6′. The signal voltage is introduced at 16, 17 through the oscillatory circuit 18: the output voltage is taken off at 19, 20. According to the invention, the anode of each valve is connected to the s.e. cathode of the other valve. The action is as follows:—Owing to the alternating voltage applied in push-pull to the two grids 3, 3′, there arise, in the two valves, anode alternating currents which are in counter-phase to each other and which produce at the ends of the [common] impedance 12 an amplified alternating voltage. The s.e. current set free at the auxiliary [s.e.] cathodes 6, 6′ flows in sympathy with the anode alternating currents but in counter-phase to these. As a result, the s.e. alternating current of valve 1 will be in phase with the anode alternating current of valve 1′, and the same applies to valves 2, 2′. The alternating voltage at the impedance 12 is thus amplified."

1419. PRACTICAL APPLICATIONS OF SIMPLE MATHEMATICS: PART VI—CONSIDERATIONS IN PUSH-PULL-AMPLIFIER DESIGN: PART VII—PUSH-PULL OPERATING CHARACTERISTICS.—E. M. Noll. (*QST*, Oct. & Nov. 1944, Vol. 28, Nos. 10 & 11, pp. 47–49 & 39–40 and 90.)

1420. THE "PHASE-COMPRESSOR" [1041 of April: Correction to Typographical Error in Sign].—D. H. Parnum. (*Wireless World*, Feb. 1945, Vol. 51, No. 2, p. 38.)

1421. FORMULAE AND NOMOGRAMS FOR THE COMPLEX CALCULATION OF WIDE-BAND AMPLIFIERS.—E. Riegel. (*Funktech. Monatshefte*, Sept. 1942, No. 9, pp. 121–132.)

1422. VOLTAGE-TRANSFORMATION OF *R-C* NETWORKS, AND ITS CALCULATION.—S. Naumann. (*Funktech. Monatshefte*, Jan. 1943, No. 1, pp. 13–16.)

1423. A PUSH-PULL RESISTANCE-CAPACITY COUPLED OSCILLATOR [for Frequencies between 0.1 c/s and 80 kc/s].—W. F. Lovering. (*Phil. Mag.*, Nov. 1944, Vol. 35, No. 250, pp. 715–735.)

"Elaborate decoupling is usually necessary to minimise the bad effects of the h.t. source impedance. Three-phase oscillators have been described using three valves, each handling a signal 120° out of phase with that handled by the other valves (Aughtie, ref. "3": van der Pol, ref. "4"). With these circuits there is no alternating component in the current drawn from the h.t. source and the effects of supply impedance are thus removed. Though useful for some purposes, these oscillators are rather complicated and hard to adjust.

"This article describes a simple two-valve oscillator which, by the use of a push-pull connection, provides freedom from h.t. impedance troubles and at the same time gives the improvement in wave-form which is usual with push-pull circuits . . . The output wave-form and frequency stability are both very good, and are to a great extent independent of the characteristics of the h.t. and l.t. sources used. Four types of feedback circuit are analysed and compared, and the complete oscillator circuit is also analysed. It is shown that a multivibrator, using triode valves and short time constants, can be considered as one form of this type of oscillator.

"Circuit values are given for oscillators for 500 c/s, in which frequency drift is less than one-tenth of 1%, and details of very low frequency oscillators are given," the low-frequency limit attained (with a reasonably close approximation to a sine-wave) having a period of 50 seconds. "At such low frequencies the effect of dielectric polarisation is very marked; the capacities of the condensers are very much greater than their nominal values, and power losses in the dielectric may be expected to exert an influence."

Appendix II derives "the equation for oscillation taking account of anode/grid capacity."

1424. A CIRCUIT STUDY [prompted by Ginzton & Hollingsworth's "Phase-Shift Oscillators," 2161 of 1941: a Circuit possessing Exactly the Same Properties, & using the Same Number of Circuit Elements, as the Widely-Used Wien Circuit].—B. Dueño. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 66–67.)

1425. THEORY OF THE MULTIVIBRATOR [introduced by a Discussion of the Eccles–Jordan Trigger Circuit].—Webb & Becker. (*See* 1534.)

1426. TRIODE LINEAR SAW-TOOTH-CURRENT OSCILLATOR.—Malling. (*See* 1561.)

1427. PRODUCING RECTANGULAR R.F. PULSES OF KNOWN AMPLITUDE.—Piggott. (*See* 1536.)

1428. CIRCUIT FOR THE PRODUCTION OF RECTANGULAR PULSES FROM PULSES WITH ROUNDED FLANKS.—Anon. (*See* 1517.)

1429. INTRODUCTION TO TRANSIENTS: PART I [Graphical and Mathematical Treatment of Lumped Linear Circuits excited by Non-Sinusoidal Wave-Forms under Steady-State Conditions.]—B. Dudley. (*Electronics*, Aug. 1944, Vol. 17, No. 8, pp. 132–139 and 392..399.) First of a "serialised elementary treatment."

1430. THE PHYSICAL REALISABILITY OF ELECTRICAL NETWORKS HAVING PRESCRIBED CHARACTERISTICS, WITH PARTICULAR REFERENCE TO THOSE OF THE PROBABILITY-FUNCTION TYPE.—F. F. Roberts & J. C. Simmonds. (*Phil. Mag.*, Nov. 1944, Vol. 35, No. 250, pp. 778–783.)

"In two earlier papers (1158 & 3827 of 1944) the properties of exponential-recurrent and probability-function electrical pulses have been discussed, and it has been shown that interesting results are obtained when circuits having probability-function responses are excited with probability-function pulses. For example, if a pulse of this form is applied to a network also of this form, then the output wave has the same mathematical form as the applied pulse. However, in the earlier discussions, although a practical means of approximating the theoretical pulse wave-form was mentioned, no consideration was given to the practical possibility of obtaining the corresponding frequency response combined with the linear phase response tacitly assumed throughout the analysis. Discussion of this particular point would seem justified, for it may appear at first sight that the networks involved are not realisable in practice."

It is first shown that a probability-function amplitude response and a linear phase response are physically consistent, provided that these responses are restricted to a finite frequency range, however large. Next, a possible method is given of designing a network with a probability-function type of response : " it is seen that a tolerably good approximation [amplitude Fig. 2, phase Fig. 3] can be obtained with a value of $r$ equal to 4, that is, with eight simple sections in the composite network, and that the degree of approximation is closest in the region of low attenuation, where errors are more likely to have disturbing effects on the transient response."

Finally, it is shown that a high-pass response of probability form, combined with linear phase response, can be obtained by a suitable connection (in parallel on the input side and in series on the output side, through isolating transformers or valve stages if necessary) of such a composite network and a network with the response of eqn. 22, the response of a delay network with fixed attenuation.

1431. Introduction to the Construction of Filters according to the Theory of the Wave Parameters.—K. H. Haase. (*T.F.T.*, June 1944, Vol. 33, No. 6, pp. 107–120.)

" Content and purpose of the work :—The laboratory engineer often finds himself faced with the need, for experimental set-ups, of filters with less rigid technical requirements than those of industrially manufactured filters—as to economy in material and labour, quality of components, and constancy under variations of temperature, for example. In many cases he possesses no very comprehensive knowledge of this special field of communication engineering, and is little disposed to delve into the literature intended rather for the specialist.

" The present paper is designed to give him a short survey of the theory [as developed by Piloty, 2477 of 1937 and 2226 of 1938] so far as a knowledge of it seems necessary for the construction of filters for laboratory use, and to bring together in three tables the individually known formulae by which the circuit components of a filter network can be calculated from the given frequency of the attenuation poles, cut-off limits, and characteristic impedance. Finally, some examples are worked out, some photographs illustrate two actual filters constructed from easily made parts, and some measurements are given for comparison with the pre-calculated results. The work is limited to low-pass, high-pass, and band-pass filters, the less practically important band-blocking filter being omitted."

One of the examples worked out (pp. 118–120) is a filter to have a pass-band from 30.7 to 34.5 kc/s, the practical cut-off limits lying 1 kc/s below and above these frequencies : in the pass-band the filter is to be matched to 1000 ohms : the attenuation in the cut-off region is to be as high as possible, and not less than 8 nepers. On account of the components available, the inductances are not to exceed 6 mH, nor the capacitances 0.5 $\mu$F. It is this filter that is illustrated in the photograph, Fig. 15b. Of the two graphical techniques employed, the first is the one developed by the present writer and dealt with in 1307 of 1942, and the second is the " template " method developed by Rumpelt and dealt with in 729 of 1943.

1432. Analysis of Voltage-Regulator Operation.—W. R. Hill, Jr. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 38–45.)

Author's summary :—" The performance of any regulator circuit is analysed in terms of two parameters defined as the internal resistance and the regulation factor [" The analysis of regulator operation in terms of two parameters was suggested by Hunt & Hickman (1691 of 1939). The present article extends this analysis to the use of equivalent circuits and alternating components familiar to the communications engineer "]. These two factors together with a simple equivalent circuit permit calculation of the regulator performance in conjunction with any load circuit and d.c. supply.

" Typical regulator circuits are analysed to evaluate the two parameters and to show the effect of circuit changes in improving regulator performance. A compensated circuit is presented [Fig. 5] which makes it possible to provide an output voltage that is substantially independent of any input-voltage or load-current change."

1433. The Servo Problem as a Transmission Problem [and the Application of the Nyquist and Bode Methods, so useful in Electrical-Feedback Amplifier Design].—E. B. Ferrell. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 54–55 : short summary only.)

## TRANSMISSION

1434. On a Possibility of Generating Very Strong Ultra-Short Waves by Means of Magnetrons with Density-Compression [Velocity-Modulation].—H. H. Klinger. (*Funktech. Monatshefte*, Jan. 1943, No. 1, pp. 8–9.)

Suggested combination of Jobst's " shock excitation " of u.s.w. oscillations (4354 of 1939) with Rice's magnetron with inhomogeneous magnetic field (4006 of 1936.)

1435. Reflex Oscillators [and Their Behaviour : Power Production, Electronic Tuning, Frequency Variation with Resonator Voltage, Effect of Modulation Coefficient, & Influence of Load].—J. R. Pierce. (*Proc. I.R.E.*, Feb. 1945, Vol. 33, No. 2, pp. 112–118.)

1436. A Vacuum-Contained Push-Pull Triode Transmitter [Resonant Circuits inside the Evacuated Envelope, to reduce Lead Effects and increase Anode Dissipation].—H. A. Zahl, J. E. Gorham, & G. F. Rouse. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 60 : summary only.)

" The combined tube, transmitter, and appropriate shielding occupy a much smaller volume than is required for external resonant circuits at frequencies of 200 to 700 Mc/s, and weigh only a few pounds . . . "

1437. Frequency Stabilisation in the 100–1000 Mc/s Band [Short Survey].—J. Menke.

(*Funktech. Monatshefte*, Oct. 1942, No. 10, pp. 142–143.)

" The best and latest type of stabilisation in this frequency band is the separate-excitation method, now possible for frequencies up to about 650 Mc/s." Stability up to $5 \times 10^{-7}$ is thus attainable and modulation and other difficulties are avoided. " Experimental results have not yet been published, and therefore a later paper will deal with this problem " : *see* " Generation of Decimetric Waves with Diodes," 3132 of 1944.

1438. Back - Coupled Valves as Frequency Modulator in the Ultra-Short-Wave Field [Frequency Deviation over ±500 kc/s attainable in Decimetric-Wave Range without Appreciable Amplitude Modulation].—J. Menke. (*Funktech. Monatshefte*, Jan. 1943, No. 1, pp. 10–12.)

1439. Frequency and Phase Modulation [Criticism of Hund's Letter].—Stockman & Hok : Hund. (*See* 1451.)

1440. Historic Firsts : the Heising (Constant-Current) Modulator.—R. A. Heising. (*Bell Lab. Record*, Jan. 1945, Vol. 23, No. 1, pp. 6–7.)

1441. Frequency Adjustment of Quartz-Oscillator Plates by X-Rays, *and* Equipment for Frequency Adjustment of Quartz-Oscillator Plates by X-Rays.—Frondel : Roddy. (*See* 1529 & 1530.)

1442. The Standardisation of Quartz-Crystal Units, and Other Papers on Piezoelectric Crystals.—Van Dyke, Fair, & others. (*See* 1525/8 & 1531/3.)

1443. Pi Networks as Coupled Tank Circuits [Theory : Design Procedure : Curves for Matching the Output Stage directly to Feeder or Aerial].—F. D. Schottland. (*Electronics*, Aug. 1944, Vol. 17, No. 8, pp. 140–144.)

1444. Papers relating to Oscillators of Various Kinds.—(*See* under " Properties of Circuits.")

1445. An Electronic Keyer : Making Use of Inked Tape.—Haskins. (*See* 1715.)

## RECEPTION

1446. Notes on Selectivity-Design Parameters of Super-Regenerative Receivers [General Impression that S-R Reception & Poor Selectivity are Synonymous is Erroneous : Tests on Specific Designs reviewed & analysed].—A. Easton. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 54 : four-line summary only.)

1447. New Advance in Frequency-Modulation Receivers : the " Frequency-Dividing Locked-In-Oscillator F.M. Receiving System."—G. L. Beers. (*Science*, 20th Oct. 1944, Vol. 100, No. 2599, Supp. p. 10 : paragraph only.) *See* 1448, below.

1448. A Frequency-Dividing Locked-In-Oscillator Frequency-Modulation Receiver [New Type of System giving Improved Adjacent-Channel Selectivity and Other Advantages].—G. L. Beers. (*Proc. I.R.E.*, Dec. 1944, Vol. 32, No. 12, pp. 730–737.)

A continuously operating local oscillator is frequency-modulated by the signal : in a specimen receiver the oscillator is locked-in with the signal at one-fifth of the i.f. With this five-to-one relation between i.f. and oscillator frequency, an equivalent reduction in the frequency variation of the local oscillator is obtained : signal-frequency variations of, say, ±75 kc/s are reproduced as ±15 kc/s variations in the oscillator frequency. Thus the locked-in oscillator reduces the frequency deviation corresponding to any modulation frequency but does not change the modulation frequency. The f.m. signal derived from the oscillator is applied to a discriminator designed for this reduced range of frequencies.

