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Editorial

Analysis of the Ionosphere

A MONOGRAPH (B-1241) with the above title by Karl K. Darrow has recently been published by the Bell Telephone System in their "contemporary physics" series. It also appeared in the *Bell System Technical Journal* of July 1940 pp. 455-488). It gives in 34 pages a general (review of the subject from its inception down to the present day in terms that will be intelligible to any electrical engineer or physicist. It always distinguishes clearly between experimental facts and working assumptions. The author begins in the 'eighties with Balfour Stewart's idea of a conducting layer in the upper atmosphere as an explanation of magnetic fluctuations, and Kennelly and Heaviside's similar assumption in 1902 as an explanation of the ability of wireless signals to travel around the earth. By this time Thomson's work on ions gave some reasonable expectation that such a notion would be justified, and, as Darrow says, "never was an expectation better founded." The theoretical and practical problems involved in the determination of the nature and distribution of the ionisation of the upper atmosphere were tackled with great success in the middle and late 'twenties, especially by Appleton, and as the author says "the interplay between theory and experiment has seldom been so well exemplified."

In explaining the reflection of signals sent vertically upwards, the author comforts the reader by assuring him that, although the effects of the collisions between the ions and the neutral molecules, and of the earth's magnetic field, give algebraic expressions of fearful complexity, the theory is strictly classical. "No relativity, no quantum theory, no suggested revision of the concepts of space and time, afflict the student thereof. It is the working-out of the basic principle of Maxwell and Lorentz."

Of the various methods of determining the virtual height which a signal reaches before being reflected, the one now used almost exclusively was developed mainly by Breit and Tuve. It consists in sending vertically upwards a short sharp signal or wave-group, and determining the time that elapses before the receipt of the echo. This interval is only a few milliseconds but it can be readily determined by recording both the despatch of the signal and the receipt of the echo on a moving film. We said "virtual height" because the assumption that the signal travels all the way with the velocity of light is not strictly correct. In the ionosphere the signal is slowed down before it stops and begins the return journey, and the actual height reached is therefore less than that calculated. If only we knew the distribution of ionisation we could allow for this effect, but the object of the experiment is to determine this distribution. As the density of the ions increases with increasing penetration into the ionised layer, so the velocity of the signal decreases until it reaches the "mirror-density," that is, the density at which the velocity is reduced to zero and the signal is reflected. The higher the frequency of the signal the greater the ionic density required to effect its reflection and the further, therefore, its penetration into the ionosphere before it reaches its mirror-density; above a certain frequency this may never be reached and the signal will then pass out into space. It will be seen that reflection can only occur in regions in which the ionic density is increasing with height. The records are complicated by the fact that the returning signal is reflected by the earth's surface and may travel to and fro, or "fro and to" as Darrow has it, several times, thus giving a succession of records of decreasing intensity.

If the experiment is rapidly repeated with signals of increasing frequency, the echo-delay and, therefore, the virtual height of the corresponding mirror-density, increase steadily as a rule up to a certain frequency and then suddenly jump to a much higher value, indicating that they have penetrated the first ionised layer, the so-called *E* layer, and have now encountered another layer of higher ionic density—the so-called *F* layer. There are sometimes indications of further stratification, the *F* layer being then regarded as subdivided into two layers designated F_1 and F_2. Although we are dealing with heights of from 100 to 1,000 kilometres it is striking that *N*, the number of ions per cubic centimetre, reaches values of 10^5 to 2.10^5 in the *E* layer and up to 10^6 in the *F* layer even under normal circumstances.

Darrow explains how the phenomena are complicated by the effect of the earth's magnetic field. To simplify matters he assumes that waves are transmitted vertically upwards at a point on the earth's magnetic equator. A station was set up by the Carnegie Institution of Washington specially for this purpose at Huancayo in the Peruvian Andes. If the transmitting aerial is a horizontal wire running north and south, the electric field will be in the same direction as the magnetic field and the oscillations of the electrons will be unaffected by it. If, however, the transmitting aerial runs east and west, the electric field and the consequent movement of the electrons in the ionosphere will be at right angles to the magnetic field. The electron paths will therefore be distorted and it can be shown that these so-called extraordinary waves will be reflected at lower values of *N* than the ordinary waves. They will therefore have a lower virtual height, and in a composite wave, such as that transmitted from an aerial running NW–SE the extraordinary component may be reflected from the *E* layer whilst the ordinary component goes on to be reflected from the F layer. By suitably arranging the receiving aerial one may record the return of either the one or the other or of both components. Much work on this subject has been done at Huancayo by Wells and Berkner. It is possible from the results to calculate the strength of the earth's field and the calculated value comes out slightly less than its value at the earth's surface, which, as Darrow says, is very probable. By doing the experiments on the magnetic equator one avoids any wave transmission along the direction of the magnetic field with the consequent rotation of the plane of polarisation and the critical frequency known as the "gyro-frequency" which is something like a resonant frequency and plays an important part in the transmission. It is interesting to note that the rotation of the plane of polarisation is in opposite directions in the northern and southern hemispheres, since the vertical component of the field is in the reverse direction. It was the agreement of the experimental results with the calculations of the effects of the magnetic field that proved conclusively that the effects in the ionosphere are due to electrons and not to charged atoms. Owing to their large mass the magneto-ionic effect of the latter would be very small.

There are two allied phenomena that call for explanation. We have already pointed out that the lower the frequency, the lower the electron-density required for its reflection and the lower therefore the virtual height of its "ceiling." But if the frequency is decreased below a certain critical value there is no echo. The other phenomenon is that occasionally all the echoes vanish whatever the frequency. As Darrow says: "Over broad areas the extinction is sudden and simultaneous in many fade-outs, more gradual in others; the restoration is as a rule more gradual."

This phenomenon cannot be due to any change in the reflecting layers because they show no change up to the moment of fade out and on the return of the normal reflection the virtual height is quite normal. It appears almost certain that below the reflecting layers there is some ionisation where the density of the air is so great that the moving electrons collide with the molecules and, giving up some of their energy, cause the wave energy to be absorbed. Below a certain frequency the loss *en route* is such that no signal ever returns, and occasionally there is such an abnormal burst of radiation from the sun that the ionisation is so great and extends downwards into air of such a density that signals of all frequencies are absorbed. Such fade-outs often coincide with visible eruptions on the sun, although the author is careful to point out that the rays that bring us this visual information cannot be the cause of the phenomenon. The ionosphere provides still a number of problems and a number of mysteries. "Not a very satisfactory situation for the present, but at any rate one which offers endless promise."

G. W. O. H.

To anyone reading the monograph we would point out that (*a*) the author uses *m* as a symbol for a million and not the internationally recognised *M*; (*b*) on page 28 a frequency is given as 1.3 10^6 megacycles per second; this should be 1.3 Mc/s; (*c*) the page references are to the original pages in the journal, but the correct page reference is obtained by subtracting 454; (*d*) "frequency *c*" near the foot of p. 11 should be "frequency f_c"; there is something not quite right with Figs. 3A and 3B as is shown by the reference to the dashed parts of Fig. 3A and the gaps in Fig. 3B. The relation between the two curves would be shown more clearly if Fig. 3A were plotted like Fig. 3B with the altitude as the ordinate.

A Theory of the Practical Triode*

Its Application to Valve Design

By I. A. Harris

SUMMARY.—In this paper an attempt is made to deduce, by approximate methods, relations between valve geometry and the characteristics of a practical triode with plane anode and "W" filament.

The theory is introduced by a consideration of requirements imposed by design data based on the classical equation for the ideal triode: it is concluded by an example of design and calculation of characteristic curves accurate enough for the estimation of harmonic distortion.

The well-known failure of the classical equation (equ. 1) to express the observed mutual conductance in terms of I_a is traced to the effect of grid supports, and a simple modification of the older equation is given which accounts for this effect.

Introduction

THE generally accepted relationship between the anode current I_a, the grid voltage V_g and the anode voltage V_a of a triode is based on the results of Child and Langmuir⁽¹⁾ for a diode. The expression is:

$$I_a = k\left(\frac{V_a + \mu V_g}{\mu + A}\right)^{3/2} \quad \cdots \quad \cdots \quad (1)$$

where the constants A and μ characterise the anode-grid geometry, and k depends on the cathode to grid spacing. The constant μ is the (ideal) amplification factor of the triode.

In its application to valve design, this equation sometimes gives results differing widely from observed values, and partly for this reason valve design has become more of a process of trial and error development than being based on exact calculation.

Equation (1) when applied to practical valves is only a first approximation because it is derived on the assumption that the grid mesh is small in comparison with the grid to cathode clearance, in which case the anode and grid together act as a single electrode of potential $V_d = (V_a + \mu V_g)/(\mu + A)$ at the position of the grid. Such a triode is termed *ideal*⁽²⁾.

Practical triodes are by no means ideal in this sense; therefore it appears necessary to derive an expression corresponding to (1), but which is a closer approximation when applied to the practical triode.

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Before this is undertaken, however, the limitations of design requirements on the constants of equation (1), and the determination of k for a typical filament system are considered.

I.—Design Data for a Class A Amplifying Triode

We consider design data based on equation (1) in order to make a comparison with design data based on the equations for the practical triode. Use is made of the derived coefficients $g_m (= \partial I_a/\partial V_g)$ and $R_a (= \partial V_a/\partial I_a)$, the *mutual conductance* and *anode-impedance* or *A.C. resistance* respectively.

In terms of k, μ and A, equation (1) gives :

$$g_m = \frac{3}{2} k^{2/3} \left(\frac{\mu}{\mu + A} \right) I_a^{1/3} \quad \ldots \quad \ldots \quad (2)$$

$$R_a = \mu / g_m \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

Let there be a load of equivalent resistance R_l in the anode circuit and let $\bar{V}_a$, $\bar{I}_a$ be the applied direct voltage at the anode and the supply current, so that the "static" anode dissipation is $P_a = \bar{V}_a \bar{I}_a$. With a signal on the grid, the A.C. power in the load is ideally a maximum for unlimited swings of grid-potential when $R_a = R_l$, but owing to the limits of grid voltage swing and minimum anode current (assumed zero as an approximation) one chooses $R_l = nR_a$. If bars denote mean values, then the working voltage and current are determined by the relations (see note at end of section)

$$\bar{V}_a = \sqrt{P_a (n + 2) \bar{R}_a} \, , \; \bar{I}_a = P_a / \bar{V}_a \quad (4)$$

The choice of n depends on individual requirements in three cases.

First, if a maximum output is desired with a limited voltage $\bar{V}_a$, then n should be nearly 2. Secondly, the sensitivity s, which is expressed :

$$s = \frac{\bar{g}_m^{\,2}}{(1 + n)^2} n \bar{R}_a$$

or by use of (2) and (4) in the more useful form :

$$s = \frac{9}{4} k^{4/3} \left(\frac{\mu}{\mu + A} \right)^2 \cdot \frac{\bar{V}_a^{4/3}}{P_a^{1/3}} \cdot \frac{n}{(1 + n)^2 \, (n + 2)} \quad \ldots \quad \ldots \quad (5)$$

is seen to depend on a high value of k, and a value of n of about 0.6 gives a maximum for fixed $\bar{V}_a$ and P_a. Thirdly, the efficiency of the amplifier is expressed by :

$$\frac{P_l}{P_a} = \frac{n}{2 \, (n + 2)} \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

(where P_l is the A.C. power in the load, P_a is the total power supplied, and linear characteristics are assumed). Thus high efficiency demands a high value of n.

Summarising, the essentials of good design based on equations (2), (3) and (4) are :

(a) A high value of k.

(b) The value of n must be chosen according to requirements of sensitivity and efficiency.

Note on derivation of equations (4) *and* (6).

Fig. 1 shows perfectly linear anode characteristics, on which P is the class A working point and QPR is the load line.

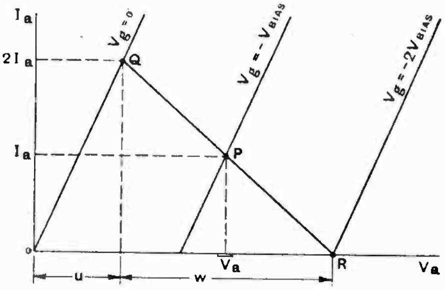

Fig. 1.

From the figure and the definitions given in section I we have

$$\bar{R}_a = \frac{u}{2\bar{I}_a} \text{ and } R_l = \frac{w}{2\bar{I}_a}$$

and it follows that $w = nu$.

The figure also gives the relation $\bar{V}_a = u + \frac{1}{2}w$, which the preceding relation reduces to $\frac{1}{2}u(2 + n)$. But $\frac{1}{2}u = \bar{R}_a \bar{I}_a$ or since $P_a = \bar{V}_a \bar{I}_a$, $\frac{1}{2}u = \frac{\bar{R}_a P_a}{\bar{V}_a}$, and from this relation and $\bar{V}_a = \frac{1}{2}u \, (2 + n)$ follows equation (4) : $\bar{V}_a = \sqrt{P_a (n + 2) \bar{R}_a}$.

The mean square A.C. current in the load is $\frac{1}{2}\bar{I}_a^2$ (for max. signal on grid), so that the A.C. power is $\frac{1}{2}R_l \bar{I}_a^2 = P_l$. But equs. (4) give $\bar{I}_a^2 = P_a/[(n + 2)\bar{R}_a]$, whence

$$P_l = \frac{nP_a}{2(n + 2)}$$

and equ. (6) follows at once.

II.—Filament Configuration and the Constant *k*

Our considerations are limited to the common practical form of a multiple-V filament system sandwiched between planar grid and anode (Fig. 2). The filament loops are assumed to approximate to parallel wires of mean spacing d.

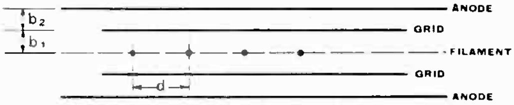

Fig. 2.

Around each wire the field is like that of the cylindrical diode of Langmuir⁽¹⁾ whilst near the grid planes it is like the planar diode of Child⁽¹⁾, and since a rigorous solution appears impossible, we use a method of interpolation which leads to the scheme:

$$k = 4 \times 2.33 \times 10^{-6} N.l \int_{0}^{d/2} \frac{dy}{u^2} \quad \ldots \quad (7)$$

In this, u is measured along a "line" of electric field which cuts the grid plane normally at a distance y from a point on the plane opposite a filament wire. The effective length of each wire limb is l and N is the number of limbs.

The field lines are approximately parabolic curves meeting the grid planes normally, given by:

$$u = \frac{b_1}{2}\left\{\sqrt{1 + \left(\frac{2y}{b_1}\right)^2} + \frac{b_1}{2y}\sinh^{-1}\left(\frac{2y}{b_1}\right)\right\}$$

and substitution in (7) leads to the result:

$$k = 18.64 \times 10^{-6} N \frac{l}{b_1} . f \quad \ldots \quad \ldots \quad (8)$$

where f is found by graphical integration and is plotted against d/b_1 in Fig. 3.

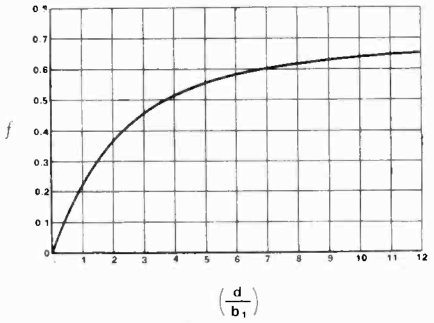

Fig. 3.

Applying (8) to condition (a) of section I, we have:—

(1) Maximum length of wire, Nl, permitted by the available filament power and nature of emitter.

(2) Adequate spreading of limbs ($d/b_1 > 4$ is indicated by Fig. 2).

(3) Minimum filament to grid clearance. This is limited by the fact that when b_1 is reduced to a value less than the grid mesh, the triode becomes far from ideal and increased curvature of the characteristics result⁽³⁾.

III.—Mathematical Treatment of the Practical Triode

For a rigorous determination of the anode current, a solution of Poisson's equation with boundary potentials at the cathode, over the grid wires and at the anode would be necessary. This presents insurmountable difficulties, so approximate methods are used whereby the triode is first treated as an electrostatic system satisfying Laplace's equation; allowance afterwards being made for the space charge before applying the anode-current equation for a diode.

With an ideal triode, the current is that of a diode-anode at the grid, of potential equal to the mean over the grid-plane; but for the practical triode we cannot assume the potential even on the average over all the grid plane.

The method used here is to *determine an equivalent diode from the intensity of the electrostatic field at the cathode surface.* We consider a simple triode of planar cathode, a grid of parallel wires and planar anode shown in section in Fig. 4 and neglect edge effects.

Reference axes x and y are drawn with origin o at a grid wire centre. The grid pitch is a, and grid wire radius ρ.

For the potential function, we use the simple expression given by Maxwell⁽⁴⁾ for the potential $V(x, y)$ at any point P on the cross section:

$$V(x, y) = -\lambda \log\left(1 + e^{\frac{4\pi x}{a}} - 2e^{\frac{2\pi x}{a}} \cos\frac{2\pi y}{a}\right) - \frac{4\pi\lambda'}{a} x + C \quad \ldots \quad \ldots \quad (9)$$

where λ, λ' and C depend on electrode dimensions and potentials, and there is the limitation $a \gg \rho$.

It is readily shown that equipotentials are circles around and near each grid wire of centre at $y = o$, $\pm a$, $\pm 2a$, etc., and that on their surfaces, $V = V_g = V(o, \rho)$ which by (9) is :

$$V(o, \rho) = -\lambda \log\left(2 - 2\cos\frac{2\pi\rho}{a}\right) + C$$

$$= -2\lambda \log\left(2\sin\frac{\pi\rho}{a}\right) + C$$

or if $\gamma = -\frac{a}{2\pi}\log\left(2\sin\frac{\pi\rho}{a}\right)$ then

$$V_g = \frac{4\pi\lambda}{a}\gamma + C \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

Assuming first that the triode is ideal, and thus $|b_1| \gg a$, $|b_2| \gg a$, and putting $x = b_2$ and $x = -b_1$, respectively in (9), we obtain approximately :

$$V(b_2, y) = V_a = -\frac{4\pi}{a}(\lambda + \lambda') \,.\, b_2 + C, \quad \ldots \quad \ldots \quad (11)$$

$$V(-b_1, y) = V_c = \frac{4\pi}{a}\lambda \,.\, b_1 + C. \quad (12)$$

With the grid considered as a plane at potential C, the ideal triode is shown by (11) and (12) to consist of two diodes,(2) of which the grid to cathode diode is the "equivalent diode" used to obtain (1). The potential across this diode is $V_d = C - V_c$ or with $V_c = o$, $V_d = C$.

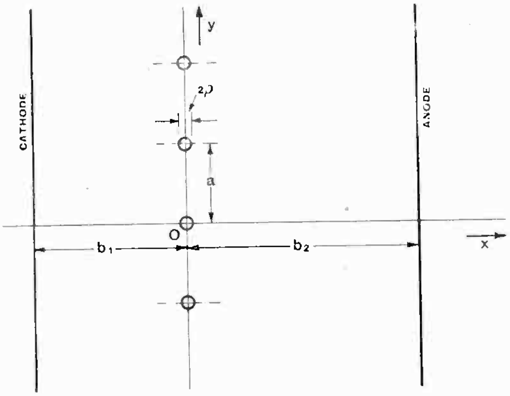

Fig. 4.

Solving equations (10), (11) and (12) for C, λ and λ', we obtain (with $V_c = o$) :

$$C = \frac{V_a + (b_2/\gamma)V_g}{1 + (b_2/\gamma) + (b_2/b_1)} \quad \ldots \quad \ldots \quad (13)$$

which is just the bracketed part of equation (1) with $\mu = b_2/\gamma$ and $A = 1 + b_2/b_1$. The expressions for λ and λ' are :

$$\lambda = \frac{a}{4\pi\gamma}\left\{\frac{V_g(1 + b_2/b_1) - V_a}{1 + (b_2/\gamma) + (b_2/b_1)}\right\} \quad \ldots \quad (14)$$

$$\lambda' = \frac{-a}{4\pi b_1}\left\{\frac{V_a + (b_2/\gamma)V_g}{1 + (b_2/\gamma) + (b_2/b_1)}\right\} \quad \ldots \quad (15)$$

We now consider the case when $|b_1| \gg a$ does not hold, and the triode is therefore non-ideal. As set out at the beginning of this section, we commence with an examination of how the field strength at the cathode plane varies along the y-direction.

In order to send electrons towards the anode, this field must be negative in the x-direction, and it will be shown that with negative V_g and positive V_a, the field is thus negative *only in isolated regions* not shadowed by the grid wires. This phenomenon is known in practice as *island formation* or *Inselbildung*(3)(6).

Though (12) does not hold strictly when b_1/a is small, we may assume it to be true on the average, since the equipotential-sections near the grid-section in Fig. 4 are wavy lines which when averaged over a length of one grid-pitch behave approximately like straight-line sections. On the strength of this intuitive assumption we make use of (14) and (15) for λ and λ', and further we assume that the field near the cathode is very nearly normal to it.

Thus for the intensity normal to the cathode, (9) yields :

$$E_x = -\frac{\partial V}{\partial x}$$

$$= \frac{4\pi}{a}\left\{\frac{e^{\frac{4\pi x}{a}} - e^{\frac{2\pi x}{a}} \,.\, \cos\left(\frac{2\pi y}{a}\right)}{1 + e^{\frac{4\pi r}{a}} - 2e^{\frac{2\pi x}{a}} \,.\, \cos\left(\frac{2\pi y}{a}\right)}\lambda + \lambda'\right\} \quad \ldots \quad . \quad (16)$$

Putting $x = -b_1$ and neglecting

$$exp\left(\frac{-4\pi b_1}{a}\right)$$

in comparison with $exp\left(\frac{-2\pi b_1}{a}\right)$, we obtain further—

$$E_x = \frac{4\pi}{a}\left\{\frac{-\lambda}{\left[exp\left(\frac{2\pi b_1}{a}\right) \Big/ \cos\left(\frac{2\pi y}{a}\right)\right] - 2} + \lambda'\right\} \quad \ldots \quad \ldots \quad (16a)$$

On plotting E_x against y for values of λ given by negative V_g, we obtain a curve such as that in Fig. 5 in which regions of y with negative E_x have been shaded under the curve.

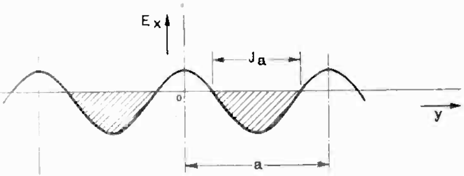

Fig. 5.

In the positive regions the field repels electrons back to the cathode. The width of a region is determined by values of y for which $E_x = 0$, given by (16) as:

$$y_1 = \frac{a}{2\pi}\cos^{-1}\left\{\frac{exp\left(\frac{2\pi b_1}{a}\right)}{\lambda/\lambda' + 2}\right\}$$

and the width of an " island " is thus $a - 2y_1 = Ja$, where J is $1 - 2y_1/a$. Hence we write:

$$J = 1 - \frac{1}{\pi}\cos^{-1}\left\{\frac{exp\left(\frac{2\pi b_1}{a}\right)}{\lambda/\lambda' + 2}\right\} \quad .. \quad (17)$$

which is the ratio of " effective " to " actual " cathode area.

The next step is to find the mean negative field-strength over an " island," choosing that one between $y = 0$ and $y = a$, extending from $y = \frac{a}{2}\left(1 - J\right)$ to $\frac{a}{2}\left(1 + J\right)$ (refer to Fig. 5). The mean intensity is given by:

$$\bar{E}_x = \frac{1}{Ja}\int_{\frac{1}{2}a(1-J)}^{\frac{1}{2}a(1+J)} E_x dy.$$

and approximate integration gives the relation

$$\bar{E}_x = \frac{4\lambda\sin(\pi J)}{Ja\ exp\left(\frac{2\pi b_1}{a}\right)} + \frac{4\pi\lambda'}{a},$$

which is the mean intensity at the cathode, excluding those parts shadowed by the grid wires. The equivalent diode potential V_d is given by the simple relation* $V_d = \int E_x dx = -b_1 E_x$, and on substituting for λ and λ' we finally obtain:

$$= \frac{b_1\sin(\pi J)}{\gamma(\pi J)\ exp\left(\frac{2\pi b_1}{a}\right)}\left\{\frac{V_a - V_g(1 + b_2/b_1)}{1 + b_2/\gamma + b_2/b_1}\right\}$$

$$+ \left\{\frac{V_a + b_2/\gamma V_g}{1 + b_2/\gamma + b_2/b_1}\right\} \quad .. \quad .. \quad (18)$$

The real part of the first term of this expression is non-zero only for values of V_g given by:—

$$\frac{V_a}{-V_g} \leq \frac{\left\{exp\left(\frac{2\pi b_1}{a}\right) - 1\right\} b_2/\gamma - b_1/\gamma}{\left\{exp\left(\frac{2\pi b_1}{a}\right) - 2\right\} - b_1/\gamma} \quad .. \quad (19)$$

a relation deduced from (17) by placing $J \leq 1$ in it.

The second term of (18) is identical with equation (13), and it is seen that when b_1/a is very large, the first term of (18) is very small for any value of V_g and thus when the triode becomes ideal, (18) merges into (13).

Both (13) and (18) have to be corrected for the space-charge near the cathode. For the ideal triode, it is known(2) that the field in the " immediate neighbourhood " of the grid plane determines V_d, and that the space charge reduces b_1 to $\frac{3}{4}$ b_1 effectively. For the practical triode, however, this is not so, and the problem is complex. Fortunately, the value of this correction is not critical on I_a values, and we can interpolate by reducing b_1 to $\frac{7}{8}$ b_1 for the correction.