By restricting the lock-in range of the oscillator to follow only the frequency variations which occur within the desired-signal channel, a material improvement in adjacent-channel selectivity is obtained : this is accompanied by an increase in distortion when the tuning is to one side of the desired signal, but this last effect may be considered to assist in the proper tuning of the receiver. Both oscillographic and field tests showed also a general superiority of the new system as regards impulse-noise reduction.

A voltage gain of about 20 is obtained at a frequency other and lower than the i.f., with the result that a corresponding improvement in freedom from over-all feedback is secured. Further, the output voltage of the oscillator is independent of the strength of the received signal—in fact, the same voltage is applied to the discriminator when no signal is being received as when the receiver is tuned to a near-by station : this makes it unnecessary to employ the customary arrangements for minimising any amplitude variations that may occur in the incoming signal.

1449. The Design of an Intermediate-Frequency System for Frequency-Modulated Receivers.—W. H. Parker, Jr. (*Proc. I.R.E.*, Dec. 1944, Vol. 32, No. 12, pp. 751–753.)

The band of frequencies assigned to f.m. broadcasting, 42–50 Mc/s, dictates the use of a receiver i.f. somewhat greater than 4 Mc/s in order to avoid image interference from other f.m. transmissions, and actually the commonest frequency at present is 4.3 Mc/s. But " with a view to the possibility that the f.m. band may be extended beyond 50 Mc/s, and also with an idea of standardising with television-receiver practice, an i.f. value of 8.25 Mc/s in superheterodyne receivers seems in order. This discussion is limited to the problems arising in the design of the i.f. amplifier when two stages are employed, using a frequency of 8.25 Mc/s, and to the transformer-design problems involved in coupling a limiter to a frequency discriminator." The i.f. amplifier described has given satisfactory results in several experimental receivers previously designed for 4.3 Mc/s operation, and indications are that no difficulties due to instability will arise when the receivers are built in production.

1450. Exalted-Carrier Amplitude- and Phase-Modulation Reception [for Elimination of Harmonic Distortion produced by Fading of Carrier with respect to Sidebands: Component Parts of Receiver: Analyses of Selectivity Effect due to Carrier Exaltation and of E.C. Diode & Multigrid Detection: Optimum Degree of C.E. and Effect of Carrier Limiting: Reception Results with E.C. Diversity System].—M. G. Crosby. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 54: short summary only.)

1451. FREQUENCY AND PHASE MODULATION [Criticism of Hund's Letter on the "Still-Existing Confusion" (39 of January)].—H. Stockman & G. Hok: Hund. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 66.) For the writers' original paper on f.m. terminology *see* 2547 of 1944.

1452. THE REDUCTION OF INTERFERENCE BY THE USE OF FREQUENCY MODULATION [in Ultra-Short & Short-Wave Broadcasting: Survey].—J. G. Lang. (*Funktech. Monatshefte*, Oct. 1942, No. 10, pp. 133–141.)

Case of unmodulated interference: of a continuous spectrum of interference: of frequency-modulated interference: effect of distortions on the quality of f.m. reception: design considerations for receivers. Special attention is given to the work of Vellat, 79 & 678 of 1942 [and 1564 of 1944].

1453. MEASUREMENT OF RECEIVER IMPULSE-NOISE SUSCEPTIBILITY [Description of Method: Typical Data for Pre-War F.M. Receivers: Application to Television-Receiver Measurements: etc.].—J. B. Minter. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 58: short summary only.)

"The general application of this method should result in improved impulse-noise rejection in post-war f.m. and television receivers . . ."

1454. PRACTICAL METHODS OF SHIELDING DIELECTRIC-HEATING INSTALLATIONS [Discussion of Field Strengths to be Expected around Unshielded Installations: Theoretical & Experimental Determination of the Shielding Required: Locating Points of Maximum Radiation: etc.].—G. W. Klingaman & G. H. Williams. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 57: short summary only.)

1455. ANALYSIS OF HIGH-FREQUENCY IGNITION CIRCUITS.—A. W. Robinson, Jr. (*Elec. Engineering*, Dec. 1944, Vol. 63, No. 12, Transactions pp. 916–919.)

1456. THE RADIO INTERFERENCE OCCURRING IN THE UNDERGROUND WORKING OF COAL MINES.—R. Burgholz: B. Beckmann. (*T.F.T.*, June 1944, Vol. 33, No. 6, pp. 120–126.)

A survey by Beckmann of Burgholz's report in the *Techn. Überwachungsverein Essen, Veröffentlichungen No. 1*, 1941/42. "With the continually increasing electrification of mines, requirements demanded of the communication services have been very greatly heightened. Not only multiple speech channels have become necessary, but also facilities for remote control and signalling. To develop new possibilities in this direction, the writer has made an investigation of various h.f. methods and their practicability [*see* also the report dealt with in 2809 of 1944]. With the help of interference-tracing and measuring instruments the h.f. interference occurring in mines has been examined as to its dependence on frequency and as to its sources . . ."

Fig. 1 gives the circuit diagram of the interference-tracing instrument, Fig. 2 that of the interference meter (with a change-over switch to enable the symmetrical and asymmetrical components to be measured in turn), and Fig. 3 the lay-out of the combined instruments. The measuring unit has frequency ranges of 150–400 and 500–1500 kc/s: a differential-condenser voltage-divider ("2" in Fig. 2) is adjusted until the pointer of the m.c. meter reaches a red mark, and the interference voltage is then read directly off the voltage-divider scale. At 160 kc/s the range is 35 000 to 80 000 $\mu$V, at 1400 kc/s it is 17 000 to 40 000 $\mu$V: the accuracy is within $\pm$ 0.5 neper. The measured values are related to a band-width of 2.2 kc/s: the equipment can be used for network voltages up to 250 v to earth.

Final summary:—"The interference measurements carried out by the writer in mines lead to the conclusion that a line-guided h.f. transmission below ground is practicable. If an interference voltage up to 1000 $\mu$V is taken as permissible on the line, only in a limited number of cases need interference-quenching measures be taken, provided that sections with overhead-supply lines for the mine-railway locomotives are avoided. In such sections the use of screened cable would be essential for satisfactory transmission. The critical consideration of the various transmission paths shows that for a regular service only the mechanical-conductor systems [*see* bottom of p. 125: "they allow the use of the simplest transmission methods and are present in all parts of the mine"], the telephone cables, and in special cases special carrier-current cable, are suitable [the power-system lines would require numerous h.f. blocking-devices, which would all have to stand up to the strains of the system: *see* beginning of section 3]. Taking into account the ordinary regular use of the apparatus and also its use in emergencies, transmitter powers of from half to one watt are found to be sufficient. Finally, some technical ideas on the accomplishment of telemetering by guided h.f. are discussed," the pulse-frequency method being recommended as being independent of fluctuations in the supply sources and in the transmission path: conversion of the meter readings into modulations of the pulse frequency may be carried out by change of resistance (Fig. 9) or of capacitance (Fig. 10).

1457. "NOISE FIGURES OF RADIO RECEIVERS" [3457 of 1944]: CORRECTION TO ERROR IN EQUATION.—H. T. Friis. (*Proc. I.R.E.*, Dec. 1944, Vol. 32, No. 12, p. 729.)

1458. WAVETRAPS: MODERN APPLICATIONS OF A WELL-TRIED DEVICE [with Particular Reference to High-Quality Receivers with Inherently Poor Selectivity].—S. W. Amos. (*Wireless World*, Feb. 1945, Vol. 51, No. 2, pp. 43–47.)

1459. COMMENTS ON HIGH FIDELITY [for Post-War Receivers & Broadcasting Systems].—Hanson. (*See* 1492.)

1460. THE APPLICATION OF DOUBLE-SUPERHETERODYNE RECEIVERS FOR BROADCAST RECEP-

TION [including "Novel Developments in respect to Shape Factor, Constructional Materials, & Tuning Methods"].—J. D. Reid. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 58–59: short summary only.) From the Crosley Corporation.

1461. A VERSATILE TWO-TUBE REGENERATIVE RECEIVER [Total Range 550 kc/s to 32 Mc/s: Entire Broadcast Band on a Single Coil].—W. E. Bradley. (*QST*, Oct. 1944, Vol. 28, No. 10, pp. 9–15.)

1462. "A 'QSL'-SIZE PORTABLE RECEIVER": CORRECTION TO CIRCUIT DIAGRAM.—P. J. Palmer. (*QST*, Oct. 1944, Vol. 28, No. 10, p. 96.) *See* 469 of February.

1463. THE FOXHOLE RECEIVER USED ON THE ANZIO BEACHHEAD [Razor-Blade/Safety-Pin (or better, Pencil-Lead) Detector].—J. Garton. (*QST*, Oct. 1944, Vol. 28, No. 10, p. 86.)

1464. ON THE WINDING OF THE UNIVERSAL COIL.—A. W. Simon. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 35–37.)

"The formula and method for calculating the gear ratio to be employed in winding universal coils were first deduced and discussed by the present author (1348 of 1937). Subsequently, using a slightly different notation and nomenclature, Hershey (3460 of 1941) covered essentially the same ground and evolved a somewhat simpler, though less accurate, formula. Hershey's theoretical treatment, however, is needlessly involved, and his formula can be deduced directly from that originally given by the present author simply by neglecting certain terms, and thus represents merely an approximate form of the same.

"The radio engineer who desires to make his own gear-ratio calculations is now confronted by two sets of nomenclature and formulas, and therefore it becomes desirable to present a critical review and comparison of the same, and that is the object of the present paper."

The practical importance of every engineer engaged in the design of such coils being able to carry out his own gear-ratio calculations is illustrated by a case in one plant where coil rejections were reduced from 30 to 3% as soon as the correct gear ratios were introduced. A table of gear-ratio formulae for frequently occurring values of $n$ (the number of cross-overs per turn) is included on p. 37.

## AERIALS AND AERIAL SYSTEMS

1465. SOME NEW ANTENNA TYPES AND THEIR APPLICATIONS [to V.H.F. & U.H.F. Broadcasting, Television, & Link Communication: Three Types, with Differing Polarisations, and Their Variations: Their Use Singly or in Directive Arrays: etc.].—A. G. Kandoian. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 56: short summary only.)

1466. THE LOADING OF A LECHER-WIRE LINE BY AN INDUCTIVELY COUPLED LOAD [especially an Aerial].—Gensel. (*See* 1410.)

1467. "HIGH-FREQUENCY TRANSMISSION LINES" [Book Review].—Willis Jackson. (*See* 1380.)

1468. APPLICATIONS OF HIGH-FREQUENCY SOLID-DIELECTRIC FLEXIBLE LINES TO RADIO EQUIPMENTS.—H. Busignies. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 53: summary only.)

1469. ON THE SOLUTION OF DEFINITE INTEGRALS OCCURRING IN ANTENNA THEORY.—S. Weinbaum. (*Journ. Applied Phys.*, Dec. 1944, Vol. 15, No. 12, pp. 840–841.)

"In the evaluation of the mutual impedance of antennas, integrals of a certain type often arise [*see* for example Harrison, 2720 of 1943]. These integrals, up to the present time, had to be evaluated numerically as no analytical expression for them was known." The writer shows how such integrals, and a similar one occurring in his own work, can be solved by the use of differential equations. The series in the final equations converge very rapidly for aerials of one wavelength or less.

1470. A CALCULATOR FOR TWO-ELEMENT DIRECTIVE ARRAYS [giving Horizontal Pattern only: Adaptable also (by Supplementary Rotary Element) to Arrays of More than Two Elements: Easily Constructed].—J. G. Rountree. (*Proc, I.R.E.*, Dec. 1944, Vol. 32, No. 12, pp. 760–767.)

"With a carefully constructed instrument of convenient size, an accuracy to three significant figures or better should be obtained": *cf.* Cronshey, 798 of March.

1471. PLYWOOD RADIO MASTS FOR SIGNAL CORPS.—(*Bell Lab. Record*, Jan. 1945, Vol. 23, No. 1, p. 22.)

## VALVES AND THERMIONICS

1472. A VACUUM-CONTAINED PUSH-PULL TRIODE TRANSMITTER.—Zahl, Gorham, & Rouse. (*See* 1436.)

1473. GRAPHICAL METHODS FOR ANALYSIS OF VELOCITY-MODULATION BUNCHING.—A. E. Harrison. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 20–32.)

*See* also 802 of March. Introduction: Applegate diagrams illustrate electron bunching: construction of an Applegate diagram: Applegate diagrams for reflex klystrons: beam-current distribution (Webster): electron-arrival-time curves: phase-shift due to distortion of the bunch: cascade-amplifier klystron (ref. "6"): computation of klystron efficiency: phase-shift from a graphical integration (Feenberg): conclusions (advantages of graphical methods: "first-order theories which assume small bunching voltages and correspondingly long drift times are not applicable to tubes with short drift distances," and even when first-order equations might apply, graphical analysis provides a physical picture which may give a better understanding of the electrical characteristics of the tube.

1474. KLYSTRON CHARACTERISTICS, *and* TWO-RESONATOR KLYSTRON OSCILLATORS.—C. Dodd: D. R. Hamilton. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 54: pp. 55–56: short summaries only, from the Sperry Gyroscope Company.)

1475. NEW MINIATURE TUBES [R.C.A. Heater-Cathode U.H.F. Types for Army & Navy, with All-Glass Bases].—R. L. Kelly & N. H. Green. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 57 : summary only.)

1476. A NEW VERY-HIGH-FREQUENCY TETRODE FOR MEDIUM POWER OUTPUT [Type 4-125-A].—C. E. Murdoch. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 58 : summary only.)

"A stable, efficient amplifier operating up to 200 Mc/s, and capable of power outputs of up to 800 w has been needed in several fields." The new valve "adequately covers this range and also permits circuit and component simplicity because of its design . . ." From the Eitel–McCullough Company.