Writing μ for b_2/γ and A for $1 + (8/7)(b_2/b_1)$, we rewrite (17), (18) and (19) in the forms:—

$$J = 1 - \frac{}{\pi}\cos^{-1}\phi \quad .. \quad .. \quad (17a)$$

where:—

$$\phi = \frac{exp\left(5{\cdot}5\frac{b_1}{a}\right)}{\left(\frac{\mu}{A - 1}\right)\cdot\frac{(V_a/ - V_g) + A}{(V_a/ - V_g) - \mu} + 2} \quad (17b)$$

and

$$V_d = \left(\frac{\mu}{A - 1}\right)\frac{K}{exp\left(\frac{5{\cdot}5b_1}{a}\right)}\left\{\frac{V_a - A\,V_g}{\mu + A}\right\}$$

$$+ \left\{\frac{V_a + \mu V_g}{\mu + A}\right\} \quad .. \quad .. \quad (18a)$$

where $K = \sin(\pi J)/(\pi J)$.

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*This is equivalent to a reduction of the electrostatic system to a ficticious parallel plate condenser, as was done in deducing equ. (1).

The anode current with negative bias is then given by the equation corresponding to (1) :—

$$I_a = k \,.\, J \,.\, V_d^{3/2} \quad .. \quad .. \quad .. \quad (20)$$

(which is in amperes when k is given by (8) and V_d is in volts.)

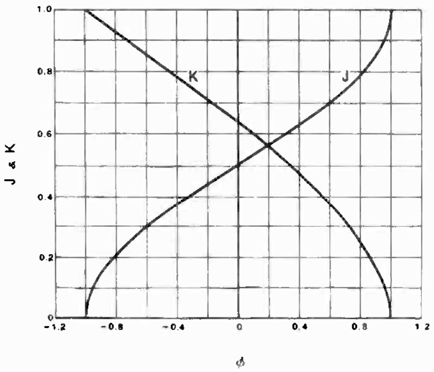


Fig. 6.

A method of calculation is as follows :—

(1) Plot ϕ against values of $V_a/ - V_g$ consistent with (19). Then the graphs in Fig. 6 give J and K.

(2) Plot the first term of (18a) against $V_a/ - V_g$, using K.

A typical set of curves given by equations (18a) and (20) for a practical triode is shown in Fig. 7. These are the curves of an imaginary valve with plane cathode, and with: $b_2 = 3.5$, $b_1 = 1.5$, $a = 3.5$ and $\rho = 0.075$ millimetres. The form of the curves agrees with forms found in practice, and in actual valve applications good quantitative agreement is found with the theory. The agreement justifies the assumptions made in this section.

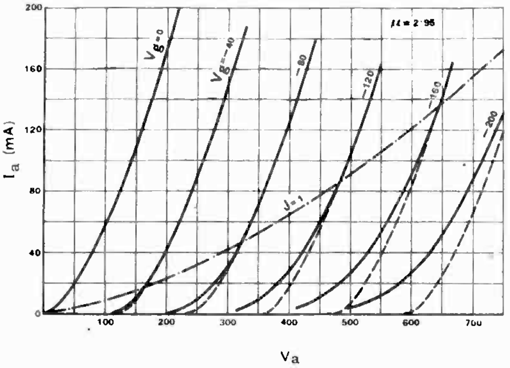


Fig. 7.—*The dotted curves are those given by equation* 1.

IV.—Effect of Grid Supports on the Characteristics

The grid of a triode is invariably supported by relatively thick wires standing at right angles to the grid wires, and the electric field is modified by these supports sufficiently to make a modification of equation (18) necessary.

Let us consider *one* grid and its supports of the system depicted in Fig. 8(a) in which four supports are shown, provisionally considering a planar cathode. The grid with its two supports may be looked upon as part of an infinite double grid of two sets of parallel wires at right angles, and its description by co-ordinates x, y, z is shown in Fig. 8(b).

The potential function :

$$\begin{aligned} V(x, y, z) = &-\lambda_1 \log\left(1 + e^{\frac{4\pi x}{a}} - 2e^{\frac{2\pi x}{a}} \,.\, \cos\frac{2\pi y}{a}\right) - \frac{4\pi}{a}\lambda' x \\ &- \lambda_2 \log\left(1 + e^{\frac{4\pi x}{a'}} - 2e^{\frac{2\pi x}{a'}} \,.\, \cos\frac{2\pi z}{a'}\right) \\ &- \frac{4\pi}{a'}\lambda' x + C \quad .. \quad .. \quad .. \quad (21) \end{aligned}$$

which is readily shown to satisfy Laplace's equation in three dimensions, approximately fits our case of a double grating. We have four potential surfaces V_a, V_c, and V_g on each set of wires for the determination of the four constants λ_1, λ_2, λ' and C.

On the grid plane $x = o$ we have :

$$V(o, y, z) = -\lambda_1 \log\left(2 - 2\cos\frac{2\pi y}{a}\right) - \lambda_2 \log\left(2 - 2\cos\frac{2\pi z}{a'}\right) + C.$$

Taking the mean of V over $z = \rho'$ to $a' - \rho'$ and putting $y = \rho$ gives :

$$V = V_g = \frac{4\pi}{a}\gamma\lambda_1 - \lambda_2\beta + C \quad .. \quad (22)$$

where $\gamma = -\dfrac{a}{2\pi}\log\left(2\sin\dfrac{\pi\rho}{a}\right)$.

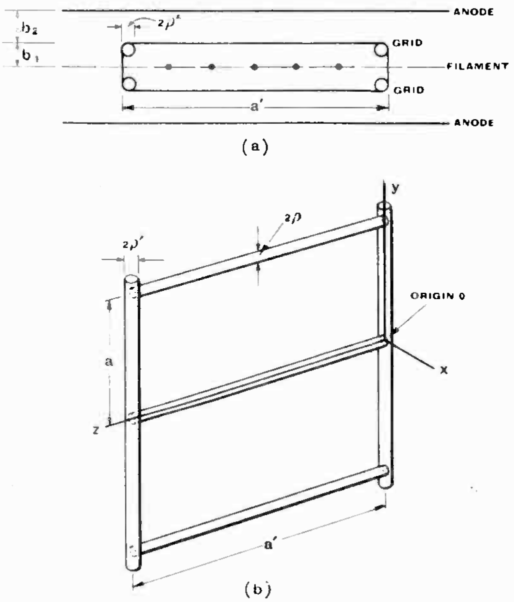
Also, taking the mean V over $y = \rho$ to $a - \rho$ and putting $z = \rho'$ we obtain :

$$V = V_g = \frac{4\pi}{a'}\gamma'\lambda_2 - \lambda_1\beta' + C \quad .. \quad (23)$$

where $\gamma' = -\frac{a'}{2\pi}\log\left(2\sin\frac{\pi\rho'}{a'}\right)$.

Since the effect of the grid supports is small compared with that of the grid in the case of the "flat" triode, this treatment need be only very approximate, and we may neglect β and β' to simplify calculations. It follows that (22) and (23) give the relation between λ_1 and λ_2 as $\gamma' a\lambda_2 = \gamma a'\lambda_1$, from which it follows that (22) and (23) both become:

$$V_g = \frac{4\pi}{a}\gamma\lambda_1 + C.$$



(a)

(b)

Fig. 8.

If the triode with the double grid were ideal, we should obtain as values of the constants:

$$C = \frac{V_a + (b_2/\gamma_o)V_g}{1 + (b_2/\gamma_o) + (b_2/b_1)} \quad .. \quad (24)$$

$$\lambda_1 = \frac{-a}{4\pi\gamma}\left\{\frac{V_a - (1 + b_2/b_1)V_g}{1 + (b_2/\gamma_o) + (b_2/b_1)}\right\} \quad (25)$$

and

$$\lambda' = \frac{-aa'}{4\pi b_1(a + a')}\left\{\frac{V_a + (b_2/\gamma_o)V_g}{1 + (b_2/\gamma_o) + (b_2/b_1)}\right\} \quad .. \quad .. \quad .. \quad (26)$$

in which

$$\frac{b_2}{\gamma_o} = \frac{b_2}{\gamma} + \frac{b_2}{\gamma'} \text{ or } \mu_o = \mu + \mu'. \quad .. \quad (27)$$

We now proceed to investigate the triode as in the previous section, taking account of island formation.

The intensity E_x obtained by differentiating (21) by x now depends on x, y and z. Placing $E_x = 0$, the boundary of an island is given and is a closed curve on the yz-plane, but in order again to simplify, we split E_x into two parts, each like equation (16), to separate the variables. This gives rectangular islands.

For the grid wires, we approximate as before and get

$$J = 1 - \frac{1}{\pi}\cos^{-1}\left\{\frac{exp\left(\frac{2\pi b_1}{a}\right)}{(\lambda_1\lambda') + 2}\right\} \quad .. \quad (28)$$

but for the supports, since $a' \gg b_1$, we obtain with no approximation:

$$J' = 1 - \frac{1}{\pi}\cos^{-1}$$

$$\left\{\frac{exp\left(\frac{2\pi b_1}{a'}\right) + \left(1 + \frac{\lambda_2}{\lambda'}\right) . exp\left(\frac{-2\pi b_1}{a'}\right)}{(\lambda_2/\lambda') + 2}\right\} \quad (29)$$

The mean intensity over an "island" is given by:

$$\bar{E}_x = \frac{1}{aa'JJ'}\iint E_x\,dy\,dz$$

with the limits of integration $y = \frac{1}{2}a(1 \pm J)$ and $z = \frac{1}{2}a'(1 \pm J')$. The resulting value of $V_d(= -b_1\bar{E}_x)$ is:

$$V_d = \frac{1}{A - 1}\left\{\frac{K\mu}{exp\left(5.5\frac{b_1}{a}\right)} + \frac{K'\mu'}{exp\left(5.5\frac{b_1'}{a'}\right)}\right\}$$

$$\left\{\frac{V_a - AV_g}{\mu_o + A}\right\} + \left\{\frac{V_a + \mu_o V_g}{\mu_o + A}\right\} \quad .. \quad (30)$$

which replaces equation (18a).

For the anode current with negative grid-bias,

$$I_a = k\,.\,J.J'.\,V_d^{3/2} \quad .. \quad .. \quad (31)$$

These results are best expressed, for calculation, in terms of $(V_a/ - V_g) = v$. Thus:

$$\frac{\lambda_1}{\lambda'} = \frac{\mu\left(1 + \frac{a}{a'}\right)}{(A - 1)} \cdot \frac{v + A}{v - \mu_o} \quad .. \quad .. \quad (28a)$$

$$\frac{\lambda_2}{\lambda'} = \frac{\mu'\left(1 + \frac{a'}{a}\right)}{(A - 1)} \cdot \frac{v + A}{v - \mu_o} \quad .. \quad .. \quad (29a)$$

$$\left(\frac{V_d}{-V_g}\right)=\frac{1}{A-1}\left\{\frac{K\mu}{exp\left(5.5\,\frac{b_1}{a}\right)}+\frac{K'\mu'}{exp\left(5.5\,\frac{b_1}{a'}\right)}\right\}.$$

$$\frac{v+A}{\mu_o+A}+\frac{v-\mu_o}{\mu_o+A}\quad\cdots\quad\cdots\quad(30a)$$

$$\text{and } I_a=k.J.J'\,(-V_g)^{3/2}\cdot\left(\frac{V_d}{-V_g}\right)^{3/2}\cdots\quad(31a)$$

If the grid has two supports only, as is common with small valves, it is sufficient for the accuracy required to assume four supports of half the thickness of the two supports, situated as in Fig. 8a.

V.—Effect of Space Charge between Grid and Anode

In Fig. 9 the potential curves of the two diodes forming an ideal triode are given by straight continuous lines for the electrostatic case, and by broken curves when space-charge is present. Since the field near the grid determines V_d, we take tangents to these curves at the grid as the field-representation of two new diodes. Thus the space-charge effectively *reduces* b_1 and slightly *increases* b_2⁽²⁾.

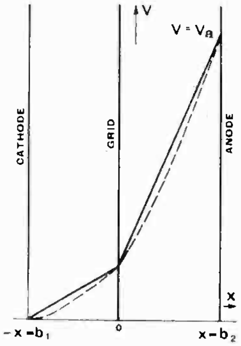


Fig. 9.

The *cathode diode* has a potential curve ⁽¹⁾:

$$V(x)=(I/k)^{2/3}\,.\,(b_1+x)^{4/3}\quad\cdots\quad(32)$$

where I is the space current. The slope of this curve at the grid plane is $\frac{4}{3}\;V_d/b_1$, whilst the static field has a slope V_d/b_1: thus the modified field has a parameter $\beta_1=\frac{3}{4}b_1$.

The *anode diode* is difficult to treat because the intensity is not zero at the grid plane and therefore (32) cannot be used. We must first determine the plane at which the field of the anode-diode has $dV/dx=0$. Let this plane be the zero of x' of new co-ordinates x', V', shown in Fig. 10. In it we have:

$$V'=(I/k')^{2/3}\,.\,x'^{\,4/3}$$

and the slope at the grid is $4/3\,.V_d'/b_2'$.

$$\text{Then } \beta_2=\tfrac{3}{4}b_2'\,\frac{V_a'-V_d'}{V_d'}$$

$$\text{or } \frac{\beta_2}{b_2}=\kappa=\tfrac{3}{4}\cdot\frac{b_2'}{b_2}\cdot\left(\frac{V_a'}{V_d'}-1\right)\quad\cdots\quad(33)$$

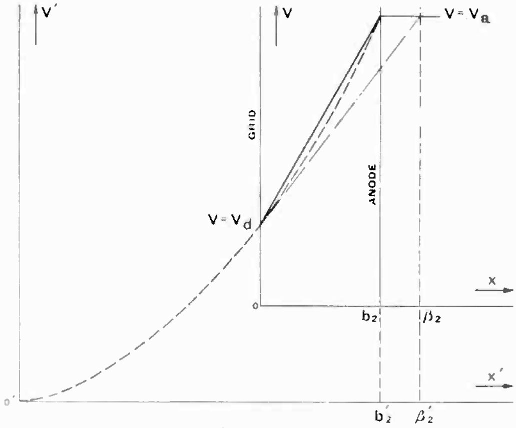


Fig. 10.

For b_2'/b_2 we have $\dfrac{b_2'+b_2}{b_2}$

$$=\left(\frac{V_a'}{V_d'}\right)^{3/4}(=q^{3/4}\text{ say})$$

$$\text{and } \frac{b_2}{b_2'}=q^{3/4}-1\quad\text{giving}\quad\kappa=\tfrac{3}{4}\cdot\frac{(q-1)}{(q^{3/4}-1)}$$

$$\cdots\quad\cdots\quad\cdots\quad\cdots\quad(34)$$

We have to connect the diode of coordinates (x', V') with the diode (x, V), and for this we assert that the *space current is the same for each diode*, which gives:

$$V_d'=\left(\frac{b_2'}{b_1}\right)^{4/3}V_d\quad\cdots\quad\cdots\quad\cdots\quad(35)$$

Fig. 9 shows that $V_a'=V_d'+(V_a-V_d)$ so that

$$\frac{V_a'}{V_d'}=q=1+\frac{V_a-V_d}{V_d'}$$

$$=1+\left(\frac{b_1}{b_2'}\right)^{4/3}\left(\frac{V_a}{V_d}-1\right)\text{ by (35).}$$

$$\text{Also, } \frac{b_1}{b_2'}=\frac{b_1}{b_2}(q^{3/4}-1)\text{ whence}$$

$$q=1+\left(\frac{b_1}{b_2}\right)^{4/3}.\,(q^{3/4}-1)^{4/3}\,.\left(\frac{V_a}{V_d}-1\right)$$

$$\text{or } \frac{(q^{3/4}-1)^{4/3}}{(q-1)}=P\text{ (say)}=\left(\frac{b_2}{b_1}\right)^{4/3}$$

$$\left(\frac{V_a}{V_d}-1\right)^{-1}\quad\cdots\quad\cdots\quad(36)$$

Together with (35), this result enables a graph to be plotted between κ and P. The graph is given in Fig. 11.

Modifying equation (13) we obtain for an ideal triode:

$$V_d = \frac{V_a + \kappa\mu V_g}{1 + \kappa\mu + \frac{4}{3}\kappa\frac{b_2}{b_1}} \quad \cdots \quad \cdots \quad (37)$$

In spite of the fact that $\kappa\mu > \mu$, the appearance of κ in the denominator actually *decreases* the measured amplification factor $(-\partial V_a/\partial V_g)$ for slightly negative V_g. Since an observed *increase* in amplification factor near zero V_g is often attributed to space charge effects, the result is interesting in so far as it disproves a customary belief. The true cause of this phenomenon is the effect of the grid supports.

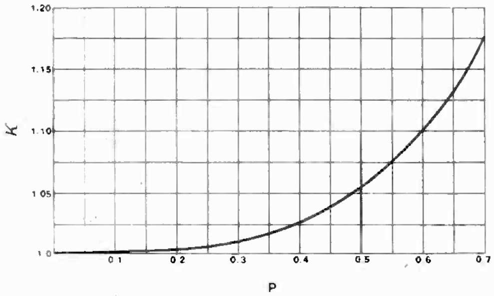


Fig. 11.—$P = \left(\frac{b_2}{b_1}\right)^{4/3}\left(\frac{V_a}{V_d} - 1\right)^{-1}$

$$\cong \left(\frac{b_2}{b_1}\right)^{4/3} \frac{1 + \mu(V_g/V_g)}{\mu(1 + V_g/V_a) + A - 1}$$

In practical valves which do not have large values of b_2/b_1, only the curve $V_g = 0$ need be corrected, and for this curve, V_d is reduced approximately in the ratio $1 : \kappa$.

VI.—Application to the Design of Triodes

The results of the preceding sections are here applied to the design and calculation of the characteristic curves of a power amplifying triode.

In the first place the design is based on equations (2), (3) and (4) of section I, and then a modification of (2) is shown to be essential if the design is to be of value. The main objects of this section are to illustrate how the characteristics may be determined by the theory and to derive a simple modification of equation (2), an equation which always gives too high a value for the slope of any valve.

Suppose the triode is to dissipate 75 watts at the anode and that the working voltage is $\overline{V}_a = 1{,}000$ volts.

To simplify the calculations, we choose n to give high sensitivity but poor efficiency and give it the value 2. Then equation (4) gives

$$\overline{R}_a = \frac{\overline{V}_a^2}{(n+2)P_a} = \frac{10^6}{4 \times 75}$$

$$= \underline{3{,}300 \text{ ohms.}} \quad \cdots \quad (38)$$

To determine k, we have to decide upon a suitable filament, a question outside the scope of this article, so we merely state that it has a total length of 320 mm. which is conveniently bent into two loops. Allowing for suspension, this fixes the effective length of one limb at 70 mm., the anode also being this length.

In equation (8) we have $N = 4$, $l = 70$, and reasonable values of b_1 and d consistent with no grid overheating are 2 mm. and 8 mm. respectively.

Then from (8) $k = 1.36 \times 10^{-3}$. With I_a in milliamperes, $k = 1.36$.

Having found k and $\overline{R}_a$, we determine g_m by (2), first roughly, then accurately after μ and A have been estimated. This gives $g_m = 6.3\ mA/V$ and $\underline{\mu = 21}$. (The high μ is due to the choice of n for high sensitivity.)

With $b_2 = 8$ mm., $a = 2$ and $\rho = 0.1$, we obtain:

$$\mu = \frac{2\pi \times 8}{2\log_e\left(\frac{2}{2\pi \times 0.1}\right)} = 22.5 \quad \cdots \quad (39)$$

which we adopt.

The nine dimensions defining the electrodes are: $d = 8$, $l = 70$, $N = 4$, $b_1 = 2$, $b_2 = 8$, $a = 2$, $\rho = 0.1$ when for the supports we have four with $\rho' = 0.7$ and $a' = 33$ millimetres.

For the determination of the characteristic curves, we use equations (30a) and (31a). Although these equations have been worked out for a triode with a plane cathode, they are also valid for our triode with the multiple-V filament, provided the values of μ and μ' are corrected.

Whilst $\mu = b_2/\gamma$ is accurate for a plane cathode provided $\rho \ll a$ (formula of Miller and King,⑸ the radial symmetry of the field around each filament wire makes μ less than this value in our case. For practical values of d/b_1 a very close approximation to μ is

$$\mu = \frac{b_2}{\gamma}\left(\frac{(b_2/\gamma) + \frac{1}{2})}{(b_2/\gamma) + 1}\right) \quad \ldots \quad \ldots \quad (40)$$

which shows that only small values of μ need be corrected.

We have for our calculation :

$$k = 1.36,\ A = \left(1 + \frac{8}{7}\frac{b_2}{b_1}\right) = 5{\cdot}58,\ \mu = 22{\cdot}5$$

and using (40) for μ', $\mu' = 0.65$ whence $\mu_o = \mu + \mu' = 23.15$.

Also, $exp\left(5{\cdot}5\,\frac{b_1}{a}\right) = 245$ and $exp\left(5{\cdot}5\,\frac{b_1}{a'}\right) = 1.4$.

Owing to the high value 245 of the exponential for the grid itself, we neglect any island formation effect of the grid and consider only that of the supports. We have :

$$\frac{\lambda_2}{\lambda_1} = 2{\cdot}48\left(\frac{v + 5{\cdot}58}{v - 23{\cdot}15}\right)$$ by (29a) and in equ. (29) :

$$J' = 1 - \frac{1}{\pi}\cos^{-1}\phi' \text{ we have } \phi'$$

$$= \frac{1{\cdot}4 + 0{\cdot}714\,(1 + \lambda_2/\lambda')}{(\lambda_2/\lambda' + 2)} \quad \ldots \quad (41)$$

Equation (30a) is now :

$$\left(\frac{V_d}{-V_g}\right) = \left\{{\cdot}00352K'\left(v + 5{\cdot}58\right)\right\}$$

$$+ \left\{{\cdot}0348\left(v - 23{\cdot}15\right)\right\} \quad \ldots \quad \ldots \quad (42)$$

$$= \alpha + \beta \text{ for brevity.}$$

The remainder of the calculation of $J'(\alpha + \beta)^{3/2}$ is readily made by slide-rule with the assistance of a system of tabulation. K' and J' are given by the graphs of Fig. 6 in terms of ϕ'. The Table is used then to plot a graph between v and $J'(\alpha + \beta)^{3/2}$ and from this a family of curves (except $V_g = o$) is obtained by using :

$$I_a = 1{\cdot}36(-V_g)^{3/2} \times J'.\,(\alpha + \beta)^{3/2}.$$

The curve $V_g = o$ is obtained from the second term of (30) :

$$I_a = 1{\cdot}36 \times (0{\cdot}0348)^{3/2}.$$

The space-charge correction to this curve is a reduction of I_a in the ratio $1 : \kappa^{3/2}$ which is $1 : 1.0075$ and is negligible. The characteristic curves are shown in Fig. 12, on which the ideal curves with $\mu = 22.5$ are drawn in dotted lines.

Comparison between the two sets of curves shows that the large grid supports reduce the slopes of the curves (a.c. resistance is increased) giving a value of $\bar{g}_m$ less than that given by equ. (2).

Further, the *measured amplification factor in the working region is nearly equal to the ideal value of* 22.5 (neglecting supports), thus showing how the well-known formulae⑸ for μ give good results on neglecting the grid supports.

Finally, near zero V_g, the amplification factor is greater than in the working region, a fact always found in practice.

Owing to the discrepancy between (2) and the value of $\bar{g}_m$ actually obtained, the working anode voltage which suits the valve is not 1,000, but according to (4) has to be changed.

The ideal $\bar{R}_a$ is 3,350, whilst the actual $\bar{R}_a = 4{,}300$, so that (4) gives

$$\bar{V}_a = \sqrt{4{,}300 \div 3{,}350} \times 1{,}000 = 1{,}130$$

volts. We take $\bar{V}_a = 1{,}100$ volts, $\bar{I}_a = 67$ *m*A and $\bar{V}_g = -30$ as the working point.

The optimum load for this with 5 per cent. 2nd harmonic distortion is 8,600 ohms and $n = 2.0$. (The output is 12.45 watts,

v	$v - \mu_0$	$v + A$	$\frac{\lambda_2}{\lambda'}$	ϕ'	J'	K'	α	β	$\alpha + \beta$	$J'(\alpha + \beta)^{3/2}$
24	0.85	29.6	86.3	0.72	0.75	0.30	0.0312	0.0296	0.0608	0.0112
30	6.85	35.6	12.9	0.76	0.77	0.27	0.0328	0.2382	0.2710	0.1087
40	16.85	45.6	6.71	0.79	0.79	0.25	0.0412	0.5870	0.6282	0.392
50	26.85	55.6	5.15	0.81	0.80	0.24	0.0470	0.933	0.980	0.778
60	36.85	65.6	4.42	0.82	0.81	0.23	0.0531	1.285	1.338	1.255

giving the low efficiency of 17 per cent.(!) which is the result of the choice of n at the outset.)

It is in general necessary to account for (a) Contact P.D. between grid and filament together with initial emission velocity, and (b) P.D. along the filament. In the example treated here (a) amounts to about + 0.5 volt on the grid and is neglected, whilst (b) is neglected on account of A.C. filament heating from a centre-tapped transformer being assumed. If D.C. heating is used in the normal manner we correct for this by *adding* $-\frac{1}{2}V_f$ to the grid potential applied.

VII.—Simplified Modification of Design Equations

We have to obtain a modified form of equ. (2) accurate over the working range of potentials and giving the correct value of g_m according to equations (30) and (31). Over this range the island formation effect of the grid wires is neglected, so $K = 0$ and $J = 1$.

Approximating to (31) by assuming J' and K' to be nearly constant over the working range of I_a, we write:

$$I_a = J'k \left\{ \frac{C'(V_a - AV_g) + (V_a + \mu_o V_g)}{\mu_o + A} \right\}^{3/2} \quad \ldots \quad \ldots \quad \ldots \quad (1a)$$

To determine C', we note from Fig. 12 that the ampl. factor at the working point is equal to the ideal μ, and equate this to the result of differentiating (1a). Thus:—

$$-\frac{\partial V_a}{\partial V_g} = \frac{\mu_o - C'A}{1 + C'}$$

which is equated to μ, giving:

$$C' = \frac{\mu_o - \mu}{\mu + A} = \frac{\mu'}{\mu + A} \quad \ldots \quad \ldots \quad (1b)$$

(Note: μ is ampl. factor of grid wires, μ' ampl. factor of supports, and μ_o their sum.)