1477. NEW TUBES : NEWLY RELEASED DATA ON G.E. AND EIMAC MILITARY TYPES [Four G.E. "Megatron" ("Lighthouse") Valves (One for Transmitting) and Some Eimac Pulse-Generating Types & Medium-Mu Triodes, 25 W Plate Dissipation : All for V.H.F. & U.H.F.].—General Electric : Eitel–McCullough. (*QST*, Oct. 1944, Vol. 28, No. 10, pp. 42–43 and 92, 94.)

1478. DISC-SEAL TUBES [and especially the "Lighthouse" Type (*see* also 1073 of April) : for Ultra-High Frequencies].—General Electric. (*Gen. Elec. Review*, Jan. 1945, Vol. 48, No. 1, pp. 50, 51.)

1479. INTRODUCING THE DISC-SEAL TUBE [*see* 1478, above : Factors limiting Operation of Grid-Controlled Valves at U.H. Frequencies : New Basic Principles in Valve Design : Cavity Circuits & the Development of the "Grid-Separation Circuit" : etc.].—E. D. McArthur. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 57–58 : summary only.) From the General Electric laboratories.

1480. VOLTAGE AMPLIFICATION BY SECONDARY-ELECTRON MULTIPLICATION [Survey, including the Question of Valve-Noise Reduction ("No Improvement by the Use of Electron Multipliers") and the Work of Behne and of Flechsig & Sandhagen (Fernseh Company : *see* 2415 of 1941)].—R. Filipowsky. (*Funktech. Monatshefte*, Jan. 1943, No. 1, pp. 1–8.)

1481. CIRCUIT ARRANGEMENT WITH TWO SECONDARY-EMISSION VALVES [in Push-Pull].—Anon. (*See* 1418.)

1482. ENHANCED THERMIONIC EMISSION [from Oxide-Coated Cathodes, by Electron Bombardment].—J. B. Johnson. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, p. 352.)

"A new type of electron emission from oxide-coated thermionic cathodes is disclosed by a method of measuring simultaneous thermionic and secondary emission . . . The emission which persists after the end of the bombardment can hardly be secondary emission but must be of thermionic origin, and presumably the equal rise of emission during the bombardment is of the same kind. This emission varies with the temperature of the target in about the same way as the steady emission, thus following roughly the Richardson law. It increases with bombarding voltage and current density, and may exceed the steady thermionic current in value. It is undoubtedly an enhanced thermionic emission excited by the electron bombardment.

"A natural assumption is that the increased emission is caused by a rise in target temperature caused by the bombardment. The temperature rise of the *surface* of the target may be calculated, and is far too small to explain the effect. One must conclude instead that the bombardment temporarily changes the thermionic activity of the oxide target.

"This effect no doubt explains the exponential rise with temperature that has been reported for the secondary-emission factor of oxide cathodes (Morgulis & Nagorsky, 1925 of 1939)" [for a temperature-dependence of s.e. from metallic surfaces, due to dissolved oxygen, *see* Suhrmann & Kundt, 812 of March].

1483. ARGUMENT ON THE PROLONGATION OF VALVE LIFE BY FILAMENT-VOLTAGE REDUCTION.—G. R. Abell, Jr. (*QST*, Oct. 1944, Vol. 28, No. 10, p. 62.)

1484. 28-VOLT OPERATION OF RECEIVING TUBES [Performance of Various Types of Pentodes & Triodes with Plate & Screen Voltages obtained directly from Aircraft Battery : Advantages & Difficulties : Grid-Leak Bias to minimise Effects of Grid Contact Potential & $G_m$ Variations : Performance of *RC*-Coupled Amplifiers].—C. R. Hammond, E. Kohler, & W. J. Lattin. (*Electronics*, Aug. 1944, Vol. 17, No. 8, pp. 116–119 and 379.)

1485. NEW DUTCH VALVES : THREE TYPES ONLY FOR ALL RECEIVING PURPOSES.—Philips Company. (*Wireless World*, Feb. 1945, Vol. 51, No. 2, p. 38.)

1486. AN ELECTROMETER TUBE AND ITS USE IN MINUTE MEASUREMENTS [down to $10^{-15}$ A and $10^{-4}$ V].—W. A. Hayes. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 56 : summary only.)

## DIRECTIONAL WIRELESS

1487. RADIOLOCATION : I—BASIC PRINCIPLES : II—HISTORY OF ITS DEVELOPMENT.—R. L. Smith-Rose. (*Wireless World*, Feb. & March 1945, Vol. 51, Nos. 2 & 3, pp. 34–37 & 66–70.) For "Diallist's" remarks on the development of radiolocation and on the term "radar" *see* the same issues, pp. 60 and 93.

1488. AIRCRAFT D.F. EQUIPMENT : 2—THE "MARCONATOR" : A SEMI-AUTOMATIC DIRECTION FINDER.—C. B. Bovill. (*Wireless World*, Feb. 1945, Vol. 51, No. 2, pp. 39–42.) For Part 1 *see* 1084 of April.

1489. APPLICATIONS OF HIGH-FREQUENCY SOLID-DIELECTRIC FLEXIBLE LINES TO RADIO EQUIPMENTS.—H. Busignies. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 53 : summary only.)

1490. AIRWAVES "SLEUTHS" [Radio Intelligence Division's Use of the "Snifter", the "Watchdog", & Adcock Long-Range Direction Finders on 40-Foot Towers].—F. C. C.

(*Sci. News Letter*, 12th Aug. 1944, Vol. 46, No. 7, p. 103.)

1491. HAMS IN THE R.I.D.: THE F.C.C.'S RADIO INTELLIGENCE DIVISION IN ACTION.—O. Read. (*QST*, Oct. 1944, Vol. 28, No. 10, pp. 18–23.)

## ACOUSTICS AND AUDIO-FREQUENCIES

1492. COMMENTS ON HIGH FIDELITY: DISCUSSION OF TECHNICAL, ECONOMIC, AND HUMAN CONSIDERATIONS INVOLVED IN HIGH-FIDELITY SOUND REPRODUCTION FOR POST-WAR RADIO RECEIVERS AND BROADCASTING SYSTEMS.—O. B. Hanson. (*Electronics*, Aug. 1944, Vol. 17, No. 8, pp. 130–131 and 385..391.)

Leading to the recommendation that the range 60–8000, or possibly 50–10 000 c/s, should be adopted for all broadcasting, including f.m., with special attention to the improvement of reproduction at the lower frequencies, rather than "publicising and creating a demand for 15 000 c/s receivers . . ."

1493. TELEVISION-RECEIVER SOUND CHANNEL [Summary of Discussion].—I.E.E. Radio Section. (*Electrician*, 5th Jan. 1945, Vol. 134, No. 3475, p. 16: *Wireless World*, Feb. 1945, Vol. 51, No. 2, p. 48.)

1494. A MIDGET LOUDSPEAKER 2½ INCHES IN DIAMETER FOR REPRODUCTION OF SPEECH AT NORMAL VOLUME. — Radio Components Manufacturers' Federation. (*Electrician*, 23rd Feb. 1945, Vol. 134, No. 3482, p. 174.) In a note on a "Secret Radio Exhibition".

1495. ALNICO V WILL REDUCE THE SIZE OF MAGNETIC STRUCTURE OF LOUDSPEAKERS BY 30%.—General Electric. (*See* 1596.)

1496. CALCULATION OF THE PIEZOELECTRIC EFFECT IN IONIC LATTICES OF THE ZINC-BLENDE TYPE.—H. Jaffe. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, pp. 357–358.) From the Brush laboratories.

1497. THE "TEXTOPHONE", A MODERN OFFICE INSTRUMENT AND PROFITABLE AID TO ORGANISATION [Steel-Wire Recording & Reproducing Equipment for Dictation, Telephone Recording, Conferences, etc.].—H. Wildbolz. (*Schweizer Arch. f. angew. Wiss. u. Tech.*, Oct. 1943, Vol. 9, No. 10, Supp. pp. 9–12.)

1498. A PUSH - PULL RESISTANCE – CAPACITY COUPLED OSCILLATOR [for Frequencies between 0.1 c/s and 80 kc/s].—Lovering. (*See* 1423.)

1499. "NIEDERFREQUENZ-VERSTÄRKER-EINRICHTUNGEN FÜR FERNSPRECH- UND RUNDFUNKLEITUNGEN" [L.F. Repeater Arrangements for Telephone & Broadcasting Circuits: Book Review].—Siemens & Halske. (*T.F.T.*, Feb. 1944, Vol. 33, No. 2, p. 40.)

1500. "DECIBEL NOTATION" [Book Review].—V. V. L. Rao. (*Sci. & Culture* [Calcutta], Dec. 1944, Vol. 10, No. 6, pp. 256–257.)

1501. A SIMPLE HIGH-IMPEDANCE VOLTMETER [primarily for Sound-Intensity Measurements: using a Single Diode-Pentode Valve].—Bhatt & Subramanian. (*See* 1541.)

1502. AN INVESTIGATION OF THE PERFORMANCE OF THE RAYLEIGH DISC.—R. A. Scott. (*Proc. Roy. Soc.*, Ser. A, 22nd Feb. 1945, Vol. 183, No. 994, pp. 296–316.)

From the Metropolitan-Vickers laboratories. "The discovery [Merrington & Oatley, 4006 of 1939] that the torque on a Rayleigh disc as calculated from König's formula can be in error at low frequency [9–22 c/s] by as much as 10% throws doubt on calibrations made at all frequencies. It is therefore important to investigate the accuracy of König's formula over the entire range of audio-frequency. In the present paper the behaviour of the Rayleigh disc over the range of frequency 250–4250 c/s is investigated . . . The investigation confirms the stability of performance of the Rayleigh disc and justifies its continued use as a standard of reference of acoustical intensity. Calculations of the particle velocity of the medium in terms of the torque on the disc must take account of the failure of the numerical factor 4/3 in König's formula, and suitable corrections amounting from 0 to 3.5% of the particle velocity [7% of the torque] must be applied according to the results of Fig. 8. For the large bulk of measurements made in acoustics with microphones, an accuracy of 1 db in intensity is adequate; in such work the corrections enumerated above, which amount to no more than 0.3 db, are barely significant."

The particle velocities were measured by an adaptation of the smoke-particle method of Andrade and of Carrière: an accuracy within about 1% was found possible up to 4000 c/s. The influence, upon the torque, of the proximity of the wall of a tube was investigated, and the precautions are discussed that are necessary to reduce to a minimum the effects of the thickness and mobility of the disc and of diffraction of sound by the disc.

1503. ANALYSING AIR-FLOW WITH TOEPLER "SCHLIEREN" AND SHADOWGRAPH EQUIPMENT.—Barnes & Bellinger. (*See* 1710.)

1504. THE ACOUSTIC STRAIN GAUGE.—Jerrett. (*See* 1703.)

1505. ACOUSTIC INTENSITY DISTRIBUTION FROM A PISTON SOURCE [evaluated by an Approximate Method: Specially Applicable to Narrow Supersonic Beams: Measurements by Radiometer & Microphone (in Water, around 1 Mc/s Frequency) show Good Agreement, excelling That given by Previous Approximations].—A. O. Williams, Jr., & L. W. Labaw. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, pp. 353–354: summary only.)

1506. WAVE-FRONT DETERMINATION IN A SUPERSONIC BEAM [without Recourse to a Standing-Wave Pattern: furnishing "a New Tool for the Study of Elastic Wave Diffraction in Liquids": Electrical Modulation Method with Advantage over All Optical Methods].—L. W. Labaw. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, p. 354: summary only.)

1507. A Theory of Singing Flames [including Case when Standing Waves in Gas-Supply Tube (assumed by Rayleigh) are *Not* formed].—A. Taber Jones. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, p. 354: summary only.)

## PHOTOTELEGRAPHY AND TELEVISION

1508. Television-Receiver Sound Channel [Summaries of Discussion].—I.E.E. Radio Section. (*Electrician*, 5th Jan. 1945, Vol. 134, No. 3475, p. 16: *Wireless World*, Feb. 1945, Vol. 51, No. 2, p. 48.)

1509. C.B.S. Soon to Broadcast Single-Transmitter Television [from Chrysler Building: Sight & Sound Signals on Same Carrier-Frequency].—Columbia Broadcasting Company. (*Elec. Engineering*, Dec. 1944, Vol. 63, No. 12, p. 456.)

1510. Coaxial Cables and Television Transmission [including the A.T. & T's Five-Year Tentative Programme].—H. S. Osborne. (*Bell Lab. Record*, Dec. 1944, Vol. 22, No. 16, pp. 619–621: excerpts from an address.)

1511. Problems of Quality in Large-Screen Projection of Television Pictures.—W. Amrein. (*Schweizer Arch. f. angew. Wiss. u. Tech.*, Oct. 1943, Vol. 9, No. 10, pp. 293–307.)

A summary of this paper was dealt with in 3522 of 1944. The writer describes a survey undertaken by the Industrial Research Division (A.F.I.F.) of the Technical Physics Institute of the E.T.H., Zurich, as a prelude to the development of the A.F.I.F. system of large-screen projection (*see* abstract quoted above). It deals in turn with (1) image definition (with particular attention to the work of Mertz & Gray, 1934 Abstracts, p. 568), (2) brightness (and a comparison with cinema pictures), (3) & (4) contrast and gradation (including the advantages of reflection-free glass surfaces), and (5) & (6) continuity of motion and the problem of flicker (and the disadvantages of interlaced scanning: "prominent experts are now of the opinion that in the near future interlaced scanning will disappear, even if a doubling of the frequency band should have to come as a result": the advantage, in this respect, of the A.F.I.F. storage system, with its "flicker screen" and halving of the frequency band). Most of the diagrams have to do with the A.F.I.F. large-screen projector and its working.