For J', a tentative empirical relation is:

$$J' = 1 - \sqrt{\frac{b_1}{2a'}} \quad \ldots \quad \ldots \quad \ldots \quad (1c)$$

Differentiating (1a) leads to the modified form of (2):

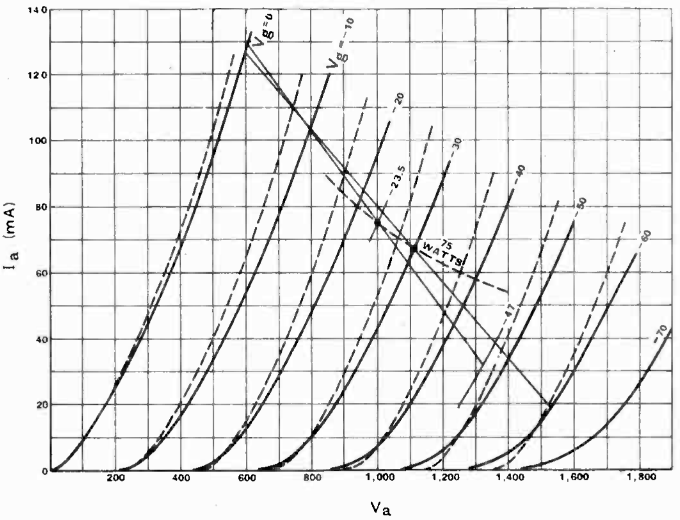


Fig. 12.

$$g_m = \tfrac{3}{2}(J'k)^{2/3}\left(\frac{\mu_o - C'A}{\mu_o + A}\right) . I_a^{\frac{1}{3}} \quad \ldots \quad (2a)$$

These formulae agree with the example worked out in detail.

Equations (1a) and (2a) should prove useful in the initial design of triodes, particularly those with small amplification factors when the effect of the grid supports is most marked.

Equations (30a) and (31a) provide means for predetermining the whole set of characteristic curves for negative grid-bias values.

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Interference in Relation to Amplitude, Phase and Frequency Modulated Systems

By O. E. Keall

(Concluded from page 17 of the January issue)

Interference Distortion when the Systems are Modulated

It is necessary to extend this analysis to determine whether, when the systems are modulated (i.e. under normal operating conditions), distortion components are greater than those revealed in the foregoing elementary analysis. It is also necessary, if the results are to bear any relation to a practical case, to consider the selectivity of the receiver as well. It should be borne in mind, though the effect will here not be taken into account, that in an actual receiver the selectivity increases with each stage and that therefore the first valve operates over a wider effective band than others. Non-linearity in this valve will result in combination tones being produced between the wanted and interfering modulation components that would not exist were the total selectivity concentrated at one point in the chain. In what follows such non-linear effects will be neglected and it will be assumed that the total selectivity is concentrated prior to the detector and is such that for amplitude modulated signals, sidebands outside the range ± 10 kc/s are attenuated to a negligible value, while for phase or frequency modulated signals, sidebands outside the maximum intelligence spectrum demanded by 100% modulation at 10 kc/s are likewise attenuated. This does not mean that really high quality transmissions are not included, for 100% modulation is very rarely approached for frequencies exceeding 5 kc/s and the spectrum associated with such high quality transmissions will therefore with very few exceptions lie within the limits chosen. In the Armstrong system the modulation depth at the high frequencies is artificially raised to give improved signal to noise ratio, an appropriate compensating circuit being used in the receiver to restore the level to its original value.

Two methods of approach are available (1) to expand the sum of the signals in the form of an equivalent modulation bracket as has already been done in the simple cases so far considered; (2) to superimpose the intelligence spectra of the two signals and pick out the sidebands likely to cause interference. In the former method the expansions yield a large number of terms, many of which have to be discarded since they give rise to tones outside the audio range. There is much to be said for the second method since a physical picture of the process is attained and the computations moreover reduced. An expansion in general form is, however, necessary in order to determine the amplitudes of the resulting interference tones.

The three systems of modulation as applied to the wanted carrier will be considered in turn and the interference determined in each case, when the interfering signal is also modulated by the three systems; detection means appropriate to the wanted signal are assumed in each case.

A. Wanted Signal Amplitude Modulated

$$(1 + K \sin \mu t) \sin \omega_0 t$$

(*i*) *Interfering signal amplitude modulated* $x(1 + p \sin vt) \sin (\omega_0 + b)t$.

Provided the interfering carrier falls outside the wanted spectrum, any interfering sideband falling within the wanted spectrum gives rise to an output of frequency $(b' - v')$ and of amplitude $p\frac{X}{2}$. This represents the major interference component. Others exist which arise as beats between the wanted sideband and the interfering sideband of frequency $(b' - v' \pm \mu')$ and amplitude $Kp\frac{X}{4}$. They are thus second order terms and may be neglected in comparison with the major interference component $(b' - v')$. The equivalent modulation bracket (first approximation) may be shown to be

$$\text{M.B.} = \left(1 + \frac{K}{1 + x^2} \sin \mu t + \tfrac{1}{2} \frac{K^2}{1 + x^2} \sin 2\mu t + p \frac{X}{2} \sin (b - v)t + \ldots \right) \quad .. \quad (52)$$

from which it will be seen that distortion of the original modulation (in the form of harmonics) also occurs as a result of the presence of an interfering component.

It will also be noted that high modulation tones associated with the interfering carrier appear as low tones in the output $(b' - v')$, and on account of the sensitivity characteristic of the ear produce interference out of proportion to their value in the interfering programme. Low modulation tones associated with the interfering signal falling outside the wanted spectrum of course produce no interference.

(*ii*) *Interfering Signal Phase Modulated.* $x \sin \{(\omega_0 + b)t + p \sin vt\}$.

Reference to Fig. 3 shows that the maximum intelligence spectrum is only fully made use of for high modulation depths and high modulation frequencies. This implies that the wanted spectrum may be situated wholly inside the maximum interfering intelligence spectrum and only suffer distortion when the interfering signal is modulated above a certain depth and only then when the modulation frequency exceeds a particular value. For instance a wanted carrier situated 75 kc/s above an interfering signal of characteristics represented by Fig. 3 will suffer no interference for modulation frequencies of 5 kc/s or less whatever the modulation depth while for 10 kc/s modulation frequency the modulation depth must be 50% or more to produce any effect. Such a depth at this frequency is very unusual.

To estimate the extent of interference it is necessary to determine (1) the number of interfering sidebands falling within the wanted spectrum, (2) their respective amplitudes. With regard to the latter an inspection of tables of Bessel coefficients shows that when the order n and argument m of $J_n(m)$ are large $J_n(m)$ rarely exceeds 0.3 so that the amplitude of the sideband rarely exceeds 0.3 x. A more accurate determination is as follows. If b' be the beat or separation frequency of the two carriers and v' the interfering modulation frequency, and if the nth order sideband be defined as that arising from the interfering modulation situated nv' cycles (or kc/s) from its associated carrier and of amplitude $J_n(m)$ (i.e. the order of the sideband is the same as the order of the Bessel coefficient which determines its amplitude) then the orders of sidebands falling within the wanted signal spectrum (± 10 kc/s) are given by

$$n = \frac{b' \pm 10}{v'} \quad \text{when } n \text{ is integral} \quad .. \quad (53)$$

where $b' \pm 10$ represents the range from $b' - 10$ to $b + 10$. If n have values n_1, n_2, n_3, . . . the corresponding sideband amplitudes are $J_{n_1}(m)$, $J_{n_2}(m)$ . . . and the corresponding interference output frequencies are $b' - n_1 v'$, $b - n_2 v'$. . . . As an example take an interfering signal represented by Fig. 3 in which $\phi_0 = 10$ radians. When $b' = 75$ kc/s with 100% modulation at 5 kc/s

$$n = \frac{75 \pm 10}{5}, \quad \therefore n_1 = 13,\ n_2 = 14, \ldots n_5 = 17.$$

Now $J_{13}(10) = 0.029$, $J_{14}(10) = 0.012$ and others are less than 0.01 and may be neglected. There will therefore be two interfering sidebands in the wanted spectrum of amplitudes 0.029 x and 0.012 x giving rise to frequencies of 10 and 5 kc/s respectively. From (37) the E.M.D. which arises is 2.9 x% at 10 kc/s and 1.2 x% at 5 kc/s.

When $v' = 7$ kc/s, $n_1 = 10$, $n_2 = 11$, $n_3 = 12$

$$J_{10}(10) = 0.20,\ J_{11}(10) = 0.12,$$
$$J_{12}(10) = 0.06.$$

The corresponding output frequencies are 5, 2 and 9 kc/s and their respective E.M.D.s $20x$%, $12x$% and $6x$% (total E.M.D. (R.M.S.) $24x$%). For no distortion at this frequency the limiting modulation depth is 60% approximately.

The above represent the major interference output frequencies. Others exist due to combination between these interfering sidebands and the wanted, but their amplitude does not exceed ¼ of the above (corresponding to 100% wanted modulation depth) and they may be neglected in comparison.

(*iii*) *Interfering Signal Frequency Modulated.* $x \sin \{(\omega_0 + b)t + p \sin vt\}$.

Reference to Fig. 4 shows that at 100% modulation, the whole of the interfering spectrum is employed whatever the modulation frequency, though a reduced spectrum is occupied for lower depths. A wanted signal spectrum falling within the maximum spectrum of an interfering signal will therefore only suffer interference when the depth of modulation of the latter exceeds a certain value. The sidebands falling within the wanted spectrum may be estimated in the manner described in (ii) and the resulting distortion deduced.

B. Wanted Signal Phase Modulated, sin $(\omega_0 t + m \sin \mu t)$

(*i*) *Interfering Carrier Only*, $x \sin (\omega_0 + b)t$.

This corresponds to the case where an atmospheric or other interfering source falls within the spectrum of the wanted signal and may be compared with equation 39 *et seq.* for the corresponding amplitude modulation case.

The phase displacement ϕ (equation 32) due to the interference is found after the manner of equation 47 to be

$$\phi = \tan^{-1} \frac{\sin \overline{m \sin \mu t} + x \sin bt}{\cos \overline{m \sin \mu t} + x \cos bt} \quad .. \quad (54)$$

$$= m \sin \mu t + x \sin (bt - m \sin \mu t)$$

$$- \frac{x^2}{2} \sin 2(bt - m \sin \mu t) + \ldots \quad .. \quad (55)$$

The equivalent modulation bracket to a first approximation is found to be

$$\text{M.B.} = 1 + K \sin \mu t + \frac{x}{\phi_0} [\sin bt\{J_0(m) + 2J_2(m) \cos 2\mu t + \ldots\} - \cos bt\{2J_1(m) \sin \mu t + 2J_3(m) \sin 3\mu t + \ldots\}] \quad .. \quad (56)$$

$$= 1 + K \sin \mu t + \frac{x}{\phi_0}[J_0(m) \sin bt + J_1(m) \sin (\pm b - \mu)t + J_2(m) \sin (b \pm 2\mu)t + \ldots] \quad .. \quad (57)$$

The original modulation is unimpaired but distortion tones of frequencies $b' \pm n\mu'$ are present and of these only those resulting in audio tones are important, i.e. those for which $b' \pm n\mu' = 10$ kc/s or less. These may be estimated as before and their amplitudes $\frac{x}{\phi_0} J_n(m)$ determined, from which the distortion is known. It is clear that if the interfering carrier be superposed on the wanted spectrum, only those sidebands that fall within a spectrum equal to the audio spectrum (± 10 kc/s) in relation to the interfering carrier are capable of producing audible output. The frequency of the output is determined by the frequency separation of these sidebands from the interfering signal.

Examples:

(a) $\phi_0 = 10$ radians $\mu' = 6$ kc/s, $K = 1$
$b' = 40$ kc/s.

$$n = \frac{40 \pm 10}{6}, \therefore n_1 = 5, n_2 = 6, n_3 = 7, n_4 = 8$$

Frequency 10 4 2 8 kc/s.

E.M.D. $\frac{x}{\phi_0} J_n(10)$ $0.023\,x$, $0.001\,x$, $0.022\,x$, $0.032\,x$.

E.M.D. (R.M.S.) = $4.5\,x$%.

Distortion ($K = 1$) = $4.5x$%.

(b) $\phi_0 = 10$, $\mu' = 6$ kc/s, $K = 0.1$, $m = 1.0 = K\phi_0$
$b' = 14$ kc/s.

$$n = \frac{14 \pm 10}{6}, \therefore n_1 = 1, n_2 = 2, n_3 = 3, n_4 = 4$$

Frequency 8 2 4 10 kc/s.

E.M.D. $\frac{x}{\phi_0} J_n(1)$ $0.044x$, $0.011x$, $0.002x$ —

E.M.D. (R.M.S.) = $4.5\,x$%.

Distortion ($K = 0.1$) = $45\,x$%.

(c) For $b' = 9$ kc/s, i.e. within audio range of wanted carrier and with same conditions as (b).

E.M.D. (R.M.S.) = $8.9x$%.

Distortion ($K = 0.1$) = $89x$%.

It is of interest to note that the equivalent modulation depth due to the interfering signal is of the order of 5% as $x \rightarrow 1.0$ wherever the signal may be situated in the spectrum except when the modulation depth of the wanted signal is low and the interfering signal is within "audio range" of the wanted carrier. (In general when $K\phi_0 < 2$).

(*ii*) *Interfering Signal Amplitude Modulated.*

The carrier and each sideband of the interfering signal may be considered separately after the manner of (i) and the total distortion determined. This will not differ appreciably from the figure for carrier alone (except when $K\phi_0 < 2$) since the sidebands are of amplitude $p\frac{x}{2}$ as against x for carrier alone.

(iii) Interfering Signal Phase Modulated.

By virtue of the characteristics of phase modulated signals interference will not occur unless both signals are simultaneously modulated above a certain depth by frequencies exceeding certain values (assuming the lower half of one spectrum to overlap the upper half of the other) as may be readily seen by super-position. When these limiting conditions are exceeded the sidebands of one transmission beat with the sidebands of the other. The phase displacement in the presence of interference may be found to be

$$\phi = m \sin \mu t + x \sin (bt + \bar{v} - \bar{\mu}) - \frac{x^2}{2} \sin 2 (bt + \bar{v} - \bar{\mu}) + \ldots\ldots \quad (58)$$

where $\bar{v} = p \sin vt$, $\bar{\mu} = m \sin \mu t$

whence the equivalent modulation bracket is

$$\text{M.B.} = 1 + K \sin \mu t + \frac{x}{\phi_0} \sin (bt + \bar{v} - \mu) - \frac{x^2}{2\phi_0} \sin 2 (bt + \bar{v} - \mu) + \ldots \quad (59)$$

Now

$$\begin{aligned} \sin (bt + \bar{v} - \bar{\mu}) = {} & \sin bt[\{J_0(p) + 2J_2(p) \cos 2vt + \ldots\} \\ & \{J_0(m) + 2J_2(m) \cos 2 \mu t + \ldots\} \\ & + \{2J_1(p) \sin vt + 2J_3(p) \sin 3vt + \ldots\} \\ & + \{2J_1(m) \sin \mu t + 2J_3(m) \sin 3\mu t + \ldots\}] \\ & + \cos bt[\{2J_1(p) \sin vt + 2J_3(p) \sin 3vt + \ldots\} \\ & \{J_0(m) + 2J_2(m) \cos 2\mu t + \ldots\} \\ & - \{J_0(p) + 2J_2(p) \cos 2vt + \ldots\} \\ & \{2J_1(m) \sin \mu t + 2J_3(m) \sin 3\mu t + \ldots\}] \quad \ldots \quad (60) \end{aligned}$$

and $\sin 2(bt + \bar{v} - \mu)$ is a similar expression in which bt is replaced by $2bt$, p by $2p$, and m by $2m$.

A typical general term of equation 60 such as $4 \sin bt \,.\, J_r(p) \cos rvt \,.\, J_n(m) \cos n\mu t$ when expanded yields four frequencies $(b' + rv' + n\mu')$, $(b' - rv' + n\mu')$, $(b' + rv' - n\mu')$ and $b' - rv' - n\mu')$ all of amplitude $J_r(p) \,.\, J_n(m)$. In general only the last is capable of providing an audible tone under 50% overlap conditions. It represents the difference frequency between a sideband of the wanted signal and a nearby sideband of the interfering signal and its amplitude is the product of their amplitudes. Since it is permissible to discard frequencies outside the audible limit, the labour involved in computing the E.M.D. from equation (60) may be very considerably reduced by employing a graphical representation of the two spectra such as Fig. 11 which shows the upper sidebands of a wanted signal modulated 100% by 5 kc/s overlapping the lower sidebands of an interfering signal modulated 100% by 6 kc/s ($\phi_0 = 10$ radians in each case), the two carriers being 100 kc/s apart. A "gate" of width ± 10 kc/s (i.e. twice the audio spectrum) may conveniently be employed and applied to each interfering sideband in turn, the products of the amplitudes of the interfering sideband and those wanted sidebands falling within the gate being determined as well as their frequency separation if desired. These products when multiplied by $\frac{x}{\phi_0} \times 100$ give the E.M.D. (per cent.) of individual distortion tones while the root of the sum of their squares gives the effective E.M.D. of the interference. If the carrier separation had been such that an appreciable number of sidebands had fallen to the left of the wanted carrier in Fig. 11 (e.g. $b' = 40$ kc/s), it would be necessary to make a further computation in order to assess the last term of equation (59), new spectra being drawn with carriers separated by $2b'$ (80 kc/s) the wanted and interfering sidebands (5 and 6 kc/s apart respectively) having amplitudes given by the coefficients $J_1(2p)$, $J_2(2p)$ . . . . $J_1(2m)$, $J_2(2m)$ . . . . etc., appropriate products being obtained as before and multiplied by $\frac{x^2}{2\phi_0} \times 100$. If x be small this second computation will not be necessary however small the carrier separation.

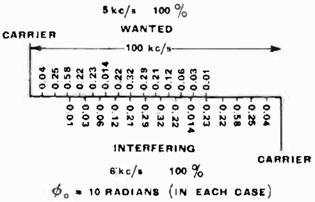

Fig. 11.

To confirm that the same result is obtained by the vector method, a phase-modulated wanted signal was assumed to suffer interference from a nearby interfering carrier, the phase distortion was estimated by representing the signals by vectors and the resulting distortion waveform analysed. The figures obtained agreed with those obtained by cross multiplication to within the limits of accuracy of the harmonic analysis.

In some cases close approximation to the total distortion or E.M.D. may be made from a cursory inspection of the spectra, for since the amplitudes of the distortion tones are proportional to the products of two Bessel coefficients and further for large values of argument these coefficients generally have a maximum value of 0.3, the maximum product rarely exceeds 0.09; for $\frac{x}{\phi_0} = 0.1$ the E.M.D. per frequency component is less than 1%. Even with 25 such components a figure which in phase modulation is seldom approached, the E.M.D. (R.M.S.) will not exceed 5%. In Fig. 11 only three products are found to be of the order of 0.09 so that to a first approximation the E.M.D. (R.M.S.) is $\frac{x}{\phi_0} \times 0.09 \times \sqrt{3}$ or $1.7x\%$. If a larger number of terms be taken into consideration a figure of $2.2x\%$ is arrived at; this is of the order of $\frac{1}{4} \cdot \frac{x}{\phi_0} \times 100\%$ which may be taken as a limiting value (for 50% overlap). Such distortion arising from overlap of spectra, although resulting in deterioration of a high quality programme, should not prove serious in a commercial service.

Other interference phenomena applicable to both phase and frequency modulated systems are of interest; these are dealt with in this section rather than the next as the effects are more readily apparent when the discriminating action with respect to the output frequency inherent in frequency modulated systems is not taken into account.

Suppose the interfering signal has the same carrier frequency as the wanted and that the former be modulated and the latter unmodulated. We may determine the E.M.D. of the wanted signal produced by the unwanted modulation. Such a case might be regarded as of academic interest only, but in the event of locked common carrier transmissions being employed it would have to be taken into consideration.

From (60) we have when $b' = 0$, $m = 0$

$$\sin(bt + \bar{v} - \bar{\mu}) = \{2J_1(p)\sin vt + 2J_3(p)\sin 3vt + \ldots\} \quad \ldots \quad (61$$

$$\sin 2(bt + \bar{v} - \bar{\mu}) = \{2J_1(2p)\sin vt + 2J_3(2p)\sin 3vt + \ldots\} \quad \ldots \quad (62)$$

whence

$$\text{M.B.} = 1 + 2\left\{\frac{x}{\phi_0}J_1(p) - \frac{x^2}{2\phi_0}J_1(2p) + \ldots\right\}\sin vt + 2\left\{\frac{x}{\phi_0}J_3(p) - \frac{x^2}{2\phi_0}J_3(2p) + \ldots\right\}\sin 3vt + \ldots \quad \ldots \quad \ldots \quad (63)$$

These series converge fairly rapidly when $x < 0.5$. For $p > 2$ the fundamental frequency v' tends to vanish, the bulk of the modulation being at an odd harmonic of the interfering modulation frequency, the higher p being, the higher the harmonic of the original interfering modulation. The depth of modulation tends to the constant value $\frac{1}{\phi_0} \cdot \frac{x}{\sqrt{1 - x^2}} \times 100\%$. For $p < 2$ the E.M.D. is given approximately by $\frac{1}{\phi_0} \cdot \frac{px}{1 + x} \times 100\%$. This is indicated graphically in Fig. 12.

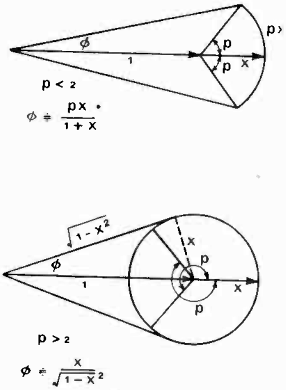

Fig. 12.

If p be sufficiently high and the interfering modulation frequency also high the interference may be inaudible, e.g. the 3rd harmonic of 5 kc/s is 15 kc/s and outside the audio range.

Using equation 63 and putting $x = 0.5$ it is found for $\phi_0 = 10$ and $p = 2$.

$$\text{M.B.} = 1 + 0.056\sin vt + 0.004\sin 3vt \quad \ldots \quad \ldots \quad (64)$$

and for $p = 4$

$$\text{M.B.} = 1 - 0.0013\sin vt + 0.052\sin 3vt + 0.008\sin 5vt \quad \ldots \quad (65)$$

Thus although the equivalent modulation depth is 5–6% in both cases, in the former the output frequency is the interfering modulation frequency, while in the latter it is three times this frequency. The more deeply is the interfering signal modulated the higher is the output frequency, whilst the equivalent modulation depth tends to a relatively small constant value (about 5%).

So far as is known this is the only case ($b = 0$) for which the method of cross multiplication of sidebands described above fails to give the correct result.

Now let the interfering signal be moved away from the wanted. For a carrier separation less than the audio limit (10 kc/s) the maximum output will occur during periods of no modulation, the output being the beat frequency between the carriers, the modulation depth being of the order of $10x\%$ (see a former section). If b' be slightly greater than the audio limit the modulation only will produce an interference output.

From equation 60 for $m = 0$ and discarding terms such as $(b + nv)t$ which are outside the audio limit we have

$$\sin (bt + \bar{v} - \bar{\mu}) = - J_1(p) \sin (b - v)t + J_2(p) \sin (b - 2v)t - \dots \quad (66)$$

in which series terms for which $(b' - nv') >$ 10 kc/s (regardless of sign) will also be inaudible and may be neglected; if $x < 0.8$ the term $\sin 2(bt + \bar{v} - \bar{\mu})$ may also be neglected. An examination of tables or graphs of Bessel coefficients (see Jahnke and Emde) shows that for $p < 2$, $J_1(p)$ is the largest coefficient while as an approximation we may say for $2 < p < 5, J_{p-1}(p)$ is the largest and for $p > 5$, $J_{p-2}(p)$ the largest. The maximum value attained by any coefficient (except $J_0(p)$) occurs for $J_1(1.85) = 0.5815$. This is conveniently taken as $J_1(2) = 0.58$. The maximum distortion will then occur on a frequency $(b' - v)$ when $p = 2$. When $\phi_0 = 10$ radians this corresponds to a 20% modulation of the interfering signal. If for the wanted signal also $\phi_0 = 10$ radians the E.M.D. (R.M.S.) is $7x$ % from equation (66).

When b' is > 20 kc/s (twice the audio limit) the term $J_1(p) \sin (b - v)t$ contributes nothing to the output assuming v' max. = 10 kc/s. The maximum value of $J_2(p)$ is 0.486 for $p = 3.1$ so that for $\phi_0 = 10$ the E.M.D. (R.M.S.) is $6x\%$ provided $v' > 5$ kc/s. The greater b' becomes, i.e. the greater the carrier separation, the less the distortion and the higher must be both the modulation depth and the modulation frequency to produce that distortion. It may be shown by the method of cross multiplication of sidebands or otherwise than when the wanted signal is modulated the E.M.D. is less than the figures given above, and the deeper the modulation the less is the E.M.D. due to the interference.

C. Wanted Signal Frequency Modulated

As has been pointed out in a former section (equation 50 *et seq.*) the E.M.D. due to interference with frequency modulated systems is proportional to the frequency of the beat tone produced and is equal to that produced in a similar phase modulated system when $\frac{\omega_D}{b} = \phi_0$ radians. If we take $\phi_0 = 10$ radians and $\omega'_D = 100$ kc/s then the distortion in the two systems is only equal when the beat tone is at the limit of audibility, i.e. 10 kc/s and is correspondingly less for lower tones. The methods of estimating distortion are similar to those used in Section B and in the equations representing the modulation bracket it is only necessary to change sine terms to cosine terms and replace $\frac{1}{\phi_0}$ by $\frac{b}{\omega_D}$. In estimating the E.M.D. by cross multiplication of sidebands, the product of the amplitudes must be multiplied by the frequency difference of the sidebands. This "weighting" of distortion or E.M.D. according to the frequency of the interference results in a lower total distortion or E.M.D. for frequency modulated systems than for those phase modulated. (Compare eqns. 58–60 *et seq.* with eqn. 67.) The modulation bracket thus takes the general form for phase or frequency modulated interfering signals:

$$\text{M.B.} = 1 + K\frac{\omega_D}{\omega_0}\cos\mu t + \sum_{r=0}^{\infty}\sum_{n=0}^{\infty} x \cdot \frac{b - rv - n\mu}{\omega_D} \cdot \frac{\omega_D}{\omega_0} J_r(p) J_n(m) \cos (b - rv - n\mu)t$$
$$- \sum_{r=0}^{\infty}\sum_{n=0}^{\infty} \frac{x^2}{2} \cdot \frac{2b - rv - n\mu}{\omega_D} \cdot \frac{\omega_D}{\omega_0} \cdot J_r(2p) J_n(2m) \cos (2b - rv - n\mu)t + \dots \quad (67)$$

This equation is developed from eqns. 58-60.

(*i*) *Interfering Carrier Only.*

$$\text{M.B.} = 1 + K\frac{\omega_D}{\omega_0}\cos\mu t + x\left[\frac{b}{\omega_D}\cdot\frac{\omega_D}{\omega_0}\cdot J_0(m)\cos bt + \frac{\pm b-\mu}{\omega_D}\cdot\frac{\omega_D}{\omega_0}\cdot J_1(m)\cos(\pm b-\mu)t\ldots+\right] \quad \ldots \quad (68)$$

from which the E.M.D. of a typical audible interference tone is $x\frac{(b-nv)}{\omega_D}J_n(m)$ and the distortion $x\frac{(b-nv)}{K\omega_D}J_n(m)$.

The following examples may be compared with the corresponding ones for phase modulation, the comparison being made on the basis of approximately equal modulation depths :—

(a) $\omega'_D = 100$ kc/s, $\mu' = 6$ kc/s, $b' = 40$ kc/s

$K = 0.96$, i.e. $m = 16$

$n = 5 \quad 6 \quad 7 \quad 8$

$f = 10 \quad 4 \quad 2 \quad 8$ kc/s.

E.M.D. $\frac{bx}{\omega_D}J_n(16) = 0.0057x,\ 0.00667x,\ 0.0033x,\ 0.0005x.$

E.M.D. (R.M.S.) $= 0.94x\%$.

Distortion $(K = 0.96) = 1.0x\%$.

(b) $\omega'_D = 100$ kc/s, $\mu' = 6$ kc/s, $b' = 14$ kc/s

$K \doteqdot 0.1, \quad m = 1.6.$

$n = 1 \quad 2 \quad 3 \quad 4$

$f = 8 \quad 2 \quad 4 \quad 10$ kc/s.

E.M.D. $\frac{xb}{\omega_D}\cdot J_n(1.6) = 0.045x,\ 0.005x,\ 0.002x,\ 0.0015x.$

E.M.D. (R.M.S.) $= 4.5x\%$.

Distortion $(K = 0.1) = 45x\%$.

(c) Conditions as for (b) but $b' = 9$ kc/s.

E.M.D. (R.M.S.) $4.7x\%$.

Distortion $(K = 0.1)\ 47x\%$.

As a rule there is a perceptible improvement for frequency modulation though occasionally, when for instance the interfering output frequencies are high, there may be little to choose between the two systems under the conditions here considered.

(*ii*) *Interfering Signal Amplitude Modulated.*

As the interfering sidebands are never more than half the carrier amplitude, they contribute but little to the total E.M.D. and may generally be neglected as in phase modulation.

(*iii*) *Interfering Signal Phase Modulated.*

The wanted signal will always occupy the whole of its allotted spectrum whenever the modulation depth approaches 100%, but the interfering signal only does so when the modulation frequency is high as well (*c.f.* Figs. 3 and 4).

In Fig. 13 are shown two typical spectra, the upper representing a signal, frequency modulated 100% by 5 kc/s and the lower a signal, phase modulated 100% by 6 kc/s. By cross multiplication of sidebands the distortion produced by the phase modulated signal on the frequency modulated one may be found to be $1.38x\%$ whilst the distortion produced by the frequency modulated one on the phase modulated signal approaches $2.25x\%$. It is clear from the characteristics of the Bessel coefficients and from the method of deriving the distortion that distortion will be a maximum when sidebands of maximum amplitude of one transmission lie in the neighbourhood of sidebands of maximum amplitude of the other. For instance taking $\phi_0 = 2$ instead of 10 for the phase modulated signal in this example gives a first order sideband amplitude of $J_1(2) = 0.58$ and the E.M.D. is $1.9x\%$ (wanted signal frequency modulated) or $3.35x\%$ (wanted signal phase modulated). Similarly it may be shown that the carrier separation to avoid maximum distortion (which will occur when an unmodulated interfering carrier is within "audible range" of the maximum sideband amplitude of the wanted spectrum, $J_1(2) = 0.58$, yielding an E.M.D. of about $6x\%$), should not be less than twice the audio limit frequency from the wanted carrier and should preferably be four times this figure (i.e. > 40 kc/s).

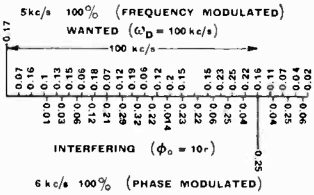

Fig. 13.

(*iv*) *Interfering Signal Frequency Modulated.*

The same considerations hold as for a phase modulated interfering signal as regards minimum carrier spacing, i.e. the separation should not be less than twice the audio limit frequency. As examples, two typical spectra are shown in Fig. 14, a wanted signal modulated 100% by 5 kc/s ($m = 20$) being situated 100 kc/s from an interfering signal modulated 96% by 6 kc/s ($m = 16$). The E.M.D. (R.M.S.) may be found to be $1.3x\%$. This compares with $2.2x\%$ for the two similarly modulated phase modulated signals of Fig. 11, which is 5 dB. worse.

It will be appreciated that the great advantages offered by frequency or phase modulated systems in relation to signal to noise or signal to interference ratios are only obtained when the modulation frequency is small compared with the width of the intelligence spectrum employed (i.e. $m > 1$). The systems are at a disadvantage compared with amplitude modulation should the reverse be the case.

Finally it will be stressed that any physical interpretation of the above equations must be carried out in relation to a wanted signal strong in comparison with an interfering one ($x < 1$ being a necessary condition for the validity of the expansions employed); that is, the result obtained will be correct when determining the effect on a wanted signal of an interfering one near to it in frequency whose amplitude is increased from zero to nearly equality, but the process will not yield correct results when the carriers are of approximately equal amplitude (since the limiter action then fails) or when the interfering signal is strong in comparison with the wanted (unless the rôles of the signals be interchanged and the "wanted" be regarded as an interference on the "interfering" signal). This also implies that the detector or frequency converter is presented with a combination of the two signals (not the two signals independently), the stronger wanted one acquiring an equivalent modulation due to the proximity of the interfering one.

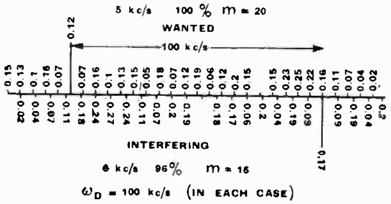

Fig. 14.

Acknowledgment

For permission to publish this paper the author is indebted to the Management of Marconi's Wireless Telegraph Co. Ltd., in whose Research Laboratories the work was carried out.

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Van der Pol: *Proc. I.R.E.*, July, 1930.
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Jahnke & Emde: Tables of Functions.
[Tables of Bessel Coefficients $J_n(0) - J_n(24)$ in 1st and 2nd edns., extended to $J_n(29)$ in 3rd edn.]
Mclachlan: Bessel Functions for Engineers (p. 42 and Tables.)

Book Review

Radio-Frequency Measurements by Bridge and Resonance Methods

By Dr. L. Hartshorn. Pp. xiv + 265. 99 Figs. Chapman & Hall, Ltd., 11, Henrietta Street, London, W.C.2. Price 21s.

This is one of a series of monographs on electrical engineering being issued by the same publishers. It should be explained at once that it deals with measurements *at* radio frequencies and not *of* radio frequencies; the title might mean either. The author is not only a Principal Scientific Officer of the National Physical Laboratory but a recognised authority, to whom much of the progress in this field is due. He explains in the preface that the book is intended for those who are setting out to *do* things by means of radio-frequency technique, and the aim has been to present a systematic account of the basic principles and general working ideas that form the tools of the practising technician.

The measurement of resistance, inductance, capacitance, etc., at radio frequencies bristles with pitfalls, and, as the author says on p. 254, nothing "fills one with humility and right vision" so much as attempts to measure the same quantity by two entirely different methods. The book is a practical guide that should enable the careful reader to know where to look for the pitfalls and how to avoid them and even—with luck—to get an approximation to the same result on measuring the same quantity by two different methods.

The book is divided into three parts; Part I, on Principles, consists of three chapters, of which the first deals with impedance and related quantities, the second with the general principles of impedance measurement and resonance methods, and the third with the radio-frequency bridge and the all-important subject of screening. Part II deals with apparatus, and is divided into five chapters headed respectively, Generators, Detectors, Standards of Capacitance, Resistors, Standard Inductors. If resistors and inductors, why not capacitors? It will be seen that Part II deals with the tools which are used in Part III on Methods of Measurement. Chap. IX discusses the measurement of capacitance and inductance by resonance methods, Chap. X the measurement of resistance, power-factor, decrement, etc., also by resonance methods, Chap. XI bridge methods and all the precautions necessary if reliable results are to be obtained at radio frequencies. The concluding chapter is devoted to methods for very short waves, where every centimetre of wire is of great importance.

The book is very clearly written and well illustrated; great care has been shown in the choice of symbols and in the type employed for various purposes. The author heads a brief bibliography of only 13 items with a humorous apologia in the form of a slightly modified quotation from Belloc: "read less, good people, and observe more; and, above all, leave us in peace." We are not sure that this has the unqualified approval of the publishers. There are, however, throughout the book, numerous references to original articles.

The book will prove invaluable to those engaged in measurements at radio frequencies.

G. W. O. H.

Correspondence

To the Editor, The Wireless Engineer

SIR,—The problem of calculating the impedance due to a beam of electrons traversing a transverse alternating deflecting field has been discussed on several occasions in your columns.* In particular, expressions for resistance and capacity of a pair of parallel plates have been given, considering only the behaviour of the beam within a uniform field. It is necessary, however, to examine the change of charge on the condenser plates as the electrons leave this field. It may be simply assumed that the emerging electrons move suddenly from a potential $(V_B + yE)$ to V_B where :—

V_B = beam voltage
y = beam displacement at emergence
E = normal intensity.

There is then a profound modification in the results.

The positive conductance due to the electrons between the plates becomes shunted by a negative conductance, so that the total conductance becomes

$$\frac{I_B}{V_B}\left(\frac{L}{2d}\right)^2 \frac{1 - \cos\omega\tau}{\frac{(\omega\tau)^2}{2}} \left(1 - \cos\frac{\omega\tau}{2}\right)$$

instead of $\dfrac{I_B}{V_B}\left(\dfrac{L}{2d}\right)^2 \dfrac{1 - \cos\omega\tau}{\frac{(\omega\tau)^2}{2}}$

New Barnet,
Herts.

S. RODDA.

Book Received

WITH the publication of the 1941 edition of *The International Mercantile Diary and Year Book*, this useful reference book reaches its 25th year of issue. A combined compendium of commercial information (which includes wartime regulations for the shipment of goods to all parts of the world) and desk diary, it is published by Syren and Shipping, Ltd., 44–46, Leadenhall Street, London, E.C.3, at 20s., including a monthly copy of *The Merchant Shipper* containing addenda to the year book. The reference section comprises 280 pp. + XXII and the diary, which shows a week to an opening, over 100 pp.

R.A.F. Technical Officers

THE Air Ministry has announced that there are vacancies in the Royal Air Force for technical officers for employment on signals duties.

Applications are invited from holders of electrical engineering or science degrees with experience of wireless and from holders of technical college or approved institution diplomas with two years' experience in telecommunications engineering (preferably on the wireless side).

A number of posts is also available for candidates possessing a sound theoretical knowledge of elementary electricity and magnetism, of the principles of wireless telegraphy and telephony, of transmitting and receiving circuits and of apparatus for the measurement of H.F. potentials and currents. Some practical experience is also desirable.

Commissions in the R.A.F.V.R. will be granted for the duration of hostilities to suitable applicants between the ages of 21 and 50 years.

Candidates should apply at once in writing to the Air Ministry, S.7 (e) 1, Adastral House, Kingsway, London, W.C.2, giving full particulars of their qualifications, training and experience. Those who are engaged on important National work should not submit applications without first consulting their employers as to the possibility of their being spared for R.A.F. duty.

Candidates who have previously applied are requested not to renew their applications.

The Industry

A. C. COSSOR, LTD., Highbury Grove, London, N.5, have issued a comprehensive instruction manual (CB57) describing the applications of their Model 3389 A.C. Impedance Bridge (with C.R. tube null indicator). Copies additional to that supplied with the instrument are obtainable price 1s. 6d.

A well-prepared treatise on flexible remote controls has been issued by The S.S. White Co., of Great Britain, Ltd., Britannia Works, St. Pancras Way, London, N.W.1. The mechanical properties and applications of flexible cables are fully discussed and curves of torsional deflection and hysteresis under various loads are included.

Taylor Electrical Instruments, Ltd., 419/422, Montrose Avenue, Slough, Bucks, have issued a revised price list of their instruments, dated January 1st, 1941.

A new "Vacustat" vacuum gauge is now being made by W. Edwards and Co., Southwell Road, Loughborough Junction, London, S.E.5. It is a modified form of the McLeod gauge and covers pressures from 10 to 0.01 mm/Hg.

The Brimar Type 25Z6G rectifier has been temporarily withdrawn, and is replaced by the 25Z4G. Although of the half-wave type, the pin connections are arranged so that it can be used for servicing most receivers employing the 25Z6G type.

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*W. E. Benham, *Wireless Engineer*, Dec., 1939, p. 598. F. M. Colebrook, *Wireless Engineer*, April, 1938, p. 198, and Aug., 1938, p. 441. Hollmann and Thoma, *Wireless Engineer*, July, 1938, p. 370.

Abstracts and References

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

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

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PROPAGATION OF WAVES

294. CABLES FOR HYPERFREQUENCIES [Survey].—E. Soleri. (*L'Elettrotecnica*, No. 19, Vol. 27, 1940, pp. 446–452.) Based on some 20 papers (American, French, & German) listed at the end.

295. HIGH-FREQUENCY PROPERTIES OF SOIL [and Variation of Dielectric Constant & Conductivity with Water Content, on Ultra-Short (4.45 m) Waves: Effect of Packing].—Prasad, Singh, & Sinha. (*Sci. & Culture*, Calcutta, Oct. 1940, Vol. 6, No. 4, pp. 243–244.)

The dielectric constants found by the direct (Lecher-pair) measurement of the capacity of a specially designed condenser when empty and when packed with the soil (a method developed as more convenient, for surveys over extended areas, than the buried Lecher-pair method) came out considerably higher than by the latter method, the increase being greater for the higher moisture contents. Reasons for this result are suggested.

296. ON THE ULTRA-HIGHS [Monthly Feature].—Tilton. (*See* 388.)

297. REGION FORMATION IN THE IONOSPHERE ACCORDING TO AN ATTACHMENT THEORY [Ionisation-Height Curves for Isothermal Ionised Atmosphere in which Mechanism of Electron Disappearance is Attachment to Oxygen Atoms at Rate proportional to Product of Number of Oxygen Atoms & of Electrons present: Attachment Theory alone cannot provide Basis of Interpretation for Daily Changes observed in E and (Winter) F Regions].—M. V. Wilkes. (*Proc. Cambridge Phil. Soc.*, Part 4, Vol. 36, 1940, pp. 479–484.)

298. LONG-DISTANCE RADIO COMMUNICATION: APPLICATION OF RECORDS KEPT AT IONOSPHERIC OBSERVATORIES [including Use of Max. Usable Frequency Conversion Factors and Derivation of Optimum Frequencies for Delhi-Calcutta Service].—S. P. Ghosh. (*Sci. & Culture*, Calcutta, Oct. 1940, Vol. 6, No. 4, pp. 199–204.)

299. IONOSPHERIC OBSERVATIONS DURING THE SOLAR ECLIPSE OF OCTOBER 1ST [at 3 Points in South Africa: Marked Ultra-Violet-Light Effect in F_2 Region (20% Decrease in Max. Electron Density, reaching Minimum about 30 Minutes after Totality): No Evidence for Corpuscular Effects].—Pierce, Higgs, & Halliday. (*Nature*, 7th Dec. 1940, Vol. 146, p. 747.)

300. CONVECTIVE EQUILIBRIUM AND SOLAR LIMB DARKENING [with a Conclusion on the Equilibrium of Sunspots].—A. D. Thackeray. (*Nature*, 7th Dec. 1940, Vol. 146, p. 749: summary only.)

301. SPECTRUM OF BRIGHT CHROMOSPHERIC ERUPTIONS [All Fe Lines and All Low *E.P.* Fe Lines strongly Enhanced: etc.].—C. W. Allen. (*Nature*, 7th Dec. 1940, Vol. 146, p. 749: summary only.)

Investigation based on the assumption that the great changes in the u.v. spectrum, inferred from the action of the eruptions on the atmosphere, must imply some corresponding effects in the spectral regions that can be seen and photographed.

302. THE EVANS QUARTZ MONOCHROMATOR FOR THE OBSERVATION OF SOLAR PROMINENCES.—J. W. Evans. (*Sci. News Letter*, 26th Oct. 1940, Vol. 38, No. 17, p. 262.)

303. On the Hard Component of the Cosmic Radiation in the Stratosphere [Comparison of Balloon Observations with the Photon Hypothesis].—A. Ehmert. (*E.T.Z.*, 5th Sept. 1940, Vol. 61, No. 36, pp. 831–832.) Summary of a paper in *Zeitschr. f. Phys.*, Vol. 115, 1940, pp. 326–332.

304. Fading of Received Signals produced by Moving Trains [with Critical Comments].—Oxenfart. (*E.T.Z.*, 10th Oct. 1940, Vol. 61, No. 41, p. 928.)

Summary of the paper dealt with in 927 of 1940. The writer's explanations of the observed phenomena are discredited and alternative causes suggested: among these, it is remarked that moderately well-insulated railway lines may behave like a Lecher-wire system, and form stationary waves which would be upset by the passage of a train.

305. Performance of Travelling Waves in Coils and Windings [Derivation (on Basis of New Investigation of Electromagnetic Coupling of Turns & Coils) of Differential Equation of Far-Reaching Validity relating Effects of Windings for Transients to Steady-State Values].—R. Rudenberg. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 414: summary only.)

306. Skin Effect through Eddy Currents in Sheets and Plates in an Alternating Field.—H. Meyer. (*Bull. Assoc. suisse des Élec.*, No. 18, Vol. 31, 1940, pp. 389–392: in German.)

The problem was first solved by Thomson in 1892, and his results have been included in every text book, but usually in an incomplete form. "The Thomson calculation is here further extended by the calculation of the phase behaviour of the resulting flux in the plate: it is found that with increasing skin effect there is an increasing lag of resulting flux with respect to the exciting magnetomotive force; a lag which reaches the limiting value of 45° for large skin effects. The same result is obtained by calculating the induction produced by plane electromagnetic waves penetrating both sides of the plate [section 3]. This latter treatment shows especially clearly that for high frequencies the whole process takes place at the plate surfaces, the interior of the plate playing no part."

Correction: the name of the first joint author of the paper "Ultra-Short-Wave Transmission over a 39-Mile 'Optical' Path" (5 *of January*) *was given as England: it should of course be Englund.*

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

307. Electronic Measurement of Surge-Crest Voltages [by Valve Voltmeter: particularly for Lightning Research].—J. M. Bryant & M. Newman. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 417: summary only.)

308. New Instruments for Recording Lightning Currents [Fulchronograph, Surge-Front Recorder, & Surge Integrator].—C. F. Wagner & G. D. McCann. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 417: summary only.) *See* also 3901 of 1939 and 2917 & 3751 of 1940.

309. Surge Characteristics of a Buried Bare Wire.—E. D. Sunde. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 418: summary only.)

310. Lightning Records of Communication Lines, *and* Lightning Record on Distribution Lines.—Rokkaku & others. (*Jap. Journ. of Eng., Abstracts*, Vol. 19, 1940, p. 96: pp. 96–97.)

311. Lightning and Transmission Lines [Westinghouse Researches on Miniature Line in High-Voltage Laboratory: Choice of Electrode representing Cloud, and of Wave Form: Results].—C. F. Wagner & others. (*Electrician*, 13th Dec. 1940, Vol. 125, pp. 312–313). *Cf.* Weber, 1771 of 1940.

312. Rain and the Atmospheric Electric Field [Sharp Drop & Reversal of Normal Positive Field accompanies Showers: Explanation, including Predicted Rare Occurrence of Enhancement, and Wide Fluctuations during Continuous or Heavy Rain].—A. V. R. Telang: Pillai. (*Current Science*, Bangalore, Sept. 1940, Vol. 9, No. 9, pp. 417–420.) Prompted by Pillai's results, 38 of January.

313. Ionisation of the Lower Atmosphere [including Suggested Equation for Equilibrium of Small Ions at Any Place].—J. J. Nolan. (*Nature*, 30th Nov. 1940, Vol. 146, p. 720: summary only.)

314. A Dutch Radio-Meteorograph [designed for Accuracy, Lightness, & Cheapness].—C. M. A. Insje & J. L. van Soest. (*Sci. Abstracts*, Sec. A, 25th Sept. 1940, Vol. 43, No. 513, pp. 663–664.)

315. An Improved Radio Sonde and Its Performance.—Diamond & others. (*Journ. of Res. of Nat. Bur. of Stds.*, Sept. 1940, Vol. 25, No. 3, pp. 327–367.)

PROPERTIES OF CIRCUITS

316. Natural Oscillations in Circuits with A.C.-Fed Saturated Iron-Cored Chokes.—W. Hähnle. (*E.T.Z.*, 12th Sept. 1940, Vol. 61, No. 37, pp. 845–847.)

In certain circumstances such circuits may start oscillating. This property may be useful or harmful, according to the purpose of the circuit, but in any case it is desirable to know from the circuit diagram, without laborious calculation, whether or no the circuit will oscillate. A method frequently used for this determination is the drawing of an equivalent d.c. circuit including a negative resistance; but this method is not always applicable, because only ohmic resistances and resonant circuits tuned to the mains frequency can be transferred accurately into the d.c. equivalent circuit; individual condensers and chokes do not lend themselves to such a transfer. The treatment here described is free from such limitations.

It begins by supposing that in the basic circuit of Fig. 1 (generator feeding a saturated choke and a linear impedance in parallel) there flows, in addition to the current I_1 of frequency ω_1 due to the generator (mains frequency), another current I_2 of frequency ω_2. This current, combining with the mains current, produces voltages of still other frequencies in the saturated choke, and these will send currents through the impedance which will combine with all the others to produce new voltages in the saturated choke. Self-excitation will occur at a frequency ω_2 if, after an arbitrary number of transits round the circuit, a current of frequency ω_2 occurs in the correct phase and of the right amplitude. From this point the analysis proceeds with the help of a simple approximation to the relation between the flux Φ in the saturated choke and the total current through it: this approximation is $\Phi = mI - nI^3$, where m & n are real numbers and $I = I_1 + I_2 = a \sin \omega_1 t + b \sin (\omega_2 t + \phi)$. The required quantity x, a dimensionless complex number determining the possibility or impossibility of self-excitation, is arrived at in eqn. 12 in terms of n, a, ω_1, ω_2, and A_{2-4}, B_{2-4}, where these latter come from the expressions (of general form $B + jA$) for the apparent conductivities at the frequencies ω_2, $2\omega_1 - \omega_2$, and $2\omega_1 + \omega_2$ respectively. If the x-curve encloses the point $+1$, oscillation occurs: otherwise there can be no oscillation. In special cases the expression for x becomes greatly simplified, but anyhow it is only necessary in practice to plot the x-curve for the region between $\omega_2 = 0$ and $\omega_2 = \omega_1$.

317. On the Mechanism of Group Harmonic Waves Production [by Magnetic Saturation Circuits].—H. Kato. (*Electrotech. Journ.*, Tokyo, Aug. 1940, Vol. 4, No. 8, pp. 174–179.)

Analytical study: idealisation of saturation curve: its working mechanism: mechanism of generation of higher harmonic groups: equivalent circuit of saturated circuit: definition of "shock factor."

318. A New Electronic [Frequency-] Multiplier for Power Frequencies.—W. P. Overbeck. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 416: summary only.)

319. Two Forms of Electronic Switch [for Dual Use of Single-Element Cathode-Ray Oscillograph: Advantages of "Class B" Type of Circuit (with Switching interlocked with Sweep): Version of Toomim's Eccles-Jordan Trigger Circuit, for Sweep Frequencies up to (or over) 10 kc/s].—Strong. (*Journ. of Scient. Instr.*, Dec. 1940, Vol. 17, No. 12, pp. 275–277.) For Toomim's paper *see* 3508 of 1939.

320. Silicon-Carbide Varistors [Differences from Copper-Oxide Varistors, and Their Reasons: Characteristic Curves: Manufacture].—R. O. Grisdale. (*Bell Lab. Record*, Oct. 1940, Vol. 19, No. 2, pp. 46–51.) *Cf.* 3773 of 1940.

321. The Rectifier Calculus [and Its Application to Calculation of Output of Unbalanced Rectifiers].—W. M. Goodhue. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 416: summary only.)