1512. Projection Television [and the Reflective Optical System (Spherical Mirror & Aspherical Lens): Prohibitively High Cost of Latter overcome by use of Moulded Plastic].—D. W. Epstein & I. G. Maloff. (*Sci. News Letter*, 28th Oct. 1944, Vol. 46, No. 18, p. 275.) *See* also 1111 of April.

1513. Better Television foreseen as Result of New System [of Increased Effective Sensitivity of Pick-Up Mosaic: Period between Scannings is Lengthened by Use of Pair of Scanning Tubes switched Alternately].—R. E. Selby. (*Sci. News Letter*, 28th Oct. 1944, Vol. 46, No. 18, p. 286.) Patent assigned to R.C.A.

1514. Television Pick-Up Camera with Semiconducting Mosaic Electrode [D.R.P. 740 115 of 24/11/36].—Anon. (*T.F.T.*, Feb. 1944, Vol. 33, No. 2, p. 40.)

In pick-ups with the usual multicellular photosensitive screens, the varying resistance of the individual photocells always has in series with it the constant internal resistance of the cathode-ray tube, generally many orders of magnitude greater than itself, so that the variations of the photocell resistance form only small fluctuations of the total resistance. Further, the incidence of the scanning ray on the photocells produces secondary electrons which are attracted by the neighbouring cells, since the surface of the irradiated cell takes on, with the passage of the current, a potential negative to that of its neighbours: thus the captured secondary electrons produce an apparent broadening of the electron beam at the points where it passes into the mosaic.

These fundamental difficulties are avoided by making the electron current falling on the mosaic divide into two components, the "useful" current which flows from the point of incidence through the particular photocell and a working resistance to the anode, and a second component, consisting of secondary electrons, which passes directly through the vacuum of the tube to the electron-gun anode. "If there occur many more secondary electrons than there are ray-electrons striking the mosaic, then the useful current through the individual elements will fluctuate, in accordance with the fluctuations of illumination, much more strongly. Moreover the above-mentioned coarsening of the beam will not occur, since the surface of the irradiated cell will now, owing to the excess of emerging electrons, take on a potential positive to that of its neighbours, so that these can no longer take up the secondary electrons."

1515. The Subjective Image in Stereoscopic Projection [and the Differences between It and the Original].—U. Graf. (*Zeitschr. f. Instr:kunde*, Aug. 1943, Vol. 63, No. 8, pp. 265–275.)

1516. High-Voltage Rectified Power Supply using Fractional-Mu Triode Radio-Frequency Oscillator [for Oscilloscopes & perhaps Television].—Freeman & Hergenrother. (*See* 1563.)

1517. Circuit for the Production of Rectangular Pulses [especially for Television] from Pulses with Rounded Flanks [D.R.P. 740 117 of 4/4/36].—Anon. (*T.F.T.*, Feb. 1944, Vol. 33, No. 2, p. 40.)

1518. Utilisation of "Pore Spaces" of Semipermeable Membranes [and the Production of a Photographic Film having Extreme Rapidity of Development, etc.].—Moor. (*See* 1708.)

1519. Newspapers by Radio [Note on Recent & Future Developments in Facsimile Telegraphy].—(*Science*, 1st Dec. 1944, Vol. 100, No. 2605, Supp. p. 10.)

1520. The Internal Resistance of the Selenium Rectifier Photocell, with Special Reference to the Sputtered Metal Film.—J. S. Preston & G. W. Gordon-Smith.

(*Proc. Phys. Soc.*, 1st Jan. 1945, Vol. 57, Part 1, No. 319, p. 1–11.)

"The action of this type of cell has been studied theoretically, but the studies have generally failed to give quantitative results in good accord with the measured characteristics. In part, this has been due to lack of knowledge of simple features of the cell, such as the resistance of its various elements, which are not easy to determine and may be subject to variation from cell to cell. The present paper, dealing with the 'ohmic' part of the cell resistance as distinct from the barrier layer, is therefore based principally upon experimental considerations. The object of the paper is to examine, simply, the influence of the internal resistance on the behaviour of the cell, and to form some estimate of the magnitude of this resistance. Particular attention is paid to the sputtered film, as it is believed that its resistance has not previously been measured *in situ* by a simple method such as is described below" [based on measurements, on unlacquered cells, of the distribution of potential over the film resulting from the flow of photocurrent across it when the cell is exposed to a steady uniform illumination].

"The results obtained with four cells tested gave values between 100 and 600 ohms/cm.cube for the resistivity of the film. They suggest that for a cell of normal type the value is in the region of 100–300 ohms/cm.cube, while a value exceeding 500 or 600 ohms/cm.cube is likely to be associated with non-uniformity of the film over the area of the cell, and less satisfactory performance at high values of illumination . . ." though a certain increased sensitivity at low illuminations may result from the higher optical transmission of such a film. *See* also 2920 of 1944 and 850 of March.

## MEASUREMENTS AND STANDARDS

1521. MEASUREMENT OF RECEIVER IMPULSE-NOISE SUSCEPTIBILITY.—Minter. (*See* 1453.)

1522. "HIGH-FREQUENCY TRANSMISSION LINES" [Book Review].—Willis Jackson. (*See* 1380.)

1523. A METHOD OF MEASURING ATTENUATION OF SHORT LENGTHS OF COAXIAL CABLE.—C. Stewart, Jr. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 46–48.)

Author's summary:—"Measurement of attenuation of coaxial r.f. transmission cables has generally been made by methods requiring non-standard equipment and long samples. A method of measurement employing a standard 'Q-meter' and requiring short samples [less than 5 ft in length] is described." It was developed at the Signal Corps Aircraft Radio Laboratory at Wright Field, and among other advantages it enables non-uniformities, which would be "averaged out" in tests by methods using long samples, to be detected easily. Results appear to be as reliable and accurate as those given by the more widely used methods, but the commercially available Q-meters limit the employment of the method to frequencies around 100 Mc/s. It is mentioned that the data obtained can be used for determining the velocity of propagation, if the frequency is accurately checked.

1524. FREQUENCY STABILISATION IN THE 100–1000 Mc/s BAND [Short Survey].—Menke. (*See* 1437.)

1525. THE STANDARDISATION OF QUARTZ-CRYSTAL UNITS.—K. S. Van Dyke. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 15–20.)

"The formal treatment of the crystal unit as a circuit element having conventional electrical-circuit properties has not kept pace with its practical utilisation. It appears as if most crystal oscillators were designed by the 'cut-and-try' method . . . It is a rather frequent experience to find that the set manufacturer has apparently no record of the capacitance across the crystal in sets which he has made in the past, and this is the one bit of information needed when one is to grind a new crystal to give the specified frequency . . . The long-range course of engineering development will be toward the use of the crystal's own properties in specifications, and eventually it will not be necessary to test each crystal unit in the radio set for which it was made. When it has been determined what are the necessary properties of the crystal unit, convenient instruments to measure these will become available, the crystal properties which the radio set needs will be determined, and the crystal will be specified in conventional circuit terms, impedances, or the equivalent . . ." Three such methods of specification are discussed and compared: a forthcoming paper by Fair is mentioned which will discuss crystal performance indexes involving values of certain impedances measured at the oscillation frequency: *see* 1526, below.

1526. CRYSTAL QUALITY [and the Desirability of Expressing It in terms of the Equivalent Circuit Constants: Suggested "Figure of Merit" *M* and "Performance Index" *PI*: Relations between *M*, *PI*, and Oscillator Grid Current].—I. E. Fair. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 54: summary only.) This evidently is the paper referred to at the end of 1525, above.

1527. THE PERFORMANCE INDEX METER [measuring the Antiresonant Impedance of Quartz Crystal & Associated Circuit].—C. W. Harrison. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 56: summary only.)

1528. AGING OF QUARTZ CRYSTAL UNITS.—V. E. Bottom. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 53: summary only.)

Plates for 6 Mc/s and over are now being made in large numbers. When the frequencies are adjusted by lapping, the units are unstable with respect to frequency and activity: the changes are aggravated by moisture. "The effect is associated with the surface of the plate, which is left in a disoriented condition as a result of the stresses produced in lapping. The remedy is removal of the disturbed material and adjustment of frequency by etching. The stability of the unit is also affected by the material of the holder. Most plastics are quite permeable to water vapour, resulting in unsatisfactory performance under conditions of high humidity. Much study is being given to the design of holders for tropical use.

"The new order of permanence and frequency stability which is provided and the economy in the use of the etching method in quantity production opens the door to the widespread use of thinner crystals, and thus to both higher-frequency crystal units and the extension of the range of application of *AT*-cut units, with their better temperature coefficients, to the frequency ranges now covered only with *BT*-cut plates."

1529. Frequency Adjustment of Quartz-Oscillator Plates by X-Rays [*BT* Plate irradiated with X-Rays gradually becomes Smoky and Its Frequency is Lowered: Manufacturing Application of This Effect, and Its Great Advantages].—C. Frondel. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 55: summary only.) From the Reeves Sound Laboratories.

1530. Equipment for Frequency Adjustment of Quartz-Oscillator Plates by X-Rays [Account of Preliminary Experimental Work: Need for Relatively "Soft" Radiation of High Intensity: Design of Equipment: etc.].—C. Roddy. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 59: summary only.) From the North American Philips Company. *Cf.* 1529, above.

1531. Crystal-Testing Techniques.—L. A. Elbl. (*Electronics*, Aug. 1944, Vol. 17, No. 8, pp. 120–123 and 380..382.)

From the Engineering Department of Crystal Products Company. A final section deals with aging and the various attempts to prevent its effects. If the tarnishing difficulty can be overcome, gold or silver plating would seem a promising solution: another hopeful plan is a hot-and-cold-cycles temperature treatment combined with a very thorough cleaning.

1532. Quartz-Crystal Supply Programme [Story of the Expansion of Production to 30 Million Units a Year].—E. W. Johnson. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 56: summary only.) From the Office of the Chief Signal Officer, Washington.

1533. Calculation of the Piezoelectric Effect in Ionic Lattices of the Zinc-Blende Type.—H. Jaffe. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, pp. 357–358.) From the Brush laboratories.

1534. Theory of the Multivibrator.—H. W. Webb & G. E. Becker. (*Journ. Applied Phys.*, Dec. 1944, Vol. 15, No. 12, pp. 825–834.)

Authors' summary:—"The theory of the symmetrical multivibrator has been developed in a form which makes possible the computation of the period and the currents in the tubes in a relatively simple manner. The method is largely graphical. The behaviour of the corresponding Eccles–Jordan trigger circuit is first determined and a 'trigger' characteristic constructed, giving the values of the grid voltages of each tube when triggering takes place and the corresponding values of the currents in the tubes before and after triggering. From this characteristic, with slight changes, the operating conditions and the period of the multivibrator circuit are determined. It is found that the grid currents play an important part in determining these conditions and the period. The method was applied to an actual circuit and the computed values agreed well with the experimental results. The effect on the period and operating conditions of varying the parameters is discussed theoretically and the conclusions are compared with experiment." The asymmetrical multivibrator may be treated in a similar manner, but the problem in this case is much more complicated.

1535. Rectangular Voltage Waves from a Low-Impedance Source.—Rehfisch. (*See* 1562.)

1536. Producing Rectangular R.F. Pulses of Known Amplitude [Development of Equipment with Amplitude, Duration, & Recurrence-Frequency all Independently Variable: Accuracy & Stability equal to That of Conventional Standard-Signal Generator: Applications].—W. R. Piggott. (*Wireless Engineer*, March 1945, Vol. 22, No. 258, pp. 119–125.)

An appendix deals with the application of such an equipment to the adjustment of transient response characteristics. "The utility of a standard pulse-modulated signal generator for examining the behaviour of pulse equipment and for pulse field-strength measurements is immediately obvious, but it is not generally realised that this instrument is capable of demonstrating the response of a given system to any type of transient or continuous signal in a quick and convenient manner. This property is of very great value in complex problems in which transient response is of importance, as the latter cannot be predicted from a knowledge of the response to c.w. inputs alone; *e.g.* it is possible to build filter circuits which will reject certain c.w. signals almost completely, but which will not operate in the case where the signal frequencies are modulated by transients. A standard transient is particularly convenient when it is necessary to adjust a complex system so as to produce given response characteristics, as this is equivalent to adjusting the system until the transient is distorted to a given form . . ." The technique is outlined.

1537. Law-Linearity of Semicircular-Plate Variable Condensers.—W. H. F. Griffiths. (*Wireless Engineer*, March 1945, Vol. 22, No. 258, pp. 107–118.)

Author's summary:—"When used primarily as standards of capacitance [rather than as a calibrated means of adjusting a circuit to resonance], variable condensers having linear laws of capacitance are preferable to those having linear frequency laws [dealt with in a previous paper, 1647 of 1944]. The law imperfection caused by the peripheral edge capacitance in variable condensers of the latter type are absent in the former, but appreciable imperfection of the same kind may be introduced by eccentricity of moving and fixed plates relative to the axis of rotation. Formulae are developed for the law errors due to this cause, and for the inaccuracy of interpolation introduced by such errors.

"The linearity of law is impaired also by the edge capacitance of the leading and trailing radial edges of the moving plates. That of the latter is the more important and this is dealt with quantitatively, formulae being developed by an approximate method both for law error and for the correction of the shape of moving plate which will sensibly eliminate such error.

"There are further causes of law imperfection which, unlike the foregoing, are a function of frequency. These are the constant and variable components of the residual self-inductance of the variable condenser. Formulae are developed for the effects of these upon the law of a condenser and for the inaccuracies attending such effects.

"Finally, formulae are developed for the design of a variable condenser to have a perfectly linear law of capacitance at any given high frequency even though that frequency is sufficiently high to produce frequency corrections of considerable magnitude."

1538. Production Tester for Mica Capacitors [with Other Applications such as Thickness or Moisture Measurement].—(*Electronics*, Aug. 1944, Vol. 17, No. 8, pp. 156..161.)

1539. The Polarising Angle for Reflection at the Boundary between Two Absorbing Media [and a Possible Method for the Measurement of Dielectric Constants & Conductivities].—Pincherle. (*See* 1379.)

1540. A High-Frequency Wattmeter and Its Uses in Industrial Applications [especially for Separation of Power fed into Charge of H.F. Heating Generator from Radiation & Circuit Losses, etc.].—E. Mittelmann. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 58: short summary only.)

The readings are independent, within wide limits, of the frequency; and also of the geometrical configurations of the load and of the electrodes.

1541. A Simple High-Impedance Voltmeter [primarily for Sound-Intensity Measurements: using a Single Diode-Pentode Valve].—N. B. Bhatt & B. Subramanian. (*Current Science* [Bangalore], Dec. 1944, Vol. 13, No. 12, p. 324.)

The diode system of the compound valve is preceded by the pentode stage, for which the diode system, together with the indicating meter, forms a part of the load. "This offers the obvious advantage for a voltmeter circuit, which should ideally have an infinite input impedance at all frequencies; the high input impedance of the pentode section is not seriously impaired by the load, and its lower input capacitance offers a wider uniform frequency-response . . ." The performance is said to be essentially the same as that given by the more complex 2-valve bridge circuit described by Ledward (2664 [and 3928] of 1944).

1542. Bridge Circuit with Double-Coil Crossed-Coil Instruments [for the Accurate Measurement of Quotients over a Wide Range in Spite of Magnetic-Field Inhomogeneity Difficulties: D.R.P.744 290 of 14/12/1940].—Anon. (*T.F.T.*, June 1944, Vol. 33, No. 6, p. 128.)

1543. An Electrometer Tube and Its Use in Minute Measurements.—Hayes. (*See* 1486.)

1544. Method of Balancing for Direct-Current Amplifiers with Two or More Stages [especially for Measuring Purposes].—Anon. (*See* 1416.)

1545. A New Temperature-Dependent Magnetic Material [for obtaining Constancy of Field under Change of Temperature].—Schweizerhof: Ackermann. (*See* 1595.)

1546. Measuring Fine Wires [as used for suspending Galvanometer Mirrors: Measurement to a Millionth of an Inch by Embedding in Plastic, Sawing across, to give Undistorted Cross Section which is then examined under Microscope with Micrometer Eyepiece].—General Electric. (*Gen. Elec. Review*, Dec. 1944, Vol. 47, No. 12, p. 60.)

1547. A Photoelectric Method for the Determination of the Average Diameter of Fine Wires, Filaments, Fibres, etc.—N. Ahmad & R. L. N. Iyengar. (*Current Science* [Bangalore], Oct. 1944, Vol. 13, No. 10, p. 256.)

1548. Apparatus for the Production and Measurement of Small Motions [Cantilever Bar for producing Motions of the order of $10^{-5}$ cm & More, and Interferometer for Measuring Them.]—G. F. Hull, Jr. (*Review Scient. Instr.*, Dec. 1944, Vol. 15, No. 12, pp. 340–342.)

1549. Conversion of Non-Rationalised c.g.s. to Rationalised m.k.s. Units in Electromagnetism [and the Proposed Introduction of a New c.g.s. Unit, the "Statlorentz"].—H. Jehle. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, p. 353: summary only.)

1550. The Fixing of Confidence Limits to Measurements [Summary of I.E.E. Paper & Discussion].—H. J. Josephs. (*Electrician*, 26th Jan. 1945, Vol. 134, No. 3478, pp. 83–84.) *See* also *Nature*, 27th Jan. 1945, Vol. 155, No. 3926, p. 106.

## SUBSIDIARY APPARATUS AND MATERIALS

1551. On the Winding of the Universal Coil.—Simon. (*See* 1464.)

1552. Six-Element "Baby" Permanent-Magnet Oscillograph, Type PM–17–A1.—General Electric. (*Review Scient. Instr.*, Nov. 1944, Vol. 15, No. 11, p. 329.) Weighing only about 10 lb. For a full description *see* G. H. Hupman, *Gen. Elec. Review*, Dec. 1944, Vol. 47, No. 12, pp. 53–57.

1553. The Deflection Sensitivity of Parallel-Wire Lines [used as a Deflecting System] in Cathode-Ray Oscillographs.—Rudenberg. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, p. 354: summary only.)

"The deflection angle $\theta$ of a cathode-ray beam accelerated by a potential $V$ is shown to be proportional to the linear charge density $\rho$ transverse to the beam on the interior of the electrostatic deflection system: $\theta = \rho/2V\epsilon_0$. The voltage deflection sensitivity depends on the plate-to-plate capacitance $c$ per unit width: $\theta/E = c/2V\epsilon_0$. This includes edge effects and permits a determination of the sensitivity from capacitance measurements or a simple graphical evaluation from the dimensions of the deflection system.

"The use of parallel-wire lines as a deflection system is suggested, and its deflection sensitivity evaluated. Such lines have low transit-time error and are either easily tuned, or can be operated non-resonant with resistive termination."

1554. A Portable Two-Channel Recording Oscilloscope for Battery Operation [C.R. Oscilloscope primarily for Strain-Gauge & Vibration Equipments].—Wild & Culver. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 60: short summary only.) From the Brown Instrument Company.

1555. Discussion on "The Computation of Electron Trajectories in Axially Symmetric Fields" and "Electron Ray Tracing through Magnetic Lenses" [892 of March].—Goddard, Klemperer. (*Proc. Phys. Soc.*, 1st Jan. 1945, Vol. 57, Part 1, No. 319, pp. 63–66.) Methods using differences *versus* those using ordinates only: method of the characteristic function: Glaser's work in *Zeitschr. f. Phys.* [*see*, for example, 303 of 1936]: etc.

1556. Electron Microscopy [and the Ideas guiding the Design of General Electric Electrostatic Electron Microscopes].—Bensen. (*Gen. Elec. Review*, Dec. 1944, Vol. 47, No. 12, pp. 6–14.)

1557. A Truly Portable Electron Microscope [Suitcase Size].—General Electric. (*Gen. Elec. Review*, Jan. 1945, Vol. 48, No. 1, pp. 60, 61.) *See* also 1556, above.

1558. A 100 kV Electron Microscope [of Stanford University: Three-Stage Compound Microscope for Bright- and Dark-Field Illumination, Wide-Angle Stereoscopy, & Conversion into Diffraction Camera: Alignment on Optical Axis achieved by Movement of Pole-Pieces instead of Whole Coil: Fluorescent Screen for "End-On" Observation: Magazine-Type Photographic Chamber: New Design of Specimen Holder: etc.].—Marton. (*Science*, 6th Oct. 1944, Vol. 100, No. 2597, pp. 318–320.) *See* also 540 of February and 888 of March.

1559. On the Silica Replica Method of Surface Examination with the Electron Microscope [Alternative to the Heidenreich–Peck Technique of Evaporation of Silica in a High Vacuum: Chemical Deposition of Silica from $SiCl_4$: Some Results].—Baker & Nicoll. (*Journ. Applied Phys.*, Dec. 1944, Vol. 15, No. 12, pp. 803–805.)

1560. Increasing the Resolving Power of the Emission-Type Electron Microscope [Criticism of Boersch's Paper (3347 of 1942), and Boersch's Reply].—Picht: Boersch. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 24, 1943, pp. 211–216: pp. 216–217.)

1561. Triode Linear Saw-Tooth-Current Oscillator [for Cathode-Ray-Tube Magnetic Sweep Circuit].—Malling. (*Proc. I.R.E.*, Dec. 1944, Vol. 32, No. 12, pp. 753–757.)

Author's summary:—"It is shown that a triode may be used for generating a linear saw-tooth current when coupled to a suitably designed transformer. The triode is operated on a hitherto unused portion of the $E_p/I_p$ characteristics, notably the positive-grid region where the $E_p/I_p$ characteristic is a straight line of slope $R = E_p/I_p$. While the over-all efficiency of the oscillator is low, it is shown to be inherently more efficient than conventional scanning systems operating in the negative-grid region.

"Improved operating conditions and circuit efficiency may be obtained by the use of an inverted diode [Fig. 7]. The losses in a typical triode scanning oscillator are analysed and individually computed for a given design. Attention to these individual circuit losses should enable designs to be made of considerably higher efficiency."

1562. Rectangular Voltage Waves from a Low-Impedance Source.—Rehfisch. (*Proc. Phys. Soc.*, 1st Jan. 1945, Vol. 57, Part 1, No. 319, pp. 60–63.)

"'Square-wave' generators using thermionic valves have been used extensively in recent times; however, there are reasons why a reversion to a mechanical 'make-and-short' device is advantageous for demonstrations or even for work on scale models; primarily, because the internal impedance of this form of generator is very small, being composed mainly of battery and brush-commutator contact resistances—a residual few ohms at most; this compares with many and unsteady thousands of ohms contributed by alternative low-power (thermionic) generators. Hence the mechanical device allows many phenomena to be observed on a reduced frequency scale—in particular, oscillatory phenomena which, with a high-impedance generator, occur in the r.f. range, may easily be obtained at moderate audio frequencies . . ." The resulting advantages, and others, are mentioned.

The generator described consists of a battery feeding a motor-driven "Fleming–Clinton" commutator modified by the addition of another centre brush. Some observations carried out with the equipment are tabulated, with notes on the effects illustrated.

1563. High-Voltage Rectified Power Supply using Fractional-Mu Triode Radio-Frequency Oscillator [developing across Its Grid-Leak Resistor a Bias Voltage over 20 Times as High as the Anode-Supply Voltage: for Oscilloscopes & perhaps Television].—Freeman & Hergenrother. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 55: short summary only.)

1564. Analysis of Voltage-Regulator Operation [leading to a Compensated Circuit yielding Output Voltage substantially Independent of Input-Voltage or Load-Current Change].—Hill. (*See* 1432.)

1565. High-Vacuum Pumping Unit [giving Vacuum of better than $10^{-6}$ mm Hg with Traps, $10^{-4}$ mm without].—Towers & Company. (*Journ. of Scient. Instr.*, Feb.

1945, Vol. 22, No. 2, pp. 38–39.) Designed by A. R. Gilson: a compact, portable unit for general laboratory use.

1566. Sealing and Bulb Glasses [Present Standardised Types (Hysil, Intasil, etc.)].—Chance Brothers. (*Journ. of Scient. Instr.*, Feb. 1945, Vol. 22, No. 2, p. 38.) *See* also 1081 of April.

1567. Synthetic Rubber Pressure-Seal [for Extreme Conditions in High-Altitude Flights: Special Compound within Bronze Ring].—Winspear. (*Bell Lab. Record*, Jan. 1945, Vol. 23, No. 1, p. 32.)

1568. The Cyclotron of the University of Bonn [giving a Deuteron Beam of 1.5 MeV].—Schmitz & Wiebe. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 24, 1943, pp. 195–206.)

1569. The Positive Column with Curved Discharge-Path [Calculation of Carrier & Current Density Distributions].—Wasserrab. (*Zeitschr. f. Phys.*, 10th May 1943, Vol. 121, No. 1/2, pp. 54–57.)

1570. The Calculation of the Temperature of an Arc, and the Stability Problem of the Arc Column.—Mannkopff. (*Zeitschr. f. Phys.*, 12th Jan. 1943, Vol. 120, No. 3/4, pp. 228–251.)

1571. On the Significance of Steenbeck's "Minimum" Principle [of Arc Diameters: Its Usefulness & Limitations].—Rompe & Weizel. (*Zeitschr. f. Phys.*, 16th Nov. 1942, Vol. 120, No. 1/2, pp. 31–46.)

1572. New Investigations on Cathode Sputtering in the Glow Discharge: V—The Surface Constitution of the Cathode.—Güntherschulze & Tollmien. (*Zeitschr. f. Phys.*, 30th Oct. 1942, Vol. 119, No. 11/12, pp. 685–695.) For previous parts *see* 3360 of 1942.

1573. Photographic Recording of Electron Avalanches in the Cloud Chamber.—Riemann. (*Zeitschr. f. Phys.*, 16th Nov. 1942, Vol. 120, No. 1/2, pp. 16–20.)

1574. The Selenium Rectifier [Construction: Theory of Operation (Richards, 248 of 1942 [and 2817 of 1943]): Grading of Plates: Protective Coatings: Efficiency: Regulation: Capacitance: Temperature Range: Aging: Use as Voltage Regulator: etc.].—Ramsey. (*Elec. Engineering*, Dec. 1944, Vol. 63, No. 12, pp. 425–433.)

1575. Semiconducting Properties of Stannous Sulphide.—Anderson & Morton. (*Nature*, 27th Jan. 1945, Vol. 155, No. 3926, p. 112.)

1576. Optical Properties and Electronic Structure of Solid Silicon.—Mullaney. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, pp. 326–339.)

1577. Effect of Chemical Structure on Physical Properties of Synthetic Plastics.—Baker. (*Bell Lab. Record*, Dec. 1944, Vol. 22, No. 16, pp. 637–640.)

1578. Plastics [Developments in 1944: including "Textolite", of High Dielectric Strength, Low Power Factor, & Low Dielectric Constant].—General Electric. (*Gen. Elec. Review*, Jan. 1945, Vol. 48, No. 1, p. 59.)

1579. Polythene as a High-Frequency Dielectric [including Oxidation during Processing, and Its Elimination: Investigation of Possible Explanations of the Small Basic Power Factor: etc.].—Willis Jackson & Forsyth. (*Nature*, 27th Jan. 1945, Vol. 155, No. 3926, p. 118: summary of I.E.E. paper.)

1580. Fungus-Resistant Coating ["Durad" Varnish for Phenolic Parts of Communications Equipment].—Maas & Waldstein Company. (*Scient. American*, Nov. 1944, Vol. 171, No. 5, p. 230.) *Cf.* 3612 of 1944 and 926 of March.

1581. Flamenol, a Thermoplastic Synthetic Insulating Material [especially useful for Wires used in Wet Locations: Other Advantages].—General Electric. (*Gen. Elec. Review*, Jan. 1945, Vol. 48, No. 1, p. 26.)