322. Some Methods of Linear Rectification [by Copper-Oxide Rectifiers: required, *e.g.*, for Remote Measurement by Amplitude Modulation Method (2622 of 1939): Objections to Use of Swamping Series Impedance: Examination & Successful Use of Positive Feedback: Method where Distorted Voltage from One Rectifier is Amplified and applied to a Second].—T. Tomituka. (*Electrotech. Journ.*, Tokyo, Aug. 1940, Vol. 4, No. 8, pp. 171–172.)

323. Some Notes on Diode Detection: Part II.—Preisman. (*See* 371.)

324. On Circuits with Impedance reducible to an Ohmic Resistance [Analytical & Graphical Treatment of Series Compensation producing Independence of Frequency].—E. Abason: Constantinesco. (*Bull. de Math. et de Phys. p. et app. de l'École Polytech. Bucarest*, Fasc. 28/30, 10th Year, 1939, pp. 191–195: in French.)

325. Calculation and Design of Resistance-Coupled Amplifiers using Pentode Tubes [Analysis & Charts for Determination of Amplification & Phase-Shift Characteristics: Procedure for proportioning Coupling Network in Plate Circuit for (a) Max. Possible Voltage Gain or (b) Large Output Voltage].—Terman, Hewlett, Palmer, & Pan. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, pp. 413–414: summary only.)

326. Stabilisation for Self-Oscillation in Feedback Amplifiers [Analysis of Stabilisation by Mutual Relation of Phase Angle for Each Stage: by Interstage Coupling Circuit: by Local (Negative) Feedback: by Impedance of Screen-Grid Circuit: by Feedback Circuit: by Output Load Circuit].—K. Kobayashi & T. Kurokawa. (*Nippon Elec. Comm. Eng.*, July 1940, No. 21, pp. 9–15.)

327. An Experimental Study of High-Gain Duplex-Feedback Amplifier [particularly the Problem of the Transformer acting as "Unity Coupler": Advantage of Partial Application of Negative Feedback].—Y. Watanabe & S. Okamura. (*Nippon Elec. Comm. Eng.*, July 1940, No. 21, pp. 46–51.) For previous work *see* 4347 of 1939.

328. Potential Distribution in Transformer Windings [Analysis by Partial Integro-Differential Equations, taking into account Every Inductive & Capacitive Effect of Layer Elements along the Windings].—H. Ogawa. (*Electrotech. Journ.*, Tokyo, Aug. 1940, Vol. 4, No. 8, pp. 183–185.) Continuing the work dealt with in 942 of 1939.

329. Remarks on Skalicky's Paper "The Equivalent Circuit of a Transformer with Several Tappings": Reply.—Ostendorf: Skalicky. (*E.T.Z.*, 3rd Oct. 1940, Vol. 61, No. 40, pp. 923–924.)

330. Effective Resistance to Alternating Currents of Multi-Layer Windings.—E. Bennett & S. C. Larson. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 414: summary only.)

331. Skin Effect through Eddy Currents in Sheets and Plates in an Alternating Field.—Meyer. (*See* 306.)

332. Attenuator Design: Calculating the Resistance Values for Fixed and Variable Networks.—S. S. West & E. D. McConnell. (*Wireless World*, Dec. 1940, Vol. 46, No. 14, pp. 487–490.) From the Baird laboratories.

333. Series-Resonance Circuit, Coupled Circuits, and Band Filters [for Broadcast, Gramophone, & Television Design: Treatment by "Reciprocal Representation" Method].—E. de Gruyter. (*Bull. Assoc. suisse des Élec.*, No. 19, Vol. 31, 1940, pp. 416–429: to be concluded: Corrections, *ibid.*, No. 21, p. 493: in German.)

Continued from 4333 of 1939. Author's summary:—"As a conclusion to the study of circuits in parallel and in series, and as an introduction to the subsequent study of coupled circuits and band-pass filters, the writer proceeds to a comparison between rejector and absorbing circuits as used in broadcast technique. The mathematical and graphical representation takes a form so universal and striking that it can easily be reproduced from memory." In Section **B** (the remainder of the present instalment) he proceeds to deal with coupled circuits, taking first (1) fixed couplings (reactive and resistive) and then (2) more general types of coupling (band filters) in which the damping has an influence on the coupling-frequencies: reactance, resistance, and impedance couplings are treated separately, the coupling factor being assumed small in all cases. In this Section B the writer confines himself to the consideration of the natural frequencies and coupling damping of such systems, "since previous discussion has shown that these frequencies coincide, for practical approximations, with the resonance frequencies."

Section C, in the final instalment, will examine the impedance and phase conditions. Meanwhile, in (3) he points out that in most practical coupled circuits the condition that $w^2 \ll 1$ is fulfilled, even in strongly damped wide-band television filters where $w^2 = 2 \,..\, 3 \times 10^{-3}$. If however $w^2 > 10^{-2}$, the lowering of the natural frequency must be taken into account, and the full lines of Figs. 23 and 24 show the corrected coupling-frequency and additional-damping characteristics arrived at by applying the necessary correction-factor to Figs. 13 and 14.

334. The Design of a Practical Low-Pass Filter for 600-Ohm Audio Transmission Line.—Helt. (*See* 423.)

335. A Practical Limitation in Some Filter Networks [Asymmetry of Frequency-Response Curve of Ladder-Type Filter (containing Series Arm of Two Elements or Groups in Series) caused by Stray Capacity between Their Junction Point & Earth, which represents a Separate Shunt Arm: Most Troublesome in High-Impedance Filters at High Frequencies: avoided by Change to Type having Shunt Arms at Junctions of All Series Elements].—F. J. Lehany. (*A.W.A. Tech. Review*, No. 2, Vol. 5, 1940, pp. 57–60.)

336. Synthesis of Filter Networks by Ladder-Type Structure.—A. Matsumoto. (*Nippon Elec. Comm. Eng.*, July 1940, No. 21, pp. 42–45.)

337. An Extension of the Method of Symmetrical Components using Ladder Networks.—W. V. Lyon. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 414: summary only.)

338. A Useful Network Theorem [saving Time & Effort (compared with Usual Method involving Simultaneous Solution of Number of Kirchhoff's Mesh Equations) in Problems of Networks & Amplifiers, including Those with Negative Feedback].—J. Millman. (*Proc. I.R.E.*, Sept. 1940, Vol. 28, No. 9, pp. 413–417). For steady-state behaviour: its extension (involving transform-circuit analysis) to transient behaviour will be dealt with later.

339. A Transformation extending the Use of Heaviside's Operational Calculus [Simple Change of Variable allows Use to include All Linear Lumped Networks, with No Restrictions as to Initial Conditions].—A. J. Meyerhoff & M. B. Reed. (*Elec. Engineering*, Sept. 1940, Vol. 59, No. 9, pp. 385–386.)

340. "Electric Circuits" [Book Review].—Massachusetts Institute of Technology. (*Gen. Elec. Review*, Nov. 1940, Vol. 43, No. 11, p. 476.) First of a series of M.I.T. volumes.

TRANSMISSION

341. Investigations on Mercury-Vapour Arcs at High [and Ultra-High] Frequencies.—R. Schäfer. (*Arch. f. Elektrot.*, No. 9, Vol. 34, 1940, pp. 499–522: *E.T.Z.*, 10th Oct. 1940, Vol. 61, No. 41, p. 942—summary only.)

For investigations by other workers *see* 2548/50 of 1940. In the present paper it is mentioned that a control grid negatively biased with respect to the plasma immediately becomes surrounded by a cloud of positive ions, which screens the whole grid field and suppresses all electrical action on the discharge: but that under certain conditions these Langmuir layers can be used for controlling the arc. In Part I the grid input impedances of such an externally controlled rectifier are measured: Part II concentrates on the possibility of the self-excitation of such a tube in the region of metric and decimetric waves. The positive-ion layers at the grid behave in general capacitively, and the value of the capacity can be calculated from Langmuir's space-charge equation. As a result of the "swinging" of the outer parts of the layers in time with the alternating voltage, the capacity varies with frequency and the geometrical value of the layer capacity is only reached as a limit at high frequencies. At low frequencies a second limiting value is reached, which is higher than the geometrical value by an amount proportional to the square root of the grid-plasma potential. Below 1.5×10^5 c/s decreasing frequency brings to light (in certain potential regions) an additional, inductive, component: this is a result of hysteresis and of the lag of the periodic fluctuations of the carrier density in the anode plasma behind the alternating potential.

For the self-excitation of metric and decimetric waves, circuits are used which are based on the customary short-wave circuits of high-vacuum valves. The oscillation mechanism is examined by an oscillographic method. In contrast to the high-vacuum valve, the value of the grid/anode capacity, and therefore of the excited frequency, is dependent on certain influences governed by the momentary working conditions; another frequency-determining factor is the plasma inductance which is in series with the layer capacity.

342. Oscillation Phenomena in Strongly Constricted Arc Columns and in Anomalous Anode Drop.—Kleinwächter. (*See* 533.)

343. Characteristics of Electron Oscillations of "Hammer-Type" Thermionic Vacuum Tube with Lecher Wires [Grid & Anode Leads passing out at Both Faces of "Head," Cathode led out at "Shank"] and Determination of Its Input Resistance.—R. Nakamura. (*Electrotech. Journ.*, Tokyo, Aug. 1940, Vol. 4, No. 8, pp. 180–183.)

The valve employed was the Telefunken DEM 60, a retarding-field oscillator of nominal output 4.5 w at 50–60 cm: actually, in these tests the output was limited, for safety, to about 1.4 w. The writer finds the wavelength to be best given by $\lambda = 700 d_a / \sqrt{v_g}$ (when the length of the Lecher wires is adjusted for max. output). The valve input resistance is found to be 13 500 ohms by one method and 13 600 by an entirely different method.

344. A Stabilised 2½-Metre Oscillator: Simplified Construction of "Pot" Tank Circuits.—B. Goodman. (*QST*, Nov. 1940, Vol. 24, No. 11, pp. 33–35 and 102..106.)

345. Frequency-Modulated Broadcast Transmitters [particularly the General Electric 250-Watt, serving also as Exciter for Larger Types].—W. R. David. (*Communications*, Oct. 1940, Vol. 20, No. 10, pp. 8–10 and 29, 30.) An I.R.E. Pacific Coast Convention paper. *See* also 3788 of 1940.

346. System of Phase and Frequency Modulation [Analysis of General Method using Two Out-of-Phase Voltages, One varying in Amplitude in accordance with Modulating Signal: Necessity (for Large Phase Shifts) of Predistortion of Modulating Signal, to neutralise Non-Linear Relation between Signal & Phase-Shift: Derivation of Armstrong System as a Special Case].—S. Sabaroff. (*Communications*, Oct. 1940, Vol. 20, No. 10, pp. 11–12 and 24.)

347. Solutions of Mathieu's Equation [used in Study of Modulation, Super-Regeneration, etc.]: I.—Brainerd & Weygandt. (*See* 617.)

348. Modulation Systems [Another Suggestion of Linear Modulation Method not producing Sidebands].—A. Q. Morton. (*Wireless World*, Nov. 1940, Vol. 46, No. 13, pp. 473–474.)

349. On the Distortion Outputs of Ring Modulator [used as a Group Modulator in Carrier-Telephone System].—Y. Degawa. (*Nippon Elec. Comm. Eng.*, July 1940, No. 21, pp. 16–21.) For previous work *see* 2962 of 1940.

350. New Crystal Unit for Broadcasting Service [Type G30, with Temp. Coefficient below 1 Part in Million per Degree Centigrade: Control Ratio (Room Temp. Change/Change in Mean Crystal Temp.) more than 50 : 1].—(*Gen. Elec. Review*, Nov. 1940, Vol. 43, No. 11, p. 474.)

351. Cyclotron Radio-Frequency Power Unit [including Power Stage with Four RCA 833 Air-Cooled Valves working at 80% Efficiency with 5 kW Input: Frequency 10 Mc/s].—N. I. Adams & H. L. Schultz. (*Review Scient. Instr.*, Oct. 1940, Vol. 11, No. 10, pp. 303–305.)

352. A Push-Button-Tuned 50-Kilowatt Broadcast Transmitter [Short-Wave].—Rockwell & Lepple. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, pp. 428–429: summary only.)

353. Design and Construction of an Experimental 10 kW Short-Wave Transmitter [Delhi IV: being Specially for News, Some Pre-Emphasis of High and Attenuation of Bass Frequencies: Inverse Feedback: Arcing Troubles on Feeder to Horizontal Dipole System cured by Corona Rings as Capacitive "Stub," Residual Matching by Inductive Tail along Horizontal Part of Feeder].—T. K. Garudachar. (*Electrotechnics*, Bangalore, Sept. 1940, No. 13, pp. 53–58.)

354. Acceptance Tests of Broadcasting Transmitters.—P. J. Donnelly. (*Electrotechnics*, Bangalore, Sept. 1940, No. 13, pp. 44–52.)

355. Link Coupling between Transmitter Stages: Circuit Factors influencing Driver Loading.—W. Van B. Roberts. (*QST*, Nov. 1940, Vol. 24, No. 11, pp. 41 and 74.) "Results of a rather tedious mathematical analysis . . . to find out what is transferred back to the plate tank by means of a link coupling to a succeeding grid tank." *Cf.* 3795 of 1940.

356. Fool-Proof Screen Feed: Voltage-Divider Design for preventing Screen Overloads.—W. Van B. Roberts. (*QST*, Oct. 1940, Vol. 24, No. 10, pp. 38–40.)

357. A Band-Operative Oscillator [Self-Excited Oscillator offering Definite Assurance against Out-of-Band Operation: or against operating in a Certain Band, while operating on Each Side of This: Circuit making Use of Complementary Properties of Series-Resonant & Parallel-Resonant Circuits].—A. Bloch. (*Electronics*, July 1940, Vol. 13, No. 7, pp. 36..44.)

358. An Electron-Coupled Oscillator, 1941 Model: Automatic In-Band Operation and 'Phone/C.W. Switching.—F. G. Southworth. (*QST*, Nov. 1940, Vol. 24, No. 11, pp. 26–29.)

359. Magnetic Band-Switching: a Five-Band Exciter with Push-Button Control.—L. Bellem. (*QST*, Oct. 1940, Vol. 24, No. 10, pp. 54–56 and 72.)

360. Emergency Reception: Working A.C. Mains Sets from Batteries [Slight Alterations to Wiring].—B. W. F. Mainprise. (*Wireless World*, Nov. 1940, Vol. 46, No. 13, p. 456: Corrections to diagram, Dec. 1940, p. 493.)

RECEPTION

361. Papers on Frequency-Modulated-Wave Receiver Design.—D. H. Harnett: G. C. Connor. (*Proc. I.R.E.*, Sept. 1940, Vol. 28, No. 9, p. 424: p. 426: summaries only.)

From the Hazeltine and Hygrade Sylvania Corporations respectively. For other recent papers *see* 3804/6 (Shea, Schor, Roberts) and 4252/3 (Hobbs, Browning): *also* 4078 (Levy): all of 1940.

362. Receivers for Frequency-Modulated Transmissions.—(*Wireless World*, Dec. 1940, Vol. 46, No. 14, pp. 494–496.) Based on three American articles.

363. Solutions of Mathieu's Equation [used in Study of Modulation, Super-Regeneration, etc.]: I.—Brainerd & Weygandt. (*See* 617.)

364. Continuous-Wave Interference with Television Reception.—Smyth. (*See* 448.)

365. A Method of Interference-Free Radio Reception [depending on Compression of Carrier of Interfering Signal and All Sidebands (including Those of Desired Signal) but maintaining Carrier of Desired Signal at High Intensity: This Strong Carrier, and Weak Desired Sidebands, are combined as Modulation Product in Square-Law Detection, giving Strong Signal Output].—S. Matsumura & S. Kanzaki. (*Jap. Journ. of Eng., Abstracts*, Vol. 19, 1940, p. 97.)

The compression is obtained by opposition in the detector: the desired carrier is then intensified by a quartz resonator, whose circuit can be added to an ordinary superheterodyne receiver. Volume and quality have been found to be satisfactory, while the interfering signals were effectively eliminated.

366. Field Strength of Motor-Car Ignition between 40 and 450 Megacycles [including Comparisons of Horizontal & Vertical Polarisation, Old & New Cars & Trucks: Measurements at 100 ft. Distance and Theoretical Propagation Curves for Estimation at Other Distances].—R. W. George. (*Proc. I.R.E.*, Sept. 1940, Vol. 28, No. 9, pp. 409–412.) A summary was referred to in 2981 of 1940. *See* also 3973 of 1940.

367. Interference Suppressors and Engine Performance: the Problem as It Affects the Car Manufacturer and Designer [Summary of Report].—Automobile Research Committee. (*Wireless World*, Nov. 1940, Vol. 46, No. 13, pp. 476–477.) *See* also 3810 of 1940.

368. Corona Discharge on Rubber-Insulated Cables [liable to produce Interference].—Paine & Brown. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 419: summary only.)

369. Some Insulator Designs require Special Features to insure Radio Quietness.—C. J. Miller, Jr. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, pp. 429–430: summary only.)

370. The Spraying of High-Tension Insulators in Service [Successful Tests, on 110 kV Line, in Cleaning with Water Hose & Jet: Necessary Precautions], *and* The Cleaning of Extra-High-Tension Installations in Service [and the Use of Built-In Sprays].—Estorff & Weber: Roggendorf. (*E.T.Z.*, 5th Sept. 1940, Vol. 61, No. 36, pp. 817–822: pp. 823–827.)

371. Some Notes on Diode Detection: Part II [Diode Performance with Resistive Circuit: with Tuned Source Impedance: Examples of Graphical & Analytical Treatments: etc.].—A. Preisman. (*Communications*, Sept. 1940, Vol. 20, No. 9, pp. 8–10 and 18, 19, 26.)

372. Compensating for Tube Input Capacitance Variation by Double Bias Provision.—J. F. Farrington. (*Communications*, Sept. 1940, Vol. 20, No. 9, pp. 3–4 and 14.) *See* also 1843 of 1940. A 1938 *Wireless World* article dealing with the same principle applied to a pentode is referred to at the end.

373. A Biased Triode Rectifier for Automatic Volume Control in Radio Receivers [with Advantages of Very Good A.V.C. Characteristic & Negligible Load on R.F. Circuits, avoiding Distortion liable to occur with Diode Rectification].—G. Builder & J. G. Walton. (*A.W.A. Tech. Review*, No. 2, Vol. 5, 1940, pp. 51–56.)

"The additional valve is scarcely justified in broadcast receivers, except possibly in the more expensive classes; but in modern communication receivers there is an extensive demand for good a.v.c. characteristics, particularly for unattended and other remotely operated receivers . . ."

374. Automatic Fading Compensation [Survey of Modern Methods and Investigation of Requirements, etc.].—E. Kettel. (*Telefunken-Röhre*, No. 17, 1939, pp. 228–259: *E.T.Z.*, 10th Oct. 1940, Vol. 61, No. 41, p. 941—summary only.)

Including a comparison of linear, square-law, and exponential characteristics, and the reason for the general adoption of an approximation to the last-named: the advantages conferred by the use of "sliding screen-grid voltage" (*see* 533/5 of 1939): undelayed and delayed compensation: the design of automatic fading compensation in multi-stage receivers, taking into consideration modulation distortion and cross modulation: the prevention of over-control by local stations: mathematical investigation of stability, and derivation of the necessary values for the time constants.

375. Fading of Received Signals produced by Moving Trains [with Critical Comments].—Oxenfart. (*See* 304.)

376. Lamp Contrast Expander: Its Operation and Effectiveness Explained.—Amos. (*See* 432.)

377. The Electrical Testing of Radio Receiver Components [in Quantity Production].—L. G. Dobbie. (*Proc. Inst. Rad. Eng. Australia*, May 1940, Vol. 4, No. 2, pp. 18–24 and 31.)

Resistances, fixed & variable; condensers, fixed (including electrolytic) & variable (air); inductances & transformers will be dealt with in the next issue.

378. New Pen Flashlight lights around Corners [issued as Part of Standard Servicing Equipment].—Philco. (*Sci. News Letter*, 26th Oct. 1940, Vol. 38, No. 17, p. 265: paragraph only.)

379. Errors in Tracking [in Superheterodyne Receivers] and How to Reduce Them.—W. Winder. (*Wireless World*, Dec. 1940, Vol. 46, No. 14, pp. 485–486.)

380. Modernising the Regenerative Superhet: a 1941 Version with Stepped-Up Performance.—G. Grammer. (*QST*, Nov. 1940, Vol. 24, No. 11, pp. 14–17 and 76, 78.)

Retaining the basic design of regenerative mixer to give gain and improve signal/image ratio; regenerative i.f. stage for single-signal selectivity; and separate h.f. and beat oscillators for stability.

381. An Economical Commercial Receiver of Wide Application [200 kc/s to 30 Mc/s in Five Bands (Self-Contained Coils with Selector Switch) operated from Accumulators (Vibrator Unit in Receiver), Universal A.C. Mains, or D.C. Mains, according to Type: Alternative Crystal-Controlled Reception on a Spot Frequency (replacing One of the Five Bands): etc.].—J. B. Stacy & F. S. Holloway. (*A.W.A. Tech. Review*, No. 2, Vol. 5, 1940, pp. 61–75.)

382. Communications Receivers [Some U.S.A. Models].—(*Communications*, Sept. 1940, Vol. 20, No. 9, pp. 12–14.)

383. Test Report: K.B. Model 850/2-0 [Four-Waveband A.C. Superhet for Overseas Markets].—(*Wireless World*, Nov. 1940, Vol. 46, No. 13, pp. 464–465.)

384. Test Report: Premier Short-Wave S.G.3 [Straight 3-Valves + Rectifier Receiver].—(*Wireless World*, Dec. 1940, Vol. 46, No. 14, pp. 492–493.)

385. Emergency Reception: Working A.C. Mains Sets from Batteries [Slight Alterations to Wiring].—Mainprise. (*See* 360.)

AERIALS AND AERIAL SYSTEMS

386. A High-Performance Reflector Aerial for Television and Broadcast Reception.—H. Schuster. (*E.T.Z.*, 12th Sept. 1940, Vol. 61, No. 37, pp. 861–862: summary only.)

This is a half-wave aluminium rod with a similar reflector rod radiation-coupled at a quarter-wavelength distance. If the feeder connecting point A is displaced from the middle M of the dipole, where the pick-up resistance has a purely ohmic character (about 18 ohms), the pick-up resistance increases roughly as a $\cos^2$ function, up to about 2200 ohms for a dipole of 24 mm thickness. The feeder (of characteristic impedance 130 ohms) is moved to a point A rather further from M than is necessary for exact matching, so as to give the dipole the slightly increased damping required for the 6 Mc/s band width. The sheath of the feeder may carry local interference as well as phase-displaced potentials from the station being received: the point A' at the end of the sheath is the important spot, since only here can the unwanted potentials be conveyed capacitively to the central conductor. To keep this point A' free from h.f. potentials, it may be connected to M either by a short lead or by a resonant circuit (representing a short-circuit for the interference frequencies), according to its distance from M. Another method is to slide a quarter- or three-quarter-wavelength sleeve over the end of the feeder, connecting it at A' with the sheath, so that it acts as a current-fed aerial which can carry no h.f. potential at its feeding-point A'.

This reflector-aerial is less sensitive to interference than the ordinary rod dipole aerial, and the reflector produces an input voltage 1.4 times that given by the latter. The necessarily defective matching at the aerial end makes it essential to match the feeder very carefully to the receiver, in order to avoid reflections and consequent "plastic" effects on the image. The use of a separating filter (Fig. 9), containing among other components a broadcast-wave aerial transformer, enables the system to be used for broadcast and television reception simultaneously. For an R.C.A. combination aerial *see* 3838 of 1940.

387. Compensation of the Aerial Reactance of Television Transmitters.—Labus: Lindenblad. (*E.T.Z.*, 5th Sept. 1940, Vol. 61, No. 36, pp. 837–838.) Based on the papers of Labus (110 of 1940) and Lindenblad (2759 of 1939: for later work *see* 3837 of 1940).

388. On the Ultra-Highs [Monthly Feature: including Very Successful 16-Element Array and a Pair of Rhombic Aerials stacked One above the Other, at W1DEI].—E. P. Tilton. (*QST*, Nov. 1940, Vol. 24, No. 11, pp. 42–45.) Tilton's work was referred to in Colwell's paper dealt with in 4 of January.

389. The Square-Corner Reflector Beam Antenna for Ultra-High Frequencies [Gain approaching 10 db over Single Half-Wave Aerial: Foldable for Portable Work: Construction].—J. D. Kraus. (*QST*, Nov. 1940, Vol. 24, No. 11, pp. 18–23.) For a previous paper on "corner" reflectors *see* 109 of 1940.

390. Compressed Dipoles : Reducing the Dimensions of Short- [and Ultra-Short-] Wave Aerials [by Insertion of Loading Coil : Experimental Investigation, for Transmission & Reception : Unexpectedly Good Results, & Their Explanation : Array for Direction-Finding on Waves around 5 m].—E. L. Gardiner. (*Wireless World*, Nov. & Dec. 1940, Vol. 46, Nos. 13 & 14, pp. 453–456 & 501–503.)

391. Concentric Cables for H.F. Energy [Construction & Performance of Styroflex Cables for Aerial Feeders, Television Lines, etc.].—E. Keutner. (*E.T.Z.*, 12th Sept. 1940, Vol. 61, No. 37, pp. 841–844.)