1582. Wire Insulation developed by Special Formulation of Buna S ["Nubun" and Its Special Qualities].—United States Rubber. (*Scient. American*, Nov. 1944, Vol. 171, No. 5, pp. 222 and 224.)

1583. Silicone Rubbers and Their Peculiar Properties.—General Electric. (*Gen. Elec. Review*, Jan. 1945, Vol. 48, No. 1, pp. 60, 61.)

1584. Contribution to the Knowledge of the Organic Insulating Materials of Electrical Technique [General (with Various Tables, including Comparison of Properties of Cellulose, Rubber, & Polystyrol): Molecular Structure & Dielectric Behaviour: Formation of Surface-Leakage Paths: Permeability to Water].—Stäger, Bédert, & Frischmuth. (*Schweizer Arch. f. angew. Wiss. u. Tech.*, Sept. & Oct. 1943, Vol. 9, Nos. 9 & 10, pp. 261–275 & 314–321.)

1585. X-Ray Investigation of Problems in the Manufacture of Ceramic Products.—Nielson. (*Electronics*, Aug. 1944, Vol. 17, No. 8, pp. 152..156: summary only.)

1586. A Simple Method for the Preparation of Hard Moulded Ceramic Parts for Temperatures up to 1800° C.—Schmellenmeier. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 24, 1943, pp. 217–218.)

For experimental work in the laboratory the easily worked and subsequently baked steatite, and the Steatite-Magnesia A.G.'s "Ergan" (also workable with ordinary tools), have proved very useful: but the former can be employed only up to about 1200° C, the latter to about 1400° C. For higher temperatures the writer recommends the use of a pulp made of the purest aluminium-oxide powder ("Alupur" of the Degussa Company) and water. After a preliminary sintering (at about 1000° C) a moulded part of this material can be readily tooled, after which it may be highly sintered (at about 1700° C). The simple laboratory technique is described. Titanium or zirconium oxides may also be used.

1587. ELECTRICAL GLASS [Behaviour in D.C. Electric Fields: in Periodic Electric Fields: Special Forms of Electrical Glass (Fibre Glass; Multiform Glass, 2497 & 2830 of 1943; VYCOR Brand 96% Silica Electrical Glass No. 790; New Combinations in Glass/Metal Seals): Summarised Conclusions].—Guyer. (*Proc. I.R.E.*; Dec. 1944, Vol. 32, No. 12, pp. 743–750.) From the Corning Glass Works: a survey, with 21 references.

1588. SOURCES OF MICA [Correction to Statement in "Equipment and Method for Measurment of Power Factor of Mica" (Hall, 3543 of 1944) regarding "Practical Elimination of Indian Imports"].—Eckweiler: Hall. (*Proc. I.R.E.*, Dec. 1944, Vol. 32, No. 12, p. 772.)

1589. SYNTHETIC DIELECTRIC MATERIAL: "LECTROFILM", FOR R.F. BLOCKING AND BY-PASS CAPACITORS FORMERLY USING MICA.—General Electric. (*Review Scient. Instr.*, Nov. 1944, Vol. 15, No. 11, p. 331.) Already referred to in 3618 of 1944. *See* also 1590, below, and also p. 70 of the journal there quoted.

1590. CAPACITORS [Developments in 1944, for Frequencies from 180 c/s to 100 Mc/s: including High-Voltage Capacitance Dividers].—General Electric. (*Gen. Elec. Review*, Jan. 1945, Vol. 48, No. 1, p. 29.)

1591. GLASS-TO-METAL SEALED CAPACITORS AND RESISTORS.—Sprague Electric. (*Review Scient. Instr.*, Nov. 1944, Vol. 15, No. 11, p. 330.)

1592. A NEW HIGH-FREQUENCY CAPACITOR [the Three-Terminal Feed-Through "Hypass" Capacitor for Improved By-Passing or Filtering over a Wide Range of Frequencies].—Allison & Beverley. (*Elec. Engineering*, Dec. 1944, Vol. 63, No. 12, Transactions p. 914–916.) A summary was dealt with in 450 of February.

1593. LAW-LINEARITY OF SEMICIRCULAR-PLATE VARIABLE CONDENSERS.—Griffiths. (*See* 1537.)

1594. THE DIELECTRIC STRENGTH OF POINT/POINT AND POINT/PLATE ARRANGEMENTS FOR LARGE SPARK LENGTHS UNDER OIL.—Strigel. (*Wiss. Veröff. a. d. Siemens-Werken*, No. 2, Vol. 21, 1943, pp. 148–157.)

1595. A NEW TEMPERATURE-DEPENDENT MAGNETIC ALLOY: REMARKS ON ACKERMANN'S PAPER [3556 of 1943: the Present Writer's Cooling-Strain Formula for Multi-Layer Materials, and Its Misapplication: His Own Material (*Zeitschr. f. Metallkunde*, 1941, pp. 175–185) with Twice as High a Relative Temperature Coefficient of Permeability as Ackermann's "Alloys", and about 50 Times as High a Permeability].—Schweizerhof: Ackermann. (*Zeitschr. f. tech. Phys.*, No. 9, Vol. 24, 1943, pp. 218–219.)

Ackermann, in his reply (p. 219) regrets having overlooked the work in question. The comparatively low permeability of his material was due to his use of hard-rolled material without heat treatment: suitable heat treatment yields a linear permeability-rise of 7.5%/degree (compared with 2%/degree of Schweizerhof's material) with an initial permeability of 600 gauss/oersted (compared with 590 attributed to Schweizerhof's: the value of 1000, for a higher annealing temperature, given in the latter's present note, "is no doubt based on an unpublished measurement").

1596. ALNICO V WILL REDUCE THE SIZE OF MAGNETIC STRUCTURE OF LOUDSPEAKERS BY 30%.—General Electric. (*Gen. Elec. Review*, Jan. 1945, Vol. 48, No. 1, p. 51.) For ductile permanent-magnet materials *see* p. 61: these include a silver-aluminium-manganese alloy with notable properties.

1597. THE ECONOMIC UTILISATION OF MODERN PERMANENT MAGNETS [Summary of I.E.E. Paper & Subsequent Discussion].—Desmond. (*Electrician*, 23rd Feb. 1945, Vol. 134, No. 3482, pp. 171–172.) "One of the most valuable papers on permanent magnets since the classical paper by Evershed": "marks a second epoch . . . by taking Evershed's theories a step forward."

1598. QUICK-RELEASE HAND MAGNET [Permanent Magnet with Release (or Reversed Polarity) by turning Lever].—James Neill & Company. (*Journ. of Scient. Instr.*, Feb. 1945, Vol. 22, No. 2, p. 37.) *See* also p. 40.

1599. SOME RECORDS OF MAGNETIC-STATE CURVES [Conditions at the Transition from Remanent to Permanent Magnetic State, and *vice versa*, of a Permanent Magnet investigated by Photographic Records taken with Breitling's Apparatus, 2500 of 1941].—Breitling. (*Elektrot. u. Masch:bau*, 9th July 1943, Vol. 61, No. 27/28, pp. 315–317.)

1600. THE LAW OF MAGNETISATION IN WEAK FIELDS [Extension of Rayleigh's Law to the Generalised Form $\mu = aH^N(1 + bH) + 1$ (where $a$, $b$, & $N$ are Constants depending on the Material) applicable to Materials whose Permeability Characteristics are Strongly Curved near the Beginning: Applications & Experimental Confirmation: etc.].—Sixtus. (*Zeitschr. f. Phys.*, 10th May 1943, Vol. 121, No. 1/2, pp. 100–117.)

1601. THE STRUCTURE OF A FERROMAGNETIC AND THE PERMEABILITY/FREQUENCY CURVES [at Audio & High Frequencies].—Polivanov. (*Journ. of Phys.* [of USSR], No. 1, Vol. 7, 1943, pp. 18–28: in English.)

Beginning with a new method for determining the permeability of a substance from two measurements. It is applicable when the samples are isotropic and homogeneous, and yields a criterion by which it may be judged whether the observed change of permeability with frequency is only an apparent effect or a real property of the material [*see* 3158 of 1943]. The bulk of the paper gives an analysis of the influence of microscopic inhomogeneities (Weiss domains) on the permeability as a function of frequency.

1602. Decrease of Permeability with Increasing Frequency.—van Leeuwen. (*Physica*, Jan. 1944, Vol. 11, p. 35 onwards). An 8-page paper mentioned in *Review Scient. Instr.*, Oct. 1944.

1603. The Magnetic Permeability of Iron Wires at Radio-Frequencies.—Smith, Dickey, & Foor. (*Journ. Applied Phys.*, Jan. 1945, Vol. 16, No. 1, pp. 57–60.)

Authors' summary:—"The magnetic permeability of iron wires of selected diameters is measured at fields of low intensity and at frequencies corresponding to wavelengths from 54 to 1150 m. The observed permeabilities decrease with increase in frequency and increase of wire size. The results do not confirm the existence of an anomalous dispersion of permeability previously reported by some investigators."

1604. Contributions to the Theory of Co-operative Phenomena [Occurrence of Ferromagnetism, Ordering of Lattice Structure, etc.].—Temperley. (*Proc. Cambridge Phil. Soc.*, Oct. 1944, Vol. 40, Part 3, pp. 239–250.)

1605. Magnetic Properties of Nematic Powders.—Chevallier & Mathieu. (*Ann. de Physique*, Dec. 1943, Vol. 18, p. 258 onwards.) Referred to in *Review Scient. Instr.*, Aug. 1944.

1606. The Spontaneous Magnetisation and Electrical Resistance of the Alloy $Ni_3Mn$ [and the Connection between Them].—Komar. (*Journ. of Phys.* [of USSR], No. 5, Vol. 7, 1943, pp. 229–234: in English.)

1607. On the Magnetostriction of Polycrystals.—Vladimirskij. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, 10th Oct. 1943, Vol. 41, No. 1, pp. 10–13: in English.)

1608. Effect of Iron Tube on Its Magnetising Field [Investigation of Wall's Results & Conclusions (2540 of 1939): "Reduction of Magnetic Field can be accounted for by Theory of Demagnetisation without introducing Any Other Hypothesis"].—Lin: Wall. (*Phys. Review*, 1st/15th Aug. 1944, Vol. 66, No. 3/4, pp. 57–65.)

1609. New Researches in Gyromagnetism [Magnetisation by Rotation, or Barnett Effect].—Barnett. (*Phys. Review*, 1st/15th Oct. 1944, Vol. 66, No. 7/8, pp. 224–225.)

1610. Gases evolved by Magnetised Iron in Sulphuric Acid [Answer to the Query whether Oxygen is One of the Products].—Hoff & others. (*Phys. Review*, 1st/15th Aug. 1944, Vol. 66, No. 3/4, p. 92.)

1611. Two-Inch-Diameter Electric Motor giving Three Horse-Power at 18 000 r.p.m. [Freon-Cooled: Cast Silver Framework].—Sawyer. (*Sci. News Letter*, 9th Dec. 1944, Vol. 46, No. 24, p. 379.) Weight only about 4 lb: U.S. Patent 2 364 000.

1612. Storage Flashlight Cell [Rechargeable Wet Cell].—Goodrich Company. (*Scient. American*, Nov. 1944, Vol. 171, No. 5, p. 231.) *See* also 560 of February.

1613. Self-Locking Quick-Disconnect Connector for Small Wires.—Burndy Engineering. (*Gen. Elec. Review*, Jan. 1945, Vol. 48, No. 1, p. 70.)

1614. Electric Connections on Aircraft [with Examples of British, German, & Other Types], *and* Historical Development of Electric Connectors.—Stebbins & Taylor: Neifing. (*Elec. Engineering*, Dec. 1944, Vol. 63, No. 12, Transactions pp. 906–911: pp. 925–928.) The full papers, summaries of which were referred to in 562 of February.

1615. Cage-Type Speed Nut [Self-Locking in Screw-Receiving Position for Blind Attachments].—(*Scient. American*, Dec. 1944, Vol. 171, No. 6, p. 279.)

1616. Explosive Rivets [including Their Post-War Use in Radio Units, Household Appliances, etc.].—du Pont de Nemours. (*Journ. Applied Phys.*, Jan. 1945, Vol. 16, No. 1, Supp. pp. xviii and xx.) *See* also 3774 of 1944.

1617. Beryllium-Copper Wire [Advantages of "Silvercote" Wire: reduces Wear on Coiling Tools, increases Electrical Conductivity, & reduces Surface Attack during Hardening].—Little Falls Alloys. (*Review Scient. Instr.*, Nov. 1944, Vol. 15, No. 11, p. 331.)

1618. Soil-Corrosion Studies, 1941: Ferrous and Non-Ferrous Corrosion-Resistant Materials and Non-Bituminous Coatings.—Logan & Romanoff. (*Journ. of Res. of Nat. Bur. of Stds.*, Sept. 1944, Vol. 33, No. 3, pp. 145–198.)

1619. Ruled Glass for Projection Contour Construction [in Optical-Comparator Checking of Parts].—(*Engineering*, 19th Jan. 1945, Vol. 159, No. 4123, p. 57.)

1620. "Successful Soldering" [Book Review].—Taylor. (*QST*, Oct. 1944, Vol. 28, No. 10, p. 98.) An enthusiastic review. Aluminium soldering with ordinary solder is included.

## STATIONS, DESIGN AND OPERATION

1621. Very-High-Frequency and Ultra-High-Frequency Signal Ranges as Limited by Noise and Co-Channel Interference.—Norton & Allen. (*See* 1381.)

1622. Short Summaries of Bell Telephone Laboratories' Papers on the Cape-Charles/Norfolk Ultra-Short-Wave Multiplex System.—Black, Burrows, Kircher, Schlaack, & others. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 53: p. 53: p. 57: p. 59.)

1623. A Stabilised Narrow-Band Frequency-Modulation System for Duplex Working.

—Suckling. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 33–35.)

From the New Zealand Post & Telegraph Department. "A system is described whereby the two terminals of a duplex radiotelephone channel are stabilised against each other by the use of standard a.f.c. circuits and the common use of an oscillator for both transmitting oscillator and superheterodyne h.f. oscillator. The send and receive frequencies are separated from each other by an interval which is the frequency of the i.f. channel. The system can be designed to give adequate frequency stability for most applications without the use of crystal control [an editorial note points out the special sense of the term "stability," as used here: both carriers can drift equally in the same direction without bringing the corrective means into play] . . . Tests indicate that as long as the signal received is sufficient to actuate the limiter, frequency stability is maintained despite variations in power-supply voltage and despite the usual thermal variations in the oscillator circuit."

1624. Tank Radio Set [made up from Four Basic Units, BC-604 Transmitter, BC-603 Receiver, BC-605 Interphone Amplifier, & FT-237 Mounting: the *CT*-Cut Quartz Crystal, less than 1 mm Thick, & Its Mounting: etc.].—Nordahl. (*Bell Lab. Record*, Jan. 1945, Vol. 23, No. 1, pp. 1–5.)

1625. Radio-Relay Communication Systems in the United States Army [including the AN/TRC-1 F.M. Set for use in conjunction with Voice-Frequency-Carrier Equipment to provide Multi-Channel Voice & Teletype Circuits over a Single Radio Frequency].—Marks, Perkins, & Clark. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 57: summary only.)

1626. A Single-Tube WERS Transceiver: "Cathode" Modulation applied to Portable Gear [cutting Components to the Minimum & simplifying Operation].—Abell. (*QST*, Oct. 1944, Vol. 28, No. 10, pp. 32–34.) For corrections *see* Dec. issue, p. 92.

1627. The Radio Interference occurring in the Underground Working of Coal Mines.—Burgholz: Beckmann. (*See* 1456.)

## GENERAL PHYSICAL ARTICLES

1628. Unitary Representations of the Lorentz Group [and Some Applications to Quantum Mechanics, including the Theory of the Electromagnetic Field].—Dirac. (*Proc. Roy. Soc.*, Ser. A, 22nd Feb. 1945, Vol. 183, No. 994, pp. 284–295.)

1629. A Calculus of Finite Precision [Mathematical Theory which is an Inversion of Quantum-Mechanical Ideas: Generalisation & Amplification of the Work dealt with in 3295 of 1944].—Liebowitz. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, pp. 343–350.)

"A macroscopic example of this sort of thing is furnished by the cyclotron or Laurence's linear ion accelerator which preceded the cyclotron. Better examples, I believe, exist in some electronic devices. These examples require more complicated functions for their representation, but otherwise they illustrate the phenomenon of 'rectification' which arises when a particle in a wave field 'rides with the wave.' This concept of phase-mechanical resonance goes further than supplying stabilising means for electrons in special orbits; it also provides means for understanding such phenomena as electron diffraction in terms of classical physics . . . Quantum mechanics ascribes the non-classical behaviour of electrons to 'matter waves' associated with electrons; our theory would put the waves as an 'atmosphere' around the nucleus and ascribe to them a classical electromagnetic character. In the quantum case, the speed of the particle is exactly equal to the group velocity of the matter waves; in our case, the speed of a particle in phase-mechanical resonance is equal or nearly equal to the phase velocity of the electromagnetic waves." *See* also 1102 of 1944.

1630. A Note on the Hamiltonian Theory of Quantization.—Chang. (*Proc. Roy. Soc.*, Ser. A, 22nd Feb. 1945, Vol. 183, No. 994, pp. 316–328.)

A study of the field equations obtained from varying a Lagrangian subject to auxiliary conditions on the dependent variables: Weiss's method is employed. To apply the theory, the Maxwell field is quantized after imposing on it the condition $\nabla.A+(1/c)(\partial\phi/\partial t)=0$. "Though in the beginning there are more complications than in the usual theories, the final result is simple."

1631. Ellipsoidal Waves or Relativity? [Review, by H. T. H. Piaggio, of "Propagation ellipsoïdale, Relativité, Quanta": 3406 of 1944].—Varcollier. (*Nature*, 6th Jan. 1945, Vol. 155, No. 3923, p. 4.)

1632. Application of the Principle of Least Action to the Modern Electrodynamic Theories.—Liénard. (*Comptes Rendus* [Paris], 4th/26th Oct. 1943, Vol. 217, No. 14/17, pp. 319–321.)

1633. The Motion of Small Particles in Magnetic Fields [as reported by Ehrenhaft: New Experiments].—Kane & Reynolds; Ehrenhaft. (*Science*, 1st Dec. 1944, Vol. 100, No. 2605, pp. 503–504.)

The authors hope later to make quantitative measurements and also to examine the possibility of a classical theoretical interpretation of the observed phenomena.

## MISCELLANEOUS

1634. A Calculus of Finite Precision [Inversion of Quantum-Mechanical Ideas].—Liebowitz. (*See* 1629.)

1635. On the Solution of Definite Integrals occurring in Antenna Theory.—Weinbaum. (*See* 1469.)

1636. The "Escalator" Process for the Solution of Lagrangian Frequency Equations [particularly those of High Order such as occur in Practical Problems: based on Successive Introduction or Elimination of Each of the Variables Involved by Definite Self-Contained Stages].—Morris & Head. (*Phil. Mag.*, Nov. 1944, Vol. 35, No. 250, pp. 735–759.)

1637. "DIE MATHEMATIK DES NATURFORSCHERS UND INGENIEURS [Vol. 3—Analytical Geometry: Vol. 4—Differential Equations: Book Review].—Baule. (*E.T.Z.*, 23rd March 1944, Vol. 65, No. 11/12, p. 106.) For Vols. 1 & 2 *see* 957 of 1944.

1638. ON THE LINEAR SET-UP LEADING TO INTRA- AND INTER-BLOCK INFORMATIONS.—Rao. (*Sci. & Culture* [Calcutta], Dec. 1944, Vol. 10, No. 6, pp. 259–260.)

"The purpose of this note is to devise a linear set-up which is of special importance in the field experiments, and to consider the problems of estimation and testing of hypothesis in the light of the article "On Linear Estimation and Testing of Hypothesis" (264/5 of January).

1639. RELAXATION METHODS APPLIED TO ENGINEERING PROBLEMS: XI—PROBLEMS GOVERNED BY THE "QUASI-PLANE-POTENTIAL EQUATION."—Allen, Southwell, & Vaisey. (*Proc. Roy. Soc.*, Ser. A, 22nd Feb. 1945, Vol. 183, No. 994, pp. 258–283.)

1640. THE FRICTION-WHEEL GEAR AS INTEGRATOR [and the Engel–Laskowski Integrating Machine (1937) & Its Avoidance of the Bush Machine Defects].—Meyer z. Capellen. (*Zeitschr. f. Instr:kunde*, July 1943, Vol. 63, No. 7, pp. 241–258.)

1641. SOME MATHEMATICAL INSTRUMENTS BASED ON A ROLLER WHOSE AXIS IS THREADED [Integrators for Linear Differential Equations, etc.].—Obalski. (*Zeitschr. f. Instr:kunde*, March 1943, Vol. 63, No. 3, pp. 100–108.)

1642. IMPROVED SLIDE RULE ["Dualistic" Type, avoiding the "Rather Weak Combination" of the Scales in the Usual Rule].—Unique Slide Rule Company. (*Journ. of Scient. Instr.*, Feb. 1945, Vol. 22, No. 2, p. 38.)

1643. CONSTRUCTIONAL ELEMENTS OF ULTRA-SHORT-WAVE TECHNIQUE [Radiators, Circuits, Resonators, Valves, Klystrons, etc: a Survey].—Aurell. (*Teknisk Tidskrift* [Stockholm], 4th Nov. 1944, Vol. 74, No. 44, pp. 1273–1281.)

1644. THE RADIO INTERFERENCE OCCURRING IN THE UNDERGROUND WORKING OF COAL MINES.—Burgholz: Beckmann. (*See* 1456.)

1645. "SUPPLEMENT TO THE BIBLIOGRAPHY SECTION OF THE 'LEHRBUCH DER HOCHFREQUENZTECHNIK'" [2274 of 1943: Book Review].—Vilbig. (*Zeitschr. f. Fernmeldetech.*, 15th March 1943, Vol. 24, No. 3, p. 48.)

1646. CULTURAL INTERCHANGE BETWEEN THE SOVIET UNION AND THE UNITED STATES [including a Plan, now being explored by *Biological Abstracts*, for a Central Agency for Survey, Translation, & Republication].—Mudd. (*Science*, 1st Dec. 1944, Vol. 100, No. 2605, pp. 486–487.)

1647. THE METHODS OF SCIENTIFIC LITERATURE RESEARCH [Long Survey].—Janicki. (*Schweizer Arch. f. angew. Wiss. u. Tech.*, June 1943, Vol. 9, No. 6, pp. 185–192.) From the Zug, Landis & Gyr Company.

1648. ASSOCIATION OF SPECIAL LIBRARIES AND INFORMATION BUREAUX: 19TH ANNUAL CONFERENCE.—A.S.L.I.B. (*Nature*, 6th Jan. 1945, Vol. 155, No. 3923, pp. 25–27.)

1649. ELECTRONIC PAPERS [Proposal for Increased Number of Papers dealing with Electronic Devices & Methods: Appeal for Early Submission to *Proc. I.R.E.*].—I.R.E. (*Proc. I.R.E.*, Dec. 1944, Vol. 32, No. 12, p. 721.)

1650. FREE PAMPHLET ON SIMPLIFIED SPANISH.—Pan-American Society. (*Journ. Applied Phys.*, Jan. 1945, Vol. 16, No. 1, Supp. p. xx.)

1651. NEW SCHEMATIC SYMBOLS.—American Standards Association. (*QST*, Oct. 1944, Vol. 28, No. 10, pp. 16–17.) The actual use of these symbols is inaugurated in the present issue: *cf.* 1303 of April.

1652. HAMS IN THE R.I.D.: THE F.C.C.'S RADIO INTELLIGENCE DIVISION IN ACTION.—Read. (*QST*, Oct. 1944, Vol. 28, No. 10, pp. 18–23.)

1653. OCCUPATIONS OF EMINENT MEN [with Discussion of Historical, National, & Other Tables].—Smith. (*Scient. Monthly*, July 1943, Vol. 57, No. 1, pp. 52–62.)

1654. INCREASED CONTACT OF YOUNGER AND OLDER INVESTIGATORS IN RESEARCH LABORATORIES.—Cornman. (*Science*, 10th Nov. 1944, Vol. 100, No. 2602, pp. 427–428.)

1655. THE PLACE OF SCIENCE IN INDUSTRY [Summaries of Papers at Conference held at Royal Institution].—British Association. (*Nature*, 27th Jan. 1945, Vol. 155, No. 3926, pp. 96–99.) For a leading article *see* pp. 91–92.

1656. THE E.C.P.D. PROPOSED CANONS OF ETHICS [Project sponsored by the Engineers' Council for Professional Development].—Jackson. (*Elec. Engineering*, Dec. 1944, Vol. 63, No. 12, pp. 441–442.)

1657. CORRESPONDENCE ON "THE THREAT TO PURE SCIENCE" [A. W. Stern].—Robin: Feibleman. (*Science*, 8th Dec. 1944, Vol. 100, No. 2606, pp. 519–521.)

(i) "Like the unicorn, 'pure' science is a myth . . . The greatest threat that exists to science today is that we may not be able to build up a politically and economically stable post-war world which will allow for the maximum expansion of facilities for research . . ." (ii) The point raised by Stern is a crucial one . . . "A pure science which pursued its course indifferent to the demands of society for usefulness would eventually prove the most useful investment that society could make, even though such an investment may have to be amortized over a period of years."

For Stern's original letter, prompted by an address by Bridgman and his article referred to in 1274 of April, see *Science*, 20th Oct. 1944, Vol.

100, No. 2599, p. 356; and for a letter giving the other side of the picture *see* J. M. Pearson, 24th Nov. 1944, No. 2604, pp. 471–472.

1658. GIVE SCIENCE A CHANCE [Presidential Address to Indian Science Conference, after Visit to Great Britain].—Bhatnagar. (*Sci. & Culture* [Calcutta], Jan. 1945, Vol. 10, No. 7, Supp. pp. 1–5.)

1659. PHILOSOPHY OF DESIGN: THE FOUNDATION FOR BETTER PLANNING.—Ashley. (*Proc. I.R.E.*, Dec. 1944, Vol. 32, No. 12, pp. 725–729.)

"The development engineer must deal with nature in a most imperfect state where theory is frequently hidden from sight by the complexity of interactions involved . . . Experience teaches him things which his intellect would never have told him. He learns the proper balance between daring and caution, idealism and realism, theory and practice . . ." "Knowing when not to laugh an idea out of existence calls for acute foresight and sound engineering judgment": an early automobile and one of Rube Goldberg's "weekly inventions."

1660. JOBS AND CAREERS AFTER THE WAR [Note on Report just issued].—Hankey Committee. (*Journ. of Scient. Instr.*, Feb. 1945, Vol. 22, No. 2, p. 40.)

1661. PROFESSIONAL ENGINEERS' APPOINTMENTS BUREAU [Extracts from Circular on Its Objects & Organisation].—(*Engineer*, 19th Jan. 1945, Vol. 179, No. 4645, p. 55: *Engineering*, 19th Jan. 1945, Vol. 159, No. 4213, p. 53.)

1662. THE ENGINEERS' GUILD [Its Foundation in 1938: Objects & Constitution: Future Development].—Allan. (*Engineer*, 19th Jan. 1945, Vol. 179, No. 4645, p. 53.)

1663. RADIO INDUSTRY COUNCIL: INAUGURAL LUNCHEON — WAR-TIME ACHIEVEMENTS.—(*Electrician*, 26th Jan. 1945, Vol. 134, No. 3478, pp. 70–71.) *See* also pp. 67–68.

1664. IS INDUSTRIAL ELECTRONIC TECHNIQUE DIFFERENT? [Considerations for Radio Engineers thinking of entering the Industrial Electronics Field]. — Cockrell. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 54: short summary only.) From the Industrial Engineering Division, General Electric Company.