From the Felten & Guilleaume Carlswerk A.G. laboratories. Two types of wide-band coaxial cable have been used successfully : the type with spirally-wound insulation with a cord, spiral, or tape of Styroflex, and the type with suitably spaced discs of Frequenta [or Calit]. " It seems strange that the only energy-carrying cables which have so far appeared in the literature are of the disc-insulated type, such as the aerial feeder for the Beromünster broadcasting station (conducting 100 kw at 0.556 Mc/s over 1.6 km : Baumann, 3932 of 1938) and the Eiffel Tower television cable (carrying 30 kw at 46 Mc/s : Mallein & Rabuteau, 4557 of 1939). . . . There is evidently a hesitation to use Styroflex power cables, due to doubts as to the behaviour of the polystyrol to a rise of temperature. An investigation has therefore been made of a series of Styroflex cables, to examine their suitability for transmitting h.f. energy, particular attention being given to the problem of heating-up." The samples were of four types, details of which are given in Table 1 : all were insulated with ordinary Styroflex, but reference is made later to the new " Styroflex EF," a specially heat-resistant modification which can be raised to 85° C without damage, as compared with 70° C for the ordinary material.

Table 2 shows the breakdown strength and the point of onset of ionisation for the four samples, measured at 50 c/s : Fig. 2, taken with the largest sample D, shows the voltage-dependence of the loss angle—the latter being too small to be measured at voltages up to 19 kv, when ionisation sets in and the curve rises steeply, the air-space insulation being favourable to the rapid spread of ionisation. Assuming that the cable, run partly in the open and partly up an aerial tower, may have a natural temperature up to 40° C, so that a permissible internal temperature rise would be 30° for ordinary and 45° for " EF " Styroflex, Table 3 is described as giving, for the three larger types, the measured values of power dissipation per kilometre for a temperature rise of 45° (there would seem to be some confusion here, for it is distinctly implied in the paper that the tests were with ordinary Styroflex, for which the rise allowed would be 30°), and the calculated carrying capacities at 1 Mc/s, rising to 140 kw for the largest cable. This type D cable has the lowest ratio (55/19) of all the four types for the diameters of outer and inner conductors. In general, this decrease of the ratio below the " optimum " of 3.6 for h.f. working (*cf.* Borgnis, 50 of January) produces an increased carrying capacity, since the carrying away of heat is made easier. This question, which is complicated by the dual action of conduction and convection, is discussed on p. 843, r-h column. The next column deals with the frequency-dependence of the carrying capacity and efficiency of such cables. Fig. 6 shows how the efficiency of a Calit-disc cable, nearly equal to that of a Styroflex cable at the lower frequencies, falls well below this as the frequency is increased, so that at 40 Mc/s it is only about 57%/km compared with 70% for the latter type.

The final column deals with the question of permissible voltage : the Styroflex cable is particularly proof against surges, and no special precautions need be taken against breakdown, such as the increased internal pressure used with the Beromünster feeder. This property makes it capable of being used, if so required, for extremely large powers over short distances, where no reflections are to be feared : thus the cable seen in Fig. 7, with an external diameter of only 21 mm, will carry over 100 kw over a short length at frequencies up to 1.6 Mc/s.

392. Aerial Arrangements at the Delhi IV Short-Wave Station [and the Cure of Arcing along Feeder].—Garudachar. (*See* 353.)

393. Double-Fed Antenna in Police Service [Simultaneous Operation of Telephone and Ten-Channel Telegraph Signals from Single Vertical Aerial].—J. Beall. (*Electronics*, July 1940, Vol. 13, No. 7, p. 46.)

394. Shunt-Fed Mobile Antennas [*e.g.* for Bumper-Rod Aerial on Motor Car : Advantages in Noise Reduction, etc.].—E. W. Cruser. (*QST*, Nov. 1940, Vol. 24, No. 11, pp. 49–50.)

395. Shunt-Excited Antennas for Amateur Use [Advantages, including Possibility of using Existing Structures—Smoke-Stacks, etc : Practical Points].—C. V. Clarke. (*QST*, Oct. 1940, Vol. 24, No. 10, pp. 64–67.)

396. More on Balloon-Supported Antennas [Practical Information and Hints].—R. C. Greene. (*QST*, Nov. 1940, Vol. 24, No. 11, pp. 38–39 and 82.)

397. The Defrosting of Lines : Practical Considerations on Various Methods of Heating.—A. Maret. (*Bull. Assoc. suisse des Élec.*, No. 17, Vol. 31, 1940, pp. 373–383 : in French.)

VALVES AND THERMIONICS

398. Paper on the Telefunken " Hammer-Type " Micro-Wave Valve Type DEM 60.—Nakamura. (*See* 343.)

399. On the Magnetron with a Bowl-Type Resonator [connected to Split Anodes : H.F. Energy led out by Capacitive or Inductive Coupling : Increased Output & Permissible Anode Dissipation].—K. Owaki. (*Electrotech. Journ.*, Tokyo, Aug. 1940, Vol. 4, No. 8, p. 188.) The best result was with an unsymmetrical (3-split) anode.

400. On the Static Theory of the Magnetron.—S. V. Bellyustin [Bellustin]. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 2, Vol. 10, 1940, pp. 190–198.)

Continuing previous work (*see* 1871 of 1940) a whole-anode magnetron employing two coaxial cylinders is considered and the static characteristic of this, *i.e.* the relationship between the anode current and the emission, anode potential, and magnetic field, is discussed. In this investigation both the Maxwellian distribution of initial velocities and the effect of space charge are taken into account. Limiting values of the density of the space charge are determined, and methods are indicated for calculating the potential at any point between the two electrodes. Conditions are then established for the validity of formula (3), derived in the previous paper for determining the static characteristic. Throughout the discussion remarks are made on similar investigations by other authors.

401. A Mechanical Model for the Motion of Electrons in a Magnetic Field [Magnetic Field replaced by Spin Velocity of Gyroscope, Electric Fields by Magnetic Fields giving Same Configuration : Electron represented by One Pole of Permanent Magnet mounted on Gyroscope Axis : Mathematical Analysis : Photographs of Paths obtained, including Cyclotron & Magnetron Paths (& Comparison with Kilgore's Gas-Traced Path)].—A. Rose. (*Journ. of Applied Phys.*, Nov. 1940, Vol. 11, No. 11, pp. 711–717.)

402. On the Motion of Electrons with Equal Initial Velocities in Intersecting Electric and Magnetic Fields, taking into Account the Effect of Space Charge.—S. V. Bellustin. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 4, Vol. 10, 1940, pp. 455–469.)

A theory is developed of the movement of electrons with equal initial velocities between two flat parallel electrodes when a magnetic field parallel to the electrodes is superimposed on the electric field ; the existence of space charge is assumed. In practice such conditions are met with in the case of a valve or a wide electron beam placed in or subjected to a magnetic field.

Equations relating to the processes taking place in the inter-electrode space are derived and it is shown that 4 different classes of solution are possible. Each class is investigated separately, and methods are indicated for determining the electron trajectory, the duration of its travel, the static characteristic, and the distribution of the current, potential, and space charge. In order to provide a basis for comparison with experimental results, one of the solutions is examined in greater detail and a number of curves referring to this case are plotted.

403. Effects of Resistance and Negative Capacitance in Electronic Tubes [Analysis of Electron Motion in Plane Diode : Resistance Term indicates Possibility of Zones of Negative Values, Capacitance Term indicates Certain Conditions in which Capacitance becomes Infinite and then Negative : Explanation].—R. Warnecke. (*Sci. Abstracts*, Sec. B, 25th Oct. 1940, Vol. 43, No. 514, p. 426.)

404. Space-Potential Plotting in Thermionic Vacuum Tubes [under Operating Conditions : suitable for Configurations Too Complex for Analytical Treatment : No Assumptions necessary concerning Nature of Space-Charge Distribution : Method depending on Shadow thrown by Probe on Fluorescent Surface on Inside of Anode : Example showing Agreement with Calculated Curves for Diode under Temperature- and Space-Charge-Limited Conditions].—D. E. Kenyon. (*Review Scient. Instr.*, Oct. 1940, Vol. 11, No. 10, pp. 308–310.)

"Its application to problems in electron optics and the study of secondary-emission phenomena is indicated."

405. On the Influence of Temperature on the Secondary Electron Emission of Metals [Measurements on Tungsten between 20° and 1500° C, with a Primary-Electron Velocity of about 400 Volts : Increase of Secondary-Electron Velocity with Increasing Temperature (while the Quicker Diffused & Reflected Primary Electrons remain practically Unaffected) : Direct (Electron-Energy Increase) and Indirect (Outgassing, etc.) Actions].—W. Reichelt. (*Ann. der Physik*, Ser. 5, No. 4, Vol. 38, 1940, pp. 293–303.)

406. The Effect of a Charge on an Electron Beam during Secondary Emission.—A. Gubanov. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 2, Vol. 10, 1940, pp. 161–167.)

When an electron beam falls on an electrode, the magnitude of the resulting charge depends on the conductivity of the electrode. In the present paper it is assumed that the beam falls perpendicularly, and the following two types of electrode are considered separately : (1) electrodes made of semiconducting material, and (2) metal electrodes covered with a layer of a semiconducting oxide. Approximate mathematical methods are indicated for calculating the field of the charge and its effect on the width of the beam. The secondary electron emission is taken into account in these methods.

407. On the Nature of the Kinetic Ejection of Secondary Electrons by Positive Ions.—M. E. Gurtovoy. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 5, Vol. 10, 1940, pp. 483–496.)

The subject of this paper is the ejection of secondary electrons by positive ions whose potential energy is insufficient in itself to eject the electrons from the cathode surface, *i.e.* when $V_i < 2\phi$, where V_i is the potential energy of the ion and ϕ the output work. A brief survey of the existing theories on the subject is given and their inadequacy is pointed out. This is followed by a detailed report on experiments in which secondary electrons were ejected from thoriated tungsten by potassium and caesium ions. The theory of these experiments and their accuracy is discussed, and a number of experimental curves and tables are shown. The main conclusions reached are that in the case of kinetic ejection the bound electrons of the metal are the source of secondary electrons and that the actual mechanism of ejection is apparently similar to that of the ionisation of gas molecules caused by the impact of fast ions.

408. Simple Power-Limiting Device for Use when Heating by Electron Bombardment [to avoid Excessive Temperature when dealing with Thin Metal Films, etc.].—R. P. Winch & H. E. Farnsworth. (*Review Scient. Instr.*, Oct. 1940, Vol. 11, No. 10, p. 344.)

409. Cooling Effect of Filament due to Electron Emission [Theoretical Formulae for Decrease of Temperature due to Emission Current and for Decrease of Emission Current due to This Decrease of Temperature: Confirmation by Short-Time (within 1/100th Second) Measurements on Tungsten-Filament Diode].—O. Harashima & Y. Minobe. (*Electrotech. Journ.*, Tokyo, Aug. 1940, Vol. 4, No. 8, p. 187.)

410. Measurement of Total Electron Emission [Simple Method using Condenser Discharge to provide Anode Voltage, eliminating Cooling & Reverse Heating Effects: Example of Thoriated-Tungsten Receiving Valve].—O. Harashima & Y. Minobe. (*Electrotech. Journ.*, Tokyo, Aug. 1940, Vol. 4, No. 8, p. 191.)

411. Conductivity and Thermionic Emission of the Oxide Cathode [Experimental Confirmation of Fowler & Wilson's Theory suggesting Intimate Connection: during Activation, Both increase at Similar Rates: Similar Functions of Temperature: Conclusion that Surface Conditions do Not change during Activation].—E. Nishibori & H. Kawamura. (*Sci. Abstracts*, Sec. A, 25th Sept. 1940, Vol. 43, No. 513, p. 686.)

412. Compensating for Tube Input Capacitance Variation by Double Bias Provision.—Farrington. (*See* 372.)

413. Tube Registry [Valve Types registered by R.M.A. Data Bureau during May 1940 and during 1937].—(*Electronics*, July 1940, Vol. 13, No. 7, pp. 57–60.) A monthly feature.

DIRECTIONAL WIRELESS

414. The C.A.A.-M.I.T. Micro-Wave Instrument-Landing System.—Bowles, Barrow, & others. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 413: summary only.) For previous articles *see* 629, 3037, & 3040 of 1940.

415. Compressed Dipoles [and Their Use in Direction-Finding on Ultra-Short Waves].—Gardiner. (*See* 390.)

416. Wireless Equipment of the *Luftwaffe*: Technical Details of Apparatus recently Acquired—by Courtesy of the R.A.F.—(*Wireless World*, Nov. 1940, Vol. 46, No. 13, pp. 450–452.)

With photographs, including one of the very compact D.F. loop on an oval-section powdered-iron core a foot long and of three inches average diameter.

417. Magnetic-Induction Compass free from Effects of Variation of Magnetic Inclination, with Special Arrangements for Remote Control & Course Indication, for Aerial & Marine Navigation.—G. Giulietti. (*L'Elettrotecnica*, No. 19, Vol. 27, 1940, pp. 452–455.) For previous work *see* 3052 of 1936.

ACOUSTICS AND AUDIO-FREQUENCIES

418. Telephonic Communication in Noisy Surroundings with Microphones [including the Calculation of the Effect, on Intelligibility, of Response Curves of Microphone and of Receiver: etc.].—M. Federici. (*L'Elettrotecnica*, No. 16, Vol. 27, 1940, pp. 384–393.) *See* also 3061 of 1940.

419. A Telephone Set for Explosive Atmospheres.—H. I. Beardsley. (*Bell Lab. Record*, Oct. 1940, Vol. 19, No. 2, pp. 42–45.)

420. Some Notes on Loudspeaker Coupling Systems [and the Influence of the Loudspeaker Type, the Phasing, & the Baffle on the Quality of Reproduction in Modern Theatre Practice].—E. L. Walther. (*Proc. Inst. Rad. Eng. Australia*, April 1940, Vol. 4, No. 1, pp. 3–6.)

421. Tests of Loudspeakers in Cinemas [Difficulties due to Formation of Standing Waves avoided by Use of Pure Tone and by taking Measurements in the "Split-Second" Interval before Standing Waves are formed].—S. L. Reiches. (*Science*, 15th Nov. 1940, Vol. 92, Supp. p. 10: paragraph only.)

422. Sound on Film [Comments on Miller's Article (3902 of 1940), particularly the Advantages of Ultra-Violet Light in Variable-Area Recording].—G. Morgan: Miller. (*Wireless World*, Nov. 1940, Vol. 46, No. 13, p. 473.)

423. The Design of a Practical Low-Pass Filter for 600-Ohm Audio Transmission Line [for FCC Limitation (if Interference is caused) to 7500 c/s: for Noise Suppression on Long Lines: for improving "Sibilatory" Voices: etc.].—S. Helt. (*Communications*, Oct. 1940, Vol. 20, No. 10, pp. 6–7 and 26..28.)

424. Vibration Modes of Rochelle Salt Crystals [Powder-Patterns confirm Modes given by Equation].—N. Takagi & M. Iso. (*Electrotech. Journ.*, Tokyo, Aug. 1940, Vol. 4, No. 8, p. 186.) Extension of the work dealt with in 3521 of 1940.

425. The Location of Hysteresis Phenomena in Rochelle Salt Crystals.—W. P. Mason. (*Phys. Review*, Ser. 2, 15th Oct. 1940, Vol. 58, No. 8, pp. 744–756.)

426. Some Problems of Disc Recording [becoming More & More Important in Broadcasting & Home Entertainment Field: Commercial Discs & Their Variations, making Pick-Up Equalisation difficult: Light-Weight Pick-Ups should make Better Disc Materials possible: Lateral *versus* Vertical Cut: the

Growing Importance of Instantaneous Recording: Its Latest Technique: etc.].—S. J. Begun. (*Proc. I.R.E.*, Sept. 1940, Vol. 28, No. 9, pp. 389–398.)

427. Further Improvements in Light-Weight Record Reproducers, and Theoretical Considerations entering into Their Design [including Construction & Use of Friction-Measuring Device for Record-Wear Investigations].—A. L. Williams. (Mentioned in Begun's paper, 426, above.)

428. Some Notes on Vibratory Momentum and Groove Skating in Disc Reproduction [Experimental Investigation of These Two Governing Factors in Record Wear and Harmonic Distortion: Comparison of Three Modern Pick-Ups: Fallacy of striving for Minimum Needle-Point Pressure: Question of Frequency Range: etc.].—J. C. Parvey. (*Communications*, Oct. 1940, Vol. 20, No. 10, pp. 22 and 25, 26.) From the Audak laboratories.

429. Universal Phonograph Reproducer [Type 9A, for Lateral-Cut or Vertical-Cut Discs without Adjustment & without Loss of Quality].—H. A. Henning. (*Bell Lab. Record*, Oct. 1940, Vol. 19, No. 2, pp. 57–60.)

430. The Cranked Pick-Up Tone Arm: Mathematical Analysis of Tracking Error and the Derivation of an Optimum Design.—H. F. Huon. (*Proc. Inst. Rad. Eng. Australia*, May 1940, Vol. 4, No. 2, pp. 26–31.)

431. Acoustic "Tone Guard" [for Gramophone: System of Grooved Wells round Inside Top Edge, below Lid, acting as Tuned Filter for Surface & Mechanical Noises].—R.C.A. Victrola. (*Communications*, Oct. 1940, Vol. 20, No. 10, p. 29.)

432. Lamp Contrast Expander: Its Operation and Effectiveness Explained [Good Results, especially in Reduction of Needle Hiss, by shunting Loudspeaker by 5-Volt Torch Bulb].—S. W. Amos. (*Wireless World*, Dec. 1940, Vol. 46, No. 14, p. 504.)

433. Tone Control: Proportioning the Resistance Values.—E. O. Powell. (*Wireless World*, Dec. 1940, Vol. 46, No. 14, p. 491.)

434. On the Internal Friction and the Radiation Damping of Violins [Experimental Comparison of a Bad Modern Violin and Three Old Instruments of Fine Tone, with Practical Deductions for Construction].—E. Rohloff. (*Ann. der Physik*, Ser. 5, No. 3, Vol. 38, 1940, pp. 177–198.) For previous work *see* 570 of 1939; *cf.* also Matveev & Rimsky-Korsakov, 182 of 1938.

435. The Song, Hearing, and Musicality of Birds [Experimental Investigation].—S. Knecht. (*Naturwiss.*, 18th Oct. 1940, Vol. 28, No. 42, pp. 658–663.)

436. Reducing Noise in Enclosed Spaces [including Experiences with Accousti-Celotex Tiles of Sugar-Cane Fibre].—(*Nature*, 30th Nov. 1940, Vol. 146, p. 714: summary only.)

437. Calculation and Design of Resistance-Coupled Amplifiers using Pentode Tubes.—Terman & others. (*See* 325.)

438. The "Speedomax" Power-Level Recorder—Clark. (*See* 488.)

439. The Thermal Effect of an Alternating Electric Field on the Suspension of Dielectric Particles in a Liquid.—D. V. Sivukhin. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 6, Vol. 10, 1940, pp. 679–693.)

Supersonic waves are excited in a liquid when this is placed in an alternating electric field. These waves are quickly absorbed by the liquid and their energy is transformed into heat. A hydrodynamic theory of this phenomenon is developed and applied to the case of a liquid containing dielectric particles in suspension. A general equation (8) determining the force acting on unit mass of the liquid is derived, and possible solutions of it are discussed. The propagation of the supersonic waves in the liquid is then investigated, and methods are indicated for determining the amount of heat thus generated.

440. The Dependence of the Supersonic Diffraction Figures in Glass on the Prism Form [Experimental Investigation on 7.6 Mc/s].—H. Rötger. (*Naturwiss.*, 4th Oct. 1940, Vol. 28, No. 40/41, pp. 644–645.)

Among other results, it is found that by a suitable choice of the base angles the transverse waves can be displaced by 90° with respect to the incident longitudinal waves, so that the transverse waves at the two "roof" surfaces reinforce each other. This angle is close to 60°: *cf.* Levi & Nath, 4495 of 1938.

441. Scattering of Ultra-Sound near the Critical Point of Mixing of Two Liquids.—A. Gorodetzky. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 6, Vol. 10, 1940, pp. 694–699.)

442. The Absorption of Sound in Carbon Dioxide: in Triatomic Gases: in CO$_2$, N$_2$O, COS, & in CS$_2$, containing Added Impurities [1% of Impurity produces Absorption-Band Shifts ranging from 20 to 4200 kc/s].—Leonard, Fricke, Knudsen. (*Journ. Acous. Soc. Am.*, Oct. 1940, Vol. 12, No. 2, pp. 241..259.)

443. Supersonic Velocities in N$_2$, NO and CO between 20° and 200° C, measured by a New Method [Interferometer, using Two-Sided Radiation & Fixed Path-Lengths: Resonance obtained by varying Temperature].—D. Bender. (*Ann. der Physik*, Ser. 5, No. 3, Vol. 38, 1940, pp. 199–214.)

Preliminary tests to decide the circuit to be used for the quartz plate showed that in an oscillator connection the quartz gradually ceased to vibrate between 200° and 300° C, and that even between room temperature and 200° amplitude "jumps" occurred: in a resonator connection the behaviour was satisfactory.

444. Vibrometers having Metal Diaphragms.—Matudaira & others. (*Nippon Elec. Comm. Eng.*, July 1940, No. 21, pp. 35–38.) For the ordinary form *see* Kobayasi, 1931 Abstracts, p. 329.

PHOTOTELEGRAPHY AND TELEVISION

445. The Generation for Television of Horizontal Synchronising Pulses from Vertical Pulses by Means of Impulse Excitation [Elimination (in Laboratory) of Complicated Frequency-Dividing-*cum*-Synchronising System for Sequential or Interlaced Scanning, by making Frame-Frequency Impulse (from Type 884 Gas Triode and Condenser) excite Damped Wave Trains in Tuned Circuit with Suitable Amount of Feedback : Trains amplified & clipped to give Rectangular Wave-Form].—J. B. Sherman. (*Proc. I.R.E.*, Sept. 1940, Vol. 28, No. 9, pp. 406–409.)

446. The Obtainment of High Voltage from the Line-Sweep Unit [of Cathode-Ray Television Receivers].—H. Bähring. (*E.T.Z.*, 5th Sept. 1940, Vol. 61, No. 36, p. 822 : summary only.)

From the Fernseh A.G. Laboratories : a theoretical investigation, with experimental confirmation of the results, of the scheme whose application to the generation of the cathode-ray-tube anode voltage in the German " Unit " receiver was dealt with in 4599/4601 of 1939. *See* also 219/220 of 1940.

447. The Influence of Small Phase Distortions on the Transmission of Television Signals.—F. Strecker. (*E.N.T.*, March 1940, Vol. 17, No. 3, pp. 51–56 : *E.T.Z.*, 17th Oct. 1940, Vol. 61, No. 42, p. 962—summary only.)

The distorted process is considered as made up of a number of undistorted processes of various amplitudes arriving at different instants at the end of the transmission system. The attenuation, or phase, of such a system with slight distortion only can be represented by an attenuation independent of frequency, or a frequency-proportional phase, such as obtains in a distortionless system, together with a residue (*i.e.* the attenuation or phase distortion) as a function of frequency. The distortionless component transmits an undistorted main process. The residue (if only a restricted frequency band is considered) can be represented by a number of sinusoidal oscillations dependent on frequency, by Fourier analysis. To each of these oscillations there corresponds a pair of undistortedly reduced minor processes, one of which follows at a definite interval behind the main process, like an echo, while the other precedes it by an equal interval. If the factors determining the magnitudes of these minor processes are represented as a function of the path time, a path-time spectrum is obtained, with the help of which the distorted processes arising from any given processes can be synthesised. In a similar way the phase path time, instead of the phase angle, can be split up into sinusoidal oscillations : in this case the minor processes obtained represent not the undistorted process itself but the differential with respect to time.

In order to deduce conclusions regarding the permissible path-time distortion in television transmission, the writer considers next a single pulse process. The distorted process is likewise a pulse, which however may carry out swings before and after the sudden rise : these swings are most violent at those points where the greatest values appear on the path-time spectrum. It is shown that with a certain succession of alternating upwards and downwards pulses these swings may mutually reinforce one another : it can be seen from the path-time spectrum with what form of signal such particularly violent disturbances will occur, what their magnitude will be, and whether or not they will exceed the permissible limits.

448. Continuous-Wave Interference with Television Reception [giving " Herring-bone " or " Feather " Effects : Problem similar to Whistle Interference in Sound Reception : Investigation of Tolerable Signal/Interference Ratio at Grid of Light-Modulating Device (Comparison between Linear & Exponential Light/Voltage Characteristics) : Conclusions : Precautions to be taken to reduce Interference].—C. N. Smyth. (*Communications*, Sept. 1940, Vol. 20, No. 9, pp. 5–7 and 14 . . 18.) From the Kolster-Brandes laboratories.

449. Field Strength of Motor-Car Ignition between 40 and 450 Megacycles.—George. (*See* 366.)

450. Compensation of the Aerial Reactance of Television Transmitters.—Labus : Lindenblad. (*See* 387.)

451. Determination of the Axial Potential Distribution in Axially Symmetrical Electrostatic Fields [for Calculation of Trajectories in Cathode-Ray Tubes, Image Converters, etc : Derivation of Definite Integral for Axial Potential in Terms of Potential along a Cylinder concentric with Axis].—Bertram. (*Proc. I.R.E.*, Sept. 1940, Vol. 28, No. 9, pp. 418–420.)

452. The Theory of the Luminous Efficiency of Complementary Colours : the White Luminescence from Braun Tubes [Efficiencies of Complementary Colours calculated according to I.C.I. Colorimetry : Combination of 430–470 mμ and 568–574 mμ is Ideal for Efficiency ($>$300 lm/W) : etc.].—T. Azuma. (*Jap. Journ. of Eng., Abstracts*, Vol. 19, 1940, p. 108.)

453. Colour Television in U.S.A. : the Columbia System described.—Goldmark. (*Wireless World*, Nov. 1940, Vol. 46, No. 13, pp. 457–459.) *See* also p. 467, and 133 of January.

454. Two-Way Television Communication Inaugurated—Another Important "First" for Amateur Radio [at New York World's Fair].—(*QST*, Nov. 1940, Vol. 24, No. 11, pp. 36–37 and 102.)

455. Television Camera-Modulator Design for Practical Amateur Operation.—J. J. Lamb. (*QST*, Oct. 1940, Vol. 24, No. 10, pp. 11–21 and 94 . . 98.)