1665. ELECTRONICS IN TOMORROW'S INDUSTRY.—(*Scient. American*, Nov. 1944, Vol. 171, No. 5, pp. 208–210.)

1666. ACTIVITIES OF THE RADIO TECHNICAL PLANNING BOARD [including the Cooperation of the I.R.E. in Its Work].—Goldsmith. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 55: five-line summary only.)

1667. NATIONAL ELECTRONICS CONFERENCE [Notes on First Meeting, Banquet, etc: including Table showing Comparative Interest in Various Topics, as judged by Attendance at Technical Sessions].—Nat. Electronics Conference. (*Proc. I.R.E.*, Dec. 1944, Vol. 32, No. 12, pp. 771–772.)

1668. REPORT OF NATIONAL RESEARCH COUNCIL CONFERENCE OF PHYSICISTS [Physics in Education: in Industry: Professional Standards: Organisation of Physicists: Physics & Government: Physics & Its Public Relations].—Nat. Research Council. (*Review Scient. Instr.*, Nov. 1944, Vol. 15, No. 11, pp. 283–328.)

1669. THE INTERDEPARTMENT RADIO ADVISORY COMMITTEE [Washington: founded 1922]. —Webster. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 59: summary only.)

"Frequency assigning, at first a minor consideration, gradually increased in importance until now it constitutes almost the entire business of the Committee . . ."

1670. ELECTRONIC RESEARCH OPENS NEW FRONTIERS [Address to National Electronics Conference].—Beal. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 5–9.)

*See* also 104 of January and 963 of March. "In conclusion, I wish to make this plea—that industrial research never relinquish its harmonious cooperation with the Army and Navy. Science, which has helped to win the war, must continue to assist in preserving the peace . . ."

1671. POST-WAR MILITARY RESEARCH.—Furer. (*Science*, 24th Nov. 1944, Vol. 100, No. 2604, pp. 461–464.) *See* also 962 of March.

1672. PATENT LAW AND THE ENGINEER [Correction to One Statement in Emmerton's Article, 1306 of April].—Bloomfield: Emmerton. (*Engineer*, 19th Jan. 1945, Vol. 179, No. 4645, p. 53.)

1673. CONCURRENT GRADUATE STUDY—ITS PLACE IN POST-WAR ENGINEERING EDUCATION [Arguments for More Extensive Development of Facilities for Graduate Study taken Concurrently with Professional Duties].—Stansel. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 3–4.)

1674. LETTER ON "POST-WAR CURRICULUMS IN ELECTRICAL ENGINEERING" [1289 of April]. —Abbott: Kloeffler. (*Elec. Engineering*, Dec. 1944, Vol. 63, No. 12, pp. 458–459.)

1675. INSTITUTE OF RADIO ENGINEERS TO ACT TO SECURE A PERMANENT HOME [Preliminary Notice, including Graphs of Membership & Pages of *Proceedings*].—I.R.E. (*Proc. I.R.E.*, Dec. 1944, Vol. 32, No. 12, pp. 768–769.)

1676. I.R.E. BOARD SETS GOAL OF BUILDING FUND AT $500 000.—I.R.E. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 62–63.) The philosophy underlying the hope of a wide response from the radio-and-electronic industry, and others, in addition to that from the Institute's membership, is expounded.

1677. RESEARCH ON THE ORIGIN OF PETROLEUM [including the M.I.T. Work on Effects of Terrestrial Radioactivity]. — Goodman. (*Phys. Review*, 1st/15th Dec. 1944, Vol. 66, No. 11/12, p. 354: summary only.)

1678. HAZARDS IN RADIOLOGY [Note including Mention of a Report (Bush, Castberg, & Macpherson) on the Danger from Valves].—(*Journ. of Scient. Instr.*, Feb. 1945, Vol. 22, No. 2, p. 40.)

1679. MEDICAL USES OF THE CYCLOTRON.—Spear. (*Journ. of Scient. Instr.*, Feb. 1945, Vol. 22, No. 2, pp. 21–27.)

1680. ELECTRONIC APPARATUS FOR RECORDING AND MEASURING ELECTRICAL POTENTIALS IN NERVE AND MUSCLE [Survey, with Description of Equipment finally developed, and Some Results].—Rogers & Parrack. (*Proc. I.R.E.*, Dec. 1944, Vol. 32, No. 12, pp. 738–742.)

The apparatus consists of a variable-frequency stimulator with volume control; a trigger circuit synchronising the sweep of a cathode-ray oscilloscope with the stimulator; and a resistance-capacitance-coupled amplifier with one balanced push-pull input stage used as a preamplifier to feed a high-level signal into a push-pull differential stage (Tönnies type, slightly modified) which cancels in-phase signals, and three single-ended stages each with an output jack (the differential stage also has a jack at its input so that it can be used as the input stage when less amplification is needed).

Evidence in favour of the "membrane" ("local circuit") theory of the nature of the nerve impulse is reviewed, and the formation of diphasic and monophasic wave-forms is described and illustrated. A method of measuring the conduction rate of the nerve impulse is discussed, and a final section deals briefly with the transmission of the impulse from nerve to muscle (study of cause of failure in degenerating nerve, drug experiments, etc.).

1681. "ÜBER SOGENANNTE KOSMISCHE RHYTHMEN BEIM MENSCHEN" [On the So-Called Cosmic Rhythms in Man: Book Review].—de Rudder. (*Funktech. Monatshefte*, Oct. 1942, No. 10, p. 148.) For other work by the same writer (director of the Frankfort University Children's Clinic) *see* 3341 of 1944.

1682. "KÜNSTLICHE FIEBERERZEUGUNG MIT KURZWELLEN" [Artificial Production of Fever by Short Waves: Book Review].—Raab. (*Funktech. Monatshefte*, Oct. 1942, No. 10, p. 148.)

1683. A PROBLEM OF HEAT CONDUCTION WITH SPHERICAL SYMMETRY [suggested by the Heating-Up of a Body placed at the Centre of a Furnace Cavity: Exact & Simple Approximate Solutions].—Bell. (*Proc. Phys. Soc.*, 1st Jan. 1945, Vol. 57, Part 1, No. 319, pp. 45–48.)

1684. THE PINCH EFFECT: AN ELECTROSTATIC PHENOMENON.—G. W. O. H. (*See* 1413.)

1685. SOME PECULIARITIES OF HEATING STEEL BY INDUCTION [Principal Electrical & Magnetic Characteristics of Steel: the Striated Heating Effect & Its Utilisation].—Babat. (*Journ. Applied Phys.*, Dec. 1944, Vol. 15, No. 12, pp. 835–839.) *See* also 276/7 of 1943.

1686. THE USE OF RADIO FREQUENCIES TO OBTAIN HIGH-POWER CONCENTRATIONS FOR INDUSTRIAL-HEATING APPLICATIONS.—Roberds. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, pp. 9–14.)

"Radio-frequency heating is not so much a substitute method as it is a *supplementary* process. That is, although it can be used to heat almost anything yet its particular value lies in a few applications where the unique properties of r.f. power can best be utilised. In such applications it is possible to perform heating operations that would be utterly impossible by any other method, or the r.f. method may speed up production rates by several hundred per cent, and in other instances may provide great savings in cost, time, and space."

In the induction heating of steel or other metals, the application of 100 kw to a square inch of area on the work is not difficult. At a frequency of 1 Mc/s, 99% of the resulting heat generation is confined to a layer approximately 1/16th inch thick. With r.f. dielectric heating, power concentrations of the order of 1 kw per cubic inch can be obtained in thick wood sections (heated press platens give only about 0·05 w per cubic inch).

1687. HIGH-FREQUENCY HEATING: FUNDAMENTAL PRINCIPLES, METALLURGICAL EFFECTS, AND SOME ECONOMIC ASPECTS.—Robiette. (*BEAMA Journ.*, Dec. 1944, Vol. 51, No. 90, pp. 405–406: summary, from *Iron & Coal Trades Review*, 1944.)

1688. RADIO-FREQUENCY HEATING: NATURE OF THE EQUIPMENT [including Remarks on the Restriction of Radiated Energy].—Langton. (*BEAMA Journ.*, Dec. 1944, Vol. 51, No. 90, p. 405: summary, from *Electrical Times*, 1944.) *Cf.* 1454, above.

1689. THE RADIO-FREQUENCY DEHYDRATION OF MATERIALS LABILE WITH HEAT [especially Pharmaceutical Materials: the Two Discrete Steps in Pencillin Dehydration: Extension to Other Biological Substances].—Brown & others. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 53: summary only.)

1690. EFFICIENCY OF INDUCTION HEATING COILS [" including Analysis of Current Distribution in Work Coil and Load, Relation between Frequency & Coupling Efficiency, Impedance Considerations, & Discussion of Factors affecting Choice of Frequency"].—Brown. (*Electronics*, Aug. 1944, Vol. 17, No. 8, pp. 124–129 and 382..385.)

1691. OPERATING EXPERIENCES WITH [Many Hundreds of Large-Capacity] INDUCTION-HEATING OSCILLATORS, *and* HEATING WITH HIGH-FREQUENCY ELECTRIC FIELDS.—Rudd: Zottu. (*Proc. I.R.E.*, Jan. 1945, Vol. 33, No. 1, p. 59: p. 60: short summaries only.)

1692. ELECTRONIC HEATING OF PLASTIC PREFORMS [and the R.C.A. Model 2-B Dielectric Heating Unit].—R.C.A. (*Electronics*, Aug. 1944, Vol. 17, No. 8, pp. 146, 148.)

1693. ELECTRONIC VULCANIZING OF TYRES FOR ARMY TRUCKS.—Vogt. (*Electronics*, Aug. 1944, Vol. 17, No. 8, pp. 148..152.)

1694. PRACTICAL METHODS OF SHIELDING DIELECTRIC-HEATING INSTALLATIONS.—Klingaman & Williams. (*See* 1454.)

1695. A HIGH-FREQUENCY WATTMETER AND ITS USES IN INDUSTRIAL APPLICATIONS [especially H.F. Heating].—Mittelmann. (*See* 1540.)

1696. AUTOMATIC TEMPERATURE CONTROL [of Fighter-Plane Engines: Combination of Metallic Oxides as Temperature-Sensitive Material].—General Electric. (*Gen. Elec. Review*, Jan. 1945, Vol. 48, No. 1, p. 66.)

1697. ELECTRONIC CONTROLS [Electronic Analyser for Gas Content of Air (in testing Suction Hoods in Manufacturing Plants, etc.): Supervision of Rate of Flow of Liquid in Pipeline: Control of Special Distillation System for Water used in Preparation of Phosphors, Electron-Emitting Coatings, etc.].—Zeluff. (*Scient. American*, Dec. 1944, Vol. 171, No. 6, pp. 259–261.)

1698. THE FAIRCHILD ELECTRONIC COMPUTING GUNSIGHT, TYPE "K-8," FOR AIRCRAFT MACHINE GUNS.—Hale & Doyle. (*Sci. News Letter*, 18th Nov. 1944, Vol. 46, No. 21, p. 326.)

1699. CONSIDERATIONS IN SERVO-MECHANISM DESIGN [Calculation of Steady-State & Transient Performance: General & Specific Solutions].—Herwald. (*Elec. Engineering*, Dec. 1944, Vol. 63, No. 12, Transactions pp. 871–876.)

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1701. POSITION CONTROL AS PROVIDED BY SINGLE-PHASE A.C. SELSYN SYSTEMS.—Fink. (*Gen. Elec. Review*, Dec. 1944, Vol. 47, No. 12, pp. 40–44.)

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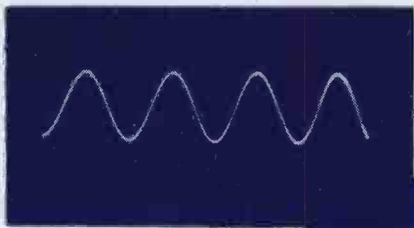

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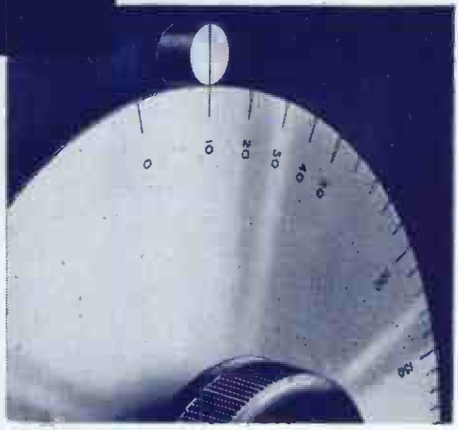

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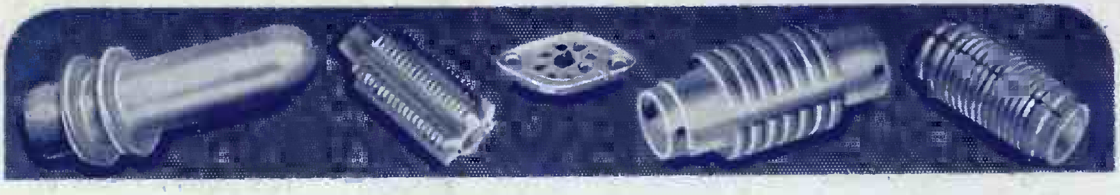

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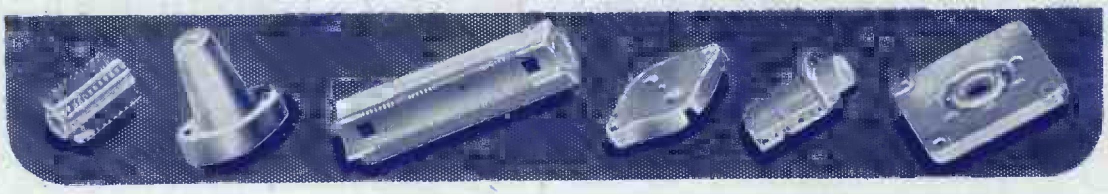

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