456. The Electron Microscope and Television [Combination of Two Techniques avoids Heating of Object and Necessity for Object to be in Vacuum: Use of X-Rays or Ultra-Violet Light].—M. Ploke. (*Science*, 1st Nov. 1940, Vol. 92, Supp. p. 8.)

457. Concentric Cables for H.F. Energy [Styroflex Cables].—Keutner. (*See* 391.)

458. Facsimile Demonstration [Aeroplane-to-Ground, and Point-to-Point over Telephone Line, using Finch Duplex Facsimile Unit].—Finch Telecommunications. (*Communications*, Oct. 1940, Vol. 20, No. 10, p. 28.)

459. The Dispersion of Magnetic Double Refraction in the Short Infra-Red Spectrum [Ratio of Cotton-Mouton Constant to Analogous Kerr Constant is a Constant independent of Wavelength, within Experimental Error: Comparison with Havelock's Law: etc.].—F. J. Davis. (*Journ. Opt. Soc. Am.*, Oct. 1940, Vol. 30, No. 10, pp. 488–494.)

460. The Dependence of the Supersonic Diffraction Figures in Glass on the Prism Form.—Rötger. (*See* 440.)

461. Abnormal Phenomena in Photocells due to Superposed Ultra-High-Frequency Voltages [Response increased 30 Times or more].—Seki, Nijoh, & Matudaira. (*Jap. Journ. of Eng., Abstracts*, Vol. 19, 1940, p. 102.) A summary was dealt with in 1110 of 1940.

462. Space Charges and Photoconductivity.—P. S. Tartakovski & D. M. Kaminker: Kaminker. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 2, Vol. 10, 1940, pp. 139–144: pp. 145–149.)

If a crystal is first illuminated, then earthed, and then re-illuminated, a photocurrent flowing in the opposite direction will be observed. It has been suggested that this phenomenon is caused by the space charge on the crystal, and in these two papers an account is given of experiments conducted to check this theory. The first paper deals with the formation of space charges on NaCl and KBr crystals. The method used in these experiments is based on observing the spectral distribution of reverse (depolarising) currents, and a number of experimental curves are shown for various temperatures (from -185°C to $+200$°C) and various durations of the dark periods elapsing between the two periods of illumination. In the second paper similar experiments with NaCl crystals, but illuminated this time with white light, are described. The investigation seems to confirm the theory and to be in contradiction with the explanation put forward by Hilsch and Pohl (polarisation of centres: the reference given is to *Zeitschr. f. Physik*, Vol. 87, 1933, p. 78. For later work *see* 1548 of 1938 and 2868 of 1939).

463. On the Theory of the Internal Photoeffect in Dielectrics.—P. Tartakovski. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 3, Vol. 10, 1940, pp. 281–287.)

It is pointed out that the usual interpretation of the internal photoeffect in dielectrics (secondary current not directly determined by the action of light), based on the conception of the average electron displacement path, leaves out of account a number of factors which in the present state of knowledge should not be disregarded. Accordingly, in this paper the internal photoeffect in alkali-halide crystals is discussed and attention is paid to the following considerations: (1) The energy spectrum of electrons represents a series of energy levels, Fig. 1; (2) the magnitude of the displacement path is determined by the drift velocity in the direction of the electric field and by the interaction between the electrons and the crystal lattice; and (3) the so-called secondary phenomena are closely connected with the primary current, and the division of photocurrents into primary and secondary is, therefore, largely a matter of convention. The effect of electron space charge is also taken into account. It is stated that this discussion should only be regarded as a preliminary investigation of the subject.

464. The Velocity Distribution of Photo-electrons in Photocells with a Barrier Layer, and the Operation of Such Cells.—Yu. P. Maslakovets. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 4, Vol. 10, 1940, pp. 393–397.)

Experiments on the illumination of a copper-oxide photocell by monochromatic light of 0.579μ wavelength, interrupted at regular intervals by a slotted rotating disc. A curve (Fig. 5) is plotted showing the energy distribution of electrons in accordance with the velocity components (in volt-electrons) perpendicular to the electrode; a similar curve, but for the velocity components expressed in cm/sec. (Fig. 6), is also plotted. On the basis of these results a study is made of the movement of electrons in the electrode, and diagrams illustrating this are drawn. It is shown that under certain conditions a "positive" photoeffect should be obtained, *i.e.* electrons under the action of light should move from the metal into the semiconducting layer, and not *vice versa* as is usually observed. Reference is made to an experiment with a Tl_2S electrode in which this positive photoeffect was actually observed.

465. Selenium Barrier-Layer Photocells [with Special Stability and a Spectral Sensitivity approximating to Normal Vision].—A. E. Evans, Ltd. (*Journ. of Scient. Instr.*, Dec. 1940, Vol. 17, No. 12, p. 282.)

466. "Geared" Magnets solve a Vacuum Problem [Use of Alnico Magnetic Drive enables 100 Aluminium Discs in Succession to be led through Process of Coating with Vaporised Selenium, in High Vacuum].—C. W. Hewlett. (*Gen. Elec. Review*, Sept. 1940, Vol. 43, No. 9, p. 387.) *Cf.* Yamaguti, 529, below.

467. The Electrical Conductivity and Thermo-electric Properties of Cu_2O_3.—V. P. Zhuze & I. N. Starchenko. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 3, Vol. 10, 1940, pp. 331–340.) "A new copper oxide recently synthesised in Russia." The thermo-e.m.f. passes through a well-defined maximum between 40° and 50°C: its sign is opposite to that of Cu_2O and CuO.

MEASUREMENTS AND STANDARDS

468. DECIMETRIC-WAVE MEASURING TECHNIQUE [Survey of Methods for Measurement of Voltage, Current, Power, Frequency, & Impedance].—F. W. Gundlach. (*E.T.Z.*, 12th Sept. 1940, Vol. 61, No. 37, pp. 853–858.)

Although intended for elementary workers, this short survey is of interest and includes a discussion of a diagram (comparing the calibration curves of pyrometric, thermal, and photocell types of current meters) taken from a 1935 paper not dealt with in these Abstracts (*see* 469, below).

469. OPTICAL CURRENT MEASURING.—J. Stanek. (*Archiv f. tech. Messen*, 1935, J 713–1.) Mentioned in 468, above.

470. MEASUREMENT OF THE [Ultra-] HIGH-FREQUENCY PROPERTIES OF SOIL.—Prasad, Singh, & Sinha. (*See* 295.)

471. ON THE NEGATIVE DISPLACEMENT.—B. K. Maibaum. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 1, Vol. 10, 1940, pp. 115–125.)

The second method of Drude for measuring dielectric constants and specific conductivities of semiconducting dielectrics within the range of metric and decimetric waves consists in observing the behaviour of a two-wire line short-circuited by two bridges, when an e.m.f. is applied to it and a condenser containing the dielectric under investigation is suspended from the line between the two bridges. The bridges are spaced half a wavelength apart, but owing to the presence of the condenser this distance is normally reduced by an amount d (displacement) to restore the resonant condition. In certain cases, however, d may acquire a negative value; *i.e.* the distance between the two bridges may actually increase. In the present paper the negative displacement is taken into account and the Drude method is discussed afresh under the following headings: (1) General solution of the equations of the system; (2) the effect of the conductivity of the dielectric and of the length of the condenser suspension straps on the negative displacement; and (3) the width of the resonance curve as determined by the position of the condenser on the line and by the dielectric conductivity.

472. ON THE SLÄTIS EFFECT.—V. I. Kalinin & Z. M. Posadskova. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 2, Vol. 10, 1940, pp. 199–201.)

Slätis has suggested (*see* 4525 of 1938) that the displacement of the Lecher-wire bridge, when using Drude's second method of measuring dielectric constants, is due to eddy currents induced in the condenser leads. In the present paper a brief report is given on experiments conducted to check this theory. The main conclusions reached are as follows: (1) The Slätis effect undoubtedly takes place; (2) the magnitude of the effect depends on the position of the condenser leads with respect to current, and reaches a maximum at the antinodes; (3) even in this position the effect is insignificant, and in practice, where the condenser is usually suspended at the middle of a half-wave system, it is almost reduced to zero.

473. MEASUREMENTS OF THE CONDUCTIVITY AND DIELECTRIC CONSTANT OF WATER AND OF AN AQUEOUS SOLUTION OF KCl AT ULTRA-HIGH FREQUENCIES.—Divilkovsky & Mash. (*See* 653.)

474. THE DIELECTRIC CONSTANTS OF SOME METALLIC SULPHATES CONTAINING VARIOUS AMOUNTS OF WATER OF CRYSTALLISATION [Measuring Technique: Water Molecules retain Their Integrity as Individual Molecules bound in Much the Same Manner as in Ice].—C. K. Cheng. (*Phil. Mag.*, Dec. 1940, Vol. 30, No. 203, pp. 505–515.)

475. GENERALISED BRIDGE NETWORK FOR DIELECTRIC MEASUREMENTS.—Balsbaugh, Howell, & Dotson. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 417: summary only.)

476. "PRÄZISIONSMESSUNGEN VON KAPAZITÄTEN, DIELEKTRISCHEN VERLUSTEN, UND DIELEKTRIZITÄTSKONSTANTEN" [Book Review].—E. Blechschmidt. (*E.T.Z.*, 29th Aug. 1940, Vol. 61, No. 35, p. 816.)

477. NOTES ON THE POWER-FACTOR TESTING OF LONG LENGTHS OF CABLES [Error due to Resistance of Conductor & Sheath, when measuring P.F. as Ratio Watts/Volt-Amperes, varies as Square of Length: Quite Appreciable at 10 000 Feet: Correction Factors by Exact & Approximate Formulae].—E. A. Walker. (*Journ. of Applied Phys.*, Nov. 1940, Vol. 11, No. 11, pp. 717–720.)

478. TESTING ELECTROLYTICS: MEASUREMENT OF CONDENSER LEAKAGE CURRENT [Safe & Simple Method with Cathode-Ray Tuning Indicator].—F. A. Boyer. (*Wireless World*, Dec. 1940, Vol. 46, No. 14, pp. 482–484.)

479. PROVISIONAL RULES FOR THE TESTING OF INSULATING MATERIALS.—V.D.E. Committee. (*See* 566/7.)

480. MEASUREMENT OF THE POTENTIAL DISTRIBUTION ON INSULATORS [Survey of 12 Methods useful in the Design of Insulators].—H. Prinz. (*E.T.Z.*, 29th Aug. 1940, Vol. 61, No. 35, p. 810: summary only.)

481. MEASUREMENT OF VERY SHORT TIME INTERVALS [*e.g.* Time Lags of Electrical Breakdown: Electronic-Relay Method giving Definitions down to 10^{-9} Second, Direct Reading].—J. M. Bryant & M. Newman. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 417: summary only.) Thus avoiding the delays of photographic development involved in c-r-o measurements.

482. SOME PROPERTIES OF APERIODIC A.C. BRIDGES [particularly the Simultaneous Determination of Series- & Shunt-Component Losses of Imperfect Condensers by A.C. Bridge supplied with Impure Wave and using Detector (C-R-O) whose Sensitivity is Independent of Frequency: Suitability for Routine Tests, etc.].—G. F. Freeman. (*Journ. of Scient. Instr.*, Dec. 1940, Vol. 17, No. 12, pp. 277–279.)

483. A.C. Impedance Bridge [Model 3389: Accuracy better than 0.1% over Wide Range when used with C-R-O as Indicator].—A. C. Cossor, Ltd. (*Journ. of Scient. Instr.*, Dec. 1940, Vol. 17, No. 12, pp. 282–283.)

484. An Accurate Impedance Bridge.—S. Sato & N. Kobayasi. (*Researches Electrotech. Lab. Japan*, 1939, No. 432, pp. 1–22: in Japanese.)

485. Notes on Anderson Bridge [in Measurement of Self-Inductance: Wrong Assumption that Butterworth's Formula $P = R = 2Q = 2S$ for Highest Sensitivity applies to General Practice, using Telephone as Galvanometer and 1000 c/s A.C: Correct Condition is $P = \sqrt{R^2 + \omega^2 L^2}$].—S. Hoh. (*Electrotech. Journ.*, Tokyo, Aug. 1940, Vol. 4, No. 8, pp. 191–192.)

486. A Sensitive Null-Point Indicator and D.C. Detector [Amplifying Valve battery-coupled to "Magic Eye" Tuning Indicator].—B. L. Andrew. (*Journ. of Scient. Instr.*, Nov. 1940, Vol. 17, No. 11, pp. 264–265.)

487. "Radio-Frequency Measurements, by Bridge and Resonance Methods" [Book Review].—L. Hartshorn. (*Electrician*, 15th Nov. 1940, Vol. 125, p. 257.)

488. The "Speedomax" Power-Level Recorder [for Production Tests of Gain of Amplifiers, Attenuation of Filters & Lines, etc.].—W. R. Clark. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 417: summary only.)

489. Attenuator Design: Calculating the Resistance Values for Fixed and Variable Networks.—S. S. West & E. D. McConnell. (*Wireless World*, Dec. 1940, Vol. 46, No. 14, pp. 487–490.) From the Baird laboratories.

490. "Elektrische Messung mechanischer Grössen" [Electrical Measurement of Mechanical Quantities: Book Review].—Pflier. (*Bull. Assoc. suisse des Élec.*, No. 21, Vol. 31, 1940, p. 501.) Based largely on Siemens & Halske activities.

491. Recommendations for High-Voltage Testing.—E.E.I.-N.E.M.A. Subcommittee. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, Transactions pp. 598–602.)

492. Electronic Measurement of Surge-Crest Voltages [by Valve Voltmeter: particularly for Lightning Research].—J. M. Bryant & M. Newman. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 417: summary only.)

493. Use of a Lauritsen [Quartz-Fibre] Electroscope under Adverse Weather Conditions.—J. C. Hudson & R. F. Cowing. (*Review Scient. Instr.*, Oct. 1940, Vol. 11, No. 10, p. 347.) *See* 659 of 1938.

494. The Determination of the Characteristic Values of Voltage Pulses with the Help of Indicating Meters [Peak Value, Front Duration, & Half-Value Period (or on Occasion the Breakdown Time) measured by Condenser/Rectifier/Galvanometer Combination: Comparison with C-R-O Results].—K. Debus & E. Hueter. (*E.T.Z.*, 29th Aug. 1940, Vol. 61, No. 35, pp. 797–802.)

495. A Square-Law Vacuum-Tube Voltmeter [primarily for Accurate Measurement of Fluctuation-Voltage Energies at 500–600 kc/s: made to fit Pre-Marked Square-Law Scale by Simultaneous Adjustment of Screen Voltage (of Acorn Pentode) & Microammeter Shunt: Mains-Operated: No Turn-Over Error].—J. R. Ragazzini & B. R. Boymel. (*Review Scient. Instr.*, Oct. 1940, Vol. 11, No. 10, pp. 312–314.)

"Investigation into the literature showed that the only true r.m.s. meters available were those using thermocouple milliammeters. Thermocouple meters suffer from two main disadvantages, namely poor current-sensitivity and instability of calibration."

496. The Design and Application of Balance [No-Current] Voltmeters [of Special Importance for High-Resistance R.F. and A.F. Circuits owing to Absence of Loading: Previous Designs Unsatisfactory].—C. A. Parry. (*Proc. Inst. Rad. Eng. Australia*, April 1940, Vol. 4, No. 1, pp. 7–12.)

497. Degenerative Electrometer Tube Amplifier [Self-Balancing Electrometer-Valve Circuit for Measurement of Direct Currents in Range 10^{-10} to 10^{-15} Ampere].—G. P. Harnwell & L. N. Ridenour. (*Review Scient. Instr.*, Oct. 1940, Vol. 11, No. 10, pp. 346–347.)

498. A New Measuring Instrument for Direct Current [M.C. Instrument with Alnico Permanent Magnet].—H. T. Faus & A. J. Corson. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, pp. 417–418: summary only.)

499. New Developments in Current-Transformer Design [Instrument Transformers: including Closed-Torus Form for Insulation between the Two Windings].—G. Camilli. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 417: summary only.)

500. On the Right- and Left-Handedness of Quartz and Its Relation to Elastic and Other Properties [Diverse Systems of Axes & Rules of Signs used by Voigt, Wright & Stewart, Mason, & Straubel have led to Confusion: Restatement of Facts on Established Crystallographic Lines: Errors in Literature: Use of Etched Sphere of Quartz: etc.].—K. S. Van Dyke. (*Proc. I.R.E.*, Sept. 1940, Vol. 28, No. 9, pp. 399–406.) A summary of part of this paper, under a different title, was referred to in 3126 of 1940. *See* also Mason & Willard, 501, below.

501. Piezoelectric Crystals [Question of Standardisation of Quartz-Crystal Terminology: Comparison of N.P.L. Proposals and American Usage: Suggestion of Study by Appropriate Committee].—W. P. Mason & G. W. Willard. (*Proc. I.R.E.*, Sept. 1940, Vol. 28, No. 9, pp. 428–429.) Prompted by Van Dyke's paper, above. *Cf.* 502, below.

502. Piezoelectric Quartz: Crystal Cuts and the N.P.L. Notation [Description of X, Y, AT, BT, AC, & BC Cuts].—V. V. L. Rao. (*Electrotechnics*, Bangalore, Sept. 1940, No. 13, pp. 69–74.) *See* also 501. For Koga's comments on the N.P.L. notation (2482 of 1938) *see* 2042 of 1939.

503. A Piezoelectric Calibrator [using a Single X-Cut Crystal of Dimensions giving 100 kc/s (Contour Mode) and also 1000 kc/s (Thickness Mode): Former constant within ±0.03%, Latter within ±0.1%, over Crystal Temperature Range 10° to 60° C.: Modulated Signals (Anode fed with Raw A.C.) at Intervals over R.F. Spectrum: Low-Impedance Output from Cathode Circuit (Performance independent of Loading)].—J. E. Benson. (*A.W.A. Tech. Review*, No. 2, Vol. 5, 1940, pp. 47–50.)

504. Papers on Rochelle Salt Crystals.—Takagi & Iso: Mason. (*See* 424/5.)

505. Notes on the Calibration of Oscillators [Carrier-Current, up to 100 kc/s] by means of a Cathode-Ray Oscillograph.—F. O. Roe. (*Electrotechnics*, Bangalore, Sept. 1940, No. 13, pp. 59–62.)

506. Effective Resistance to Alternating Currents of Multi-Layer Windings.—E. Bennett & S. C. Larson. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 414: summary only.)

507. Acceptance Tests of Broadcasting Transmitters.—P. J. Donnelly. (*Electrotechnics*, Bangalore, Sept. 1940, No. 13, pp. 44–52.)

508. The Electrical Testing of Radio Receiver Components.—Dobbie. (*See* 377.)

SUBSIDIARY APPARATUS AND MATERIALS

509. A High-Voltage Cathode-Ray Oscillograph [Sealed-Off Tube (R.C.A. Type 912) with Beam-Intensifying Circuit for External Photographic Recording of Non-Recurrent Transients at Speeds up to 20 Inches/Microsecond: Sweep-Calibrating Oscillator providing Time-Scales on Oscillograms (Necessary because Sweep is Not of Constant Velocity): etc.].—Hall & Coombs. (*Review Scient. Instr.*, Oct. 1940, Vol. 11, No. 10, pp. 314–320.)

The circuits are somewhat different from those used by Kuehni & Ramo (666 of 1938), who employed the same tube for speeds of 10 inches/microsec.

510. Investigation of Brush Discharges produced by High Surge Voltages [with a Special Cathode-Ray Oscillograph recording Non-Recurrent Uncontrolled Phenomena of Total Duration down to 1 Microsecond: Lag of Beam-Locking Circuit reduced to 0.06 Microsecond: etc.].—Schneider. (*Arch. f. Elektrot.*, No. 8, Vol. 34, 1940, pp. 457–472: *E.T.Z.*, 19th Sept. 1940, Vol. 61, No. 38, p. 878—summary only.)

511. A Complete Oscilloscope using the 902 [Two-Inch Low-Voltage Tube: All-Glass, permitting Magnetic Deflection].—Greek. (*QST*, Oct. 1940, Vol. 24, No. 10, pp. 33–37.)

512. The Obtainment of High Voltage from the Line-Sweep Unit [of Cathode-Ray Television Receivers].—Bähring. (*See* 446.)

513. Two Forms of Electronic Switch [for Dual Use of Cathode-Ray Oscillograph].—Strong. (*See* 319.)

514. Space-Potential Plotting in Thermionic Vacuum Tubes [Shadow thrown by Probe on Fluorescent Surface on Inside of Anode].—Kenyon. (*See* 404.)

515. Determination of the Axial Potential Distribution in Axially Symmetrical Electrostatic Fields.—Bertram. (*See* 451.)

516. On the Motion of Electrons with Equal Initial Velocities in Intersecting Electric and Magnetic Fields, taking into Account the Effect of Space Charge.—Bellustin. (*See* 402.)

517. A Mechanical Model for the Motion of Electrons in a Magnetic Field.—Rose. (*See* 401.)

518. The Effect of a Charge on an Electron Beam during Secondary Emission.—Gubanov. (*See* 406.)

519. A Magnet Lens for Beta Rays of High Energy [Design of Magnetic Lens of Greater Focusing Efficiency, capable of focusing 15 MeV Electrons at Focal Length of 37.5 cm].—Cosslett. (*Journ. of Scient. Instr.*, Nov. 1940, Vol. 17, No. 11, pp. 259–264.)

520. A New Short-Focus Magnetic Lens [primarily for Electron Microscope].—Kinder & Pendzich. (*Jahrbuch AEG-Forschung*, Vol. 7, 1940, pp. 23–26: *E.T.Z.*, 3rd Oct. 1940, Vol. 61, No. 40, p. 918—summary only.)

The usual procedure of enclosing the magnetising coils, so as to reduce leakage and obtain the strongest possible field between the coaxial pole-pieces, is here abandoned, and the magnetising coils are taken right away from the pole-pieces into a position where they can be made of any desired size and can be cooled and interchanged easily. Connection with the pole-pieces is made by iron yokes, so that in the single-yoke design (Fig. 2a) the arrangement reduces to a horse-shoe electro-magnet carrying a perforated pole-piece at each free end. The double-yoke design (Fig. 2b) naturally has much better symmetry, but there is a certain amount of cylinder-lens effect due to lack of rotational symmetry with respect to the pole-pieces: this lack is remedied by the provision of two soft-iron cylinders at the pole-pieces. The refracting power with this arrangement is as great as with enclosed coils: focal lengths down to 1 mm can be obtained for 15 kv electrons, with a 5 mm gap between the pole-pieces. Permanent magnets of modern material were also tried successfully. A two-stage microscope, using the double-yoke lenses, with 2000–5000 magnification gave images as free from distortion as those obtained with enclosed coils.

521. The Electron Microscope and Television.—Ploke. (*See* 456.)

522. Improved Pole-Piece Construction of the Objective Lens of a Magnetic Electron Microscope [giving Higher Precision in Symmetry].—Prebus. (*Canadian Journ. of Res.*, Nov. 1940, Vol. 18, No. 11, Sec. A, pp. 175–177.) For the instrument dealt with in 3718 of 1939.

523. Output and Constancy of the Supply Equipment for High-Resolution Electron Microscopes.—Ruska. (*E.T.Z.*, 26th Sept. 1940, Vol. 61, No. 39, pp. 889–891.)

Author's summary :—The supply power . . . amounts to about 1.4 to 2.2 kw and is little higher with apparatus using current-excited coils as lenses than with those using permanent-magnet or electrostatic lenses. The stabilisation of the ray voltage must be especially exact for microscopes with magnetic lenses, and is carried out by an auxiliary "magnetic" [saturated-choke] regulator interposed between mains and h.t. rectifier. The cost of such a regulator is small compared with that of the whole equipment, and enables full advantage to be taken of the magnetic lenses, which give a resolving power at present better than 4 mμ and which can be used with ray voltages above 100 kv.

524. "Elektronen-Übermikroskopie" [Book Review].—von Ardenne. (*Review Scient. Instr.*, Oct. 1940, Vol. 11, No. 10, pp. 322–323.) A Swiss review was referred to in 4402 of 1940 : the present reviewer is C. J. Davisson.

525. Luminescent Materials : Part II—On the Fluorescence Spectra of ZnS.Cu Crystal Phosphors at 185°, 20°, and 150°C [and the Effects of Amount of Activator, Temperature, & Flux].—Uehara. (*Sci. Abstracts*, Sec. A, 25th Oct. 1940, Vol. 43, No. 514, p. 702.) For Part I *see* 3156 of 1940.

526. The Theory of the Luminous Efficiency of Complementary Colours : the White Luminescence from Braun Tubes.—Azuma. (*See* 452.)

527. Cyclotron Radio-Frequency Power Unit.—Adams & Schultz. (*See* 351.)

528. "Geared" Magnets solve a Vacuum Problem.—Hewlett. (*See* 466.)

529. The Rotating Device of a Body *in Vacuo* [Direct Method : Electro-Magnetic Method : with Dimensioned Drawings].—Yamaguti. (*Electrotech. Journ.*, Tokyo, Aug. 1940, Vol. 4, No. 8, pp. 172–174.)

530. Simple Power-Limiting Device for Use when Heating by Electron Bombardment.—Winch & Farnsworth. (*See* 408.)

531. On Obtaining Large Ionic Currents.—Gott, Korsunski, & Lange. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 2, Vol. 10, 1940, pp. 155–160.)

A new method is proposed in which the ionising electrons are made to oscillate and therefore to travel over longer trajectories, by adding on the other side of the accelerating grid G_1 a second grid G_2 at a potential lower than that of the filament (Fig. 1). Only one vacuum chamber is required for this method, and large ionic currents can be produced with a small expenditure of energy ; thus 18 w only are required to produce a current of 65 mA.

532. Investigations on Mercury-Vapour Arcs at High [and Ultra-High] Frequencies.—Schäfer. (*See* 341.)

533. Oscillation Phenomena in Strongly Constricted Arc Columns and in Anomalous Anode Drop.—Kleinwächter. (*Arch. f. Elektrot.*, No. 9, Vol. 34, 1940, pp. 523–530 : *E.T.Z.*, 10th Oct. 1940, Vol. 61, No. 41, p. 942—short summary only.)

If the discharge path of a vacuum arc is greatly constricted, certain conditions will produce current-interruptions at higher frequencies. The same thing occurs with extremely small anode surfaces (anomalous anode drop). By using specially shaped anodes, efficiencies of 55% were obtained in the conversion of d.c. into a.c. energy.

534. "Excitron" Mercury-Arc Rectifiers [with 40% Smaller Arc-Drop].—Marti. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 416 : summary only.)

535. Ionisation Time of Thryatrons.—Harrison. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 416 : summary only.) *See* also 4025 of 1940.

536. The Rectifier Calculus [and Its Application to Calculation of Output of Unbalanced Rectifiers].—Goodhue. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 416 : summary only.)

537. Importance of Gas in Electrodes for the Glow-to-Arc Transition.—Maxfield & others. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 419 : summary only.)

538. Discharge Phenomena in an Inhomogeneous Field with D.C. Potential [New Result of Sudden Transition from Comparatively Large-Current Brush to Small-Current Glow Discharge on Rise of Potential or on Irradiation, when Positive Electrode has a Point Field-Concentration : also Converse Phenomenon : Explanation].—Schwaiger. (*E.T.Z.*, 26th Sept. 1940, Vol. 61, No. 39, p. 902 : summary of Munich Dissertation.)

539. Empirical Formulae for A.C. Corona Loss.—Satoh & Nakagawa. (*Jap. Journ. of Eng.*, *Abstracts*, Vol. 19, 1940, p. 93.)

540. The Design of Copper-Oxide and Selenium Rectifiers.—Vitenberg. (*Automatics & Telemechanics* [in Russian], No. 1, 1940, pp. 75–94.)

Experimental formulae are derived for calculating the forward and backward resistances of the rectifiers when operating with d.c. (commutation and spark-quenching circuits); also formulae showing the effect of temperature and rectifier dimensions on these resistances. The design of a rectifier operating on a.c. is then discussed and a numerical example given. For previous work *see* 3192, 3573, & 4433, all of 1940.

541. Some Methods of Linear Rectification [by Copper-Oxide Rectifiers].—Tomituka. (*See* 322.)

542. The Electrical Conductivity and Thermo-electric Properties of Cu_2O_3.—Zhuze & Starchenko. (*See* 467.)

543. The Influence of the Solvent on the Formation of Micelles in Colloidal Electrolytes: I.—Ward. (*Proc. Roy. Soc.*, Ser. A, 1st Nov. 1940, Vol. 176, No. 966, pp. 412–427.)

544. Metal-Ceramically Produced Contact Materials [Survey of Development in Metallic Carbon, Porous Bronze, Silver-Molybdenum, & Similar Composite Materials].—Kieffer. (*E.T.Z.*, 19th Sept. 1940, Vol. 61, No. 38, p. 878: summary only.)

545. A Condensation of the Theory of Relays.—Warrington. (*Gen. Elec. Review*, Sept. 1940, Vol. 43, No. 9, pp. 370–373.)

546. The Design Characteristics of Amplidyne Generators, and Other Papers on the Amplidyne.—Alexanderson & others. (*See* 645/6.)

547. The Electronic Synchronous Coupling [for Remote Control, etc.].—Goncharski. (*See* 644.)

548. Silicon-Carbide Varistors.—Grisdale. (*See* 320.)

549. Recent Developments in Speed Regulation [*e.g.* for A.C. Generators for Signalling Purposes, where Frequency Must be Very Constant: including a New Electrical Governor and an Analytical Study].—Hanna, Oplinger, & Mikina. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 416: summary only.)

550. Signal Bells made of Special Glass [to save Metal].—Jungnitz. (*E.T.Z.*, 12th Sept. 1940, Vol. 61, No. 37, p. 862: summary only.)

551. A New "Universal" Motor for working off Various Lighting Systems [110 V D.C., 220 A.C. & D.C. without Change of Performance: Types for 0.6 and 1.2 Kilowatts].—Tardel. (*E.T.Z.*, 29th Aug. & 5th Sept. 1940, Vol. 61, Nos. 35 & 36, pp. 795–797 & 827–831.)

552. Application of, and Operating Experience with, Hydrogen-Cooled Synchronous Condensers and Alternators.—Sporn & Porter. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 415: summary only.)

553. A New Electronic [Frequency-] Multiplier for Power Frequencies.—Overbeck. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 416: summary only.)

554. Storage-Type Battery for Flashlights [replacing Two 1½-Inch Size D Dry Cells: Upper Section of Lucite enables Need for Distilled Water (from Medicine Dropper) to be seen].—(*Scient. American*, Nov. 1940, Vol. 163, No. 5, p. 275.)

555. Modern Condensers for Communication Engineering and Their Development [Paper Condensers: Synthetic-Foil (Styroflex): Mica & Ceramic Types: Electrolytic Condensers: Survey, with Curves & Data].—Linder. (*E.T.Z.*, 17th & 24th Oct. 1940, Vol. 61, Nos. 42 & 43, pp. 945–948 & 969–973.)

556. Testing Electrolytics: Measurement of Condenser Leakage Current.—Boyer. (*See* 478.)

557. The Dielectric Behaviour of Anodic Al during Its Formation, *and* The Frequency Characteristics of Anodic Al during Formation.—Miyata. (*Sci. Abstracts*, Sec. A, 25th Sept. 1940, Vol. 43, No. 513, p. 679: p. 679.) For previous work on electrolytic condensers *see* 3578 of 1940.

558. Subsidiary Questions pertaining to the Utilisation of Previously Anodised Aluminium for Electrolytic Capacitors [especially the Elimination of Chemicals retained in the Film Structure].—Miyata. (*Sci. Abstracts*, Sec. B, 25th Oct. 1940, Vol. 43, No. 514, pp. 409–410.) *See* also 557, above.

559. Electrophotography of Condenser Paper [Effect of Applied D.C. Voltage on Blackness of Electrophotogram].—Akahira & Kamazawa. (*Jap. Journ. of Eng., Abstracts*, Vol. 19, 1940, p. 98.)

560. Insulating Paper in the Telephone Industry [and the Relation of Manufacturing Procedures to Initial Properties: Chemical Properties as Criteria of Permanence: Modified Forms of Cellulose with Superior Characteristics: etc.].—Finch. (*Sci. Abstracts*, Sec. B, 25th Oct. 1940, Vol. 43, No. 514, p. 409.)

561. Glass Wool [Fibre Glass] and Its Application [American & German Techniques].—(*Naturwiss.*, 18th Oct. 1940, Vol. 28, No. 42, pp. 671–672.)

562. Glass Wool [Fibre Glass] as Insulation [Methods of Production: Mechanical & Electrical Properties: Impregnation: etc.].—Särnö. (*Sci. Abstracts*, Sec. B, 25th Oct. 1940, Vol. 43, No. 514, p. 408.) Including a discussion of Atkinson's results (3761 of 1939) and those of Gemant & Glassow (4149 of 1939).

563. A New Process for the Production of a Glass which is Very Insensitive to Sudden Large Changes of Temperature [*i.e.* with Very Low Thermal Expansion Coefficient].—Corning Glass Works. (*Naturwiss.*, 18th Oct. 1940, Vol. 28, No. 42, pp. 670–671.) *See* also 3760 of 1939.

564. The Application of Beryllium in Ceramics [including Use of BeO at Temperatures above 2000°].—(*Naturwiss.*, 18th Oct. 1940, Vol. 28, No. 42, p. 671.)

565. Ceramic Composite Materials with High Dielectric Constants for the Raising of the Spark-Over Potential [in Air, Oil, etc: for Lead-In Insulators & Other Purposes].—Obenaus & Steyer. (*E.T.Z.*, 29th Aug. 1940, Vol. 61, No. 35, pp. 793–795.)

"It is known that the breakdown potentials between the electrodes of electrical insulators can be raised by 'capacitive control of the potential,' that is by displacing the main field into the solid insulator and thus relieving the strain on the surrounding medium, air or oil. An effective control, however, can only be obtained if the capacity of the various elements is so large that the influence of stray capacities is slight. With insulating materials having a dielectric constant of the ordinary order of magnitude, such as 4–6 for paper, porcelain, or Calit, the necessary values of capacity can only be obtained by the use of very thin layers or very large surfaces. For constructional and manufacturing reasons this has only been possible in special cases such as the lead-in bushes of paper condensers. Fresh possibilities, however, are offered by insulating materials with very high dielectric constant (of the order of 100) such as are now attainable in ceramic compositions [the actual tests were made with Condensa, $\epsilon = 75$]. In this way, on the one hand, large capacities can be obtained with small dimensions for the condenser elements, and on the other hand the breakdown potential can be raised by the introduction of such material in solid form, for example as 'props' between the electrodes."

The paper describes a preliminary investigation on the raising of the breakdown potential of a simple rod/earthed-plate electrode-combination in air and in oil, by this method of potential control, at a 50 c/s frequency. Comparative tests were made on the electrode-combination by itself, with a pillar of Calit ($\epsilon = 6.5$), a pillar of Condensa, and a pile of disc condensers with Condensa dielectric. The results are seen in Fig. 1, and are discussed in detail on p. 794, where Fig. 2 shows the small change in the field produced by the introduction of the Calit "prop" between the two electrodes (in oil) and the marked changes on introducing the Condensa "prop" and the pile of condensers. A correspondingly large increase in the breakdown potential was obtained in each of the two latter cases, though the pile of condensers (whose disc-edges may have given rise to small discharges) produced little better result than the solid Condensa pillar. The results with air as the surrounding medium were quite different: apparently the advantages of "potential control" were largely neutralised by the adverse effect of the surface of the solid material. It is concluded that with strongly inhomogeneous fields such as those experimented with (and most electrodes used in high-voltage technique produce these fields) a raising of the breakdown potential by an amount up to 50%, for oil insulation, and up to 20% for air, is obtainable by using the new materials.

566. Provisional Rules for the Testing of Ceramic Insulating Materials.—V.D.E. Committee. (*E.T.Z.*, 29th Aug. 1940, Vol. 61, No. 35, pp. 803–808.) *See* also p. 815.

567. Rules for the Testing of Insulating Varnishes.—V.D.E. Committee. (*E.T.Z.*, 5th Sept. 1940, Vol. 61, No. 36, pp. 832–834.) *See* also p. 840.

568. Research on Insulating Varnish made from Sardine Oil with Phenolic and Coumarone or Alkyd Resins, etc.—Inai. (*Jap. Journ. of Eng., Abstracts*, Vol. 19, 1940, p. 89.) References only to a series of papers in Japanese.

569. The Synthetic Resins as Dielectrics [Survey, with Curves & Table: Perfections (and One Defect) of Polystyrol: Importance of Polyvinyl Chloride: etc.].—Gotusso. (*L'Elettrotecnica*, No. 13, Vol. 27, 1940, pp. 310–313.)

570. The Manufacture and Use of the Electrical Insulating Material "Styroflex."—Horn. (*E.T.Z.*, 26th Sept. 1940, Vol. 61, No. 39, p. 902: summary only.) Particularly for wide-band cables, and (in the form of foil) for rotating and roll-type condensers. *See* also 391, above.

571. Temperature Characteristics of Dielectric Losses at High Frequencies [from 100 kc/s to 10 Mc/s: Measurements over Range from 20° to 300° C].—Akahira & Kamazawa. (*Jap. Journ. of Eng., Abstracts*, Vol. 19, 1940, p. 98.)

Generally, the dielectric loss angle increases with increasing temperature, and the variation of $\tan\delta$ is much more rapid at low than at high frequencies. In some materials, such as porcelain and bakelite, the effect of moisture is very marked: it varies with change of temperature, and the variation of $\tan\delta$ is very complicated. Quartz, mica, and ambroid show little or no change in $\tan\delta$.

572. Effect of Small Projections [Metallic and Dielectric] on Breakdown in Air.—Race. (*Gen. Elec. Review*, Sept. 1940, Vol. 43, No. 9, pp. 365–369.)

573. Measurement of the Potential Distribution on Insulators [Survey of 12 Methods useful in the Design of Insulators].—Prinz. (*E.T.Z.*, 29th Aug. 1940, Vol. 61, No. 35, p. 810: summary only.)

574. Conductivity in Insulators, and Its Interpretation [Migration of Charge Carriers, Formation of "*F*" Band in Alkali-Halide Crystals, etc.].—von Hippel. (*Sci. Abstracts*, Sec. B, 25th Oct. 1940, Vol. 43, No. 514, pp. 406–407.) *See* also 829 of 1940: *also* 1067 of 1939 and 2426 & 3583 of 1940.

575. Characteristics of Restricted Ionisation and Its Relation to Voids in Insulating Materials.—Dawes & Humphries. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 419: summary only.)

576. Dielectric Strength of Insulating Liquids in a Continuously Circulating System.—Race. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 419: summary only.)

577. The Electric Strength of Gases.—Bonch-Bruevich & others. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 2, Vol. 10, 1940, pp. 171–175.)

Experiments were carried out with gaseous fluorides and for a number of these the ionisation and excitation potentials were determined. A detailed description of these experiments is given and a number of experimental tables and curves are shown. A study of the experimental results was made to correlate the breakdown strength, ionisation potentials, and molecular weights of these gases. The conclusion reached is that the breakdown strength increases with the molecular weight but is not related directly either to the ionisation potential or to the number of atoms per molecule.

578. Measurement of Very Short Time Intervals [*e.g.* Time Lags of Electrical Breakdown].—Bryant & Newman. (*See* 481.)

579. Fabric Abrasion Testing: Its Use in the Evaluation of Electric Insulation.—Mathes. (*Gen. Elec. Review*, Nov. 1940, Vol. 43, No. 11, pp. 467–470.)

580. "Prüfung und Bewertung elektrotechnischer Isolierstoffe" [Testing & Judging of Electrotechnical Insulating Materials: Book Review].—Nitsche & Pfestorf. (*E.T.Z.*, 26th Sept. 1940, Vol. 61, No. 39, p. 904.)

581. Natural Oscillations in Circuits with A.C.-Fed Saturated Iron-Cored Chokes.—Hähnle. (*See* 316.)

582. The Output and Optimum Design of Permanent Magnets subjected to Demagnetising Forces.—Hornfeck & Edgar. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, pp. 416–417: summary only.)

583. On the Study of Materials for Permanent Magnets.—Biffi & Cavallucci. (*L'Elettrotecnica*, No. 14, Vol. 27, 1940, p. 349.) Supplement to Biffi's article, 2447 of 1940.

584. Torque of Cubic Recrystallisation Textures in the Magnetic Field.—Mussmann & Schlechtweg. (*Ann. der Physik*, Ser. 5, No. 3, Vol. 38, 1940, pp. 215–231.)

585. On the Ferromagnetic Properties of Alloys.—Rudnitski. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 1, Vol. 10, 1940, pp. 63–66.)

A theoretical discussion of the relationship between the value of magnetic saturation and the degree of uniformity (homogeneity) of the alloy. The conclusions reached differ from those arrived at by Bitter (1254 of 1939).

586. Theory of the Approach to Magnetic Saturation.—Fuller. (*Phys. Review*, Ser. 2, 15th Oct. 1940, Vol. 58, No. 8, pp. 736–743.)

587. A Statistical Method for Computing Magnetic Susceptibility.—Kaner. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 1, Vol. 10, 1940, pp. 67–82.)

A statistical method is proposed for solving certain problems of quantum mechanics. The method is a development of that first used by Kirkwood for calculating the statistical sum of a binary alloy. When applied to the study of the magnetic properties of ferromagnetic bodies and of paramagnetic non-conducting salts, the new method leads to more accurate results than those obtained by Heisenberg (1928 Abstracts, p. 647).

588. The Effect of Elastic Stresses on Hysteresis Loops.—Genkin. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 2, Vol. 10, 1940, pp. 202–210.)

Experiments to determine the effect of elastic deformations (tension and torsion) of a hollow nickel cylinder on the parallel and perpendicular components of magnetisation and on the residual magnetism: the irreversible phenomena due to plastic deformation of the metal were also investigated.

589. On the Hysteresis of Ferromagnetic Bodies: *also* Hysteresis Anisotropy in Ferromagnetic Single Crystals: III: *and* The Anisotropy of the Coercive Force of Ferromagnetic Single Crystals Cooled in a Magnetic Field.—Kondorsky: Shur: Vonsovsky. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 4, Vol. 10, 1940, pp. 420–440: pp. 441–450: pp. 451–454.) For II of Shur's paper *see* 3195 of 1940: for previous work by the other two writers *see* 3196/7 & 3607 of 1940.

590. A Theory of Metamagnetic Bodies.—Kaner. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 4, Vol. 10, 1940, pp. 407–413.) For metamagnetism *see* 1739 of 1939.

STATIONS, DESIGN AND OPERATION

591. Field Comparison Tests of Wide-Band Frequency *versus* Amplitude Modulation [60% Greater Service Range for Former (Receiver in Car or Aeroplane): 25 db Improvement in Signal/Noise Ratio: etc.].—Weir. (*Proc. I.R.E.*, Sept. 1940, Vol. 28, No. 9, pp. 423–424: summary only.) *See* also 3528 of 1939 and 2067 of 1940, and 219 of January.

592. Police Radio Equipments [Survey of Recent Designs, for Frequency- and Amplitude-Modulation].—(*Communications*, Sept. 1940, Vol. 20, No. 9, pp. 20–24.)

593. TD-HF: Wired Wireless in Switzerland [4-Programme "Tele-Diffusion High-Frequency" Service giving 15 mV Input].—(*Wireless World*, Dec. 1940, Vol. 46, No. 14, p. 498: paragraph only.)

594. Wireless Equipment of the *Luftwaffe*: Technical Details of Apparatus recently Acquired—by Courtesy of the R.A.F. (*See* 416.)

595. A Sailor's Five-Tube Station [3.5 Mc/s Transceiver weighing less than 7 lb., measuring $6\frac{3}{4} \times 7\frac{3}{4} \times 4\frac{3}{4}$ Inches (without Power Supply)].—Jennings. (*QST*, Oct. 1940, Vol. 24, No. 10, pp. 69–72.)

596. Single Sideband Transmission [Short Theoretical Examination of Properties: Scope in Practice].—Rao. (*Electrotechnics*, Bangalore, Sept. 1940, No. 13, pp. 63–68.)

597. "Broadcasting in India up to 31st March 1939" [Book Reviews].—(*Electrotechnics*, Bangalore, Sept. 1940, No. 13, pp. 90–92: *Nature*, 30th Nov. 1940, Vol. 146, pp. 709–711.)

598. A Console for the Small-Station Transmitter House [for Emergency Use].—Travis. (*Electronics*, July 1940, Vol. 13, No. 7, p. 36.)

GENERAL PHYSICAL ARTICLES

599. Inner Excited States of the Proton and Neutron [Difficulties in applying Present Meson Theory to Interaction of Fast Mesons with Nuclear Particles: New Hypothesis that Charge & Spin of Electron can assume Higher Quantum States: Deductions].—Heitler & Ma. (*Proc. Roy. Soc.*, Ser. A, 1st Nov. 1940, Vol. 176, No. 966, pp. 368–397.)

600. Collision of Mesotrons with Electrons [Method of Collision Parameters applied to Problem of Ionisation and the Production of Electron Pairs by a Mesotron].—Tomonaga. (*Sci. Abstracts*, Sec. A, 25th Oct. 1940, Vol. 43, No. 514, p. 720.)

601. A Quantum Theory of Light Radiation of an Electron uniformly moving in a Medium: *also* On the Electrodynamics of Anisotropic Media: *and* The Radiation of an Electron moving with Constant Velocity in a Crystal.—Ginsburg. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 6, Vol. 10, 1940, pp. 589–600: pp. 601–607: pp. 608–613.)

602. On the Inelastic Scattering of a Beam of Particles by Hydrogen and Helium.—Kar. (*Phil. Mag.*, Dec. 1940, Vol. 30, No. 203, pp. 487–504.)

603. "Scattering of Light and the Raman Effect" [Book Review].—Bhagavantam. (*Sci. & Culture*, Calcutta, Oct. 1940, Vol. 6, No. 4, pp. 240–241.)

604. On the Quantity "Exchange Energy" [$A_{kl} = \frac{1}{2}(E_{kl} - E_{lk})$, where k & l are the Quantum Numbers of the Two Oscillators] in Quantum Mechanics.—Flügge. (*Naturwiss.*, 25th Oct. 1940, Vol. 28, No. 43, pp. 673–677.)

605. The Idea of Minimum Proper Time, and Some Consequences of It.—Fahmy. (*Phil. Mag.*, Oct. 1940, Vol. 30, No. 201, pp. 331–339.)

606. Reflection of X-Rays with Change of Frequency: Parts I, II, and III.—Raman & Nilakantan. (*Sci. Abstracts*, Sec. A, 25th Sept. 1940, Vol. 43, No. 513, p. 673.) *See* also 3226 & 3227 of 1940.

607. On the Synthesis of Wave Mechanics and Corpuscular Mechanics: Remarks on Planck's Paper: Reply by Planck.—Wessel: Planck. (*Ann. der Physik*, Ser. 5, No. 4, Vol. 38, 1940, pp. 261–273.) *See* 3231 of 1940.

608. A Thermodynamic Analogy to the Indeterminancy Principle.—Frank-Kamenetski. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 6, Vol. 10, 1940, pp. 700–702.)

It is argued that the indeterminancy principle on which quantum mechanics is based has the following analogy in classical physics: a system can be described from the standpoint of either mechanics (energy, number of particles) or thermodynamics (temperature, chemical potential) but the two sets of data can not be determined simultaneously; *i.e.* if the system is isolated, temperature and chemical potential cannot be measured, and if it is in contact with the surrounding medium, energy and the number of particles are in a state of continuous fluctuation.

609. On Anomalous Diamagnetism [of Electron Gas].—Geilikhman. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 5, Vol. 10, 1940, pp. 497–498.)

In a number of investigations on the anomalous diamagnetism of electrons, very high figures of magnetic susceptibility have been quoted. In this paper it is shown from theoretical considerations that this figure cannot exceed $\frac{1}{4}\pi$. The value of the critical field is found to be of the order 10^3 oersteds and not 10^{-7} oersted as obtained in previous investigations. *See*, for example, Papapetrou, 4243 of 1939 and back reference.

610. Investigations on the Temperature-Dependence of the Electrical Resistance, and on the Question of the Validity of the Mathiessen Rule: A New Type of Change of Electrical Resistance of an Isotropic Electron Gas in a Transverse Magnetic Field.—Kohler. (*Ann. der Physik*, Ser. 5, No. 4, Vol. 38, 1940, pp. 283–292.)

611. The Image and van der Waals Forces at a Metallic Surface.—Bardeen. (*Phys. Review*, Ser. 2, 15th Oct. 1940, Vol. 58, No. 8, pp. 727–736.)

612. The Effect of Magnetic Fields on the Thermal Conductivity of Alkali Vapours [No Senftleben Effect in These Symmetrical-Atom Gases].—Sichtig. (*Ann. der Physik*, Ser. 5, No. 4, Vol. 38, 1940, pp. 274–282.) *See* 389 of 1940: the result supports Gorter's theory of the effect.

613. On the Dissipation of Electricity in an Enclosed Air Mass, & on the Electrical Insulating Powers of Amber.—Walter. (*Ann. der Physik*, Ser. 5, No. 3, Vol. 38, 1940, pp. 232–244.) For previous work *see* 3223 of 1940 : the " Geitel " effect is now attributed to the moisture from the glass surfaces being transferred to the amber insulation.

614. The Kinetics of Chain Disintegration of Uranium.—Zeldovich & Chariton. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 5, Vol. 10, pp. 477–482.)

615. " Physics and Reality " [Book Review].—Riezler. (*Review Scient. Instr.*, Oct. 1940, Vol. 11, No. 10, p. 331.)

MISCELLANEOUS

616. " University Mathematical Texts " [Series: Book Reviews].—Aitken & others. (*Nature*, 23rd Nov. 1940, Vol. 146, pp. 665–666.)

617. Solutions of Mathieu's Equation [used in Study of Modulation, Super-Regeneration, etc.] : I.—Brainerd & Weygandt. (*Phil. Mag.*, Dec. 1940, pp. 458–477.)

" Unfortunately, in many if not most applications the periodic solutions [to which the large amount of previous work has been limited] are special cases of the more general solution of the technical problem. It is proposed in this paper to add to the groundwork necessary or desirable for the tabulation of non-periodic solutions. . . ."

618. On a Criterion for Oscillatory Solutions [Infinite Number of Zeros] of a Linear Differential Equation of the Second Order.—Miller. (*Proc. Cambridge Phil. Soc.*, Part 3, Vol. 36, 1940, pp. 283–287.)

619. Analysis of Electrostatic and Magnetic Fields by the Schwarz-Christoffel Transformation.—Yoh. (*Nippon Elec. Comm. Eng.*, July 1940, No. 21, pp. 39–41.)

620. A Transformation extending the Use of Heaviside's Operational Calculus.—Meyerhoff & Reed. (*See* 339.)

621. On the Heaviside Operational Calculus [Some Theorems, taking Definite Integration as Fundamental Operator, proved for Discrete Systems].—Jeffreys & Dalzell. (*Proc. Cambridge Phil. Soc.*, Part 3, Vol. 36, 1940, pp. 267–282.)

622. A Method of calculating Probability by means of Differential Operator [Inversion of Bromwich-Wagner Type of Integral].—Nakagami. (*Nippon Elec. Comm. Eng.*, July 1940, No. 21, pp. 28–34.)

623. " Theory of Probability " [Book Review].—Jeffreys. (*Review Scient. Instr.*, Oct. 1940, Vol. 11, No. 10, pp. 331–332.)

624. " Graphische Tafeln zur Beurteilung statistischer Zahlen " [Graphical Tables for the Estimation of Statistical Figures : Book Review].—Koller. (*E.T.Z.*, 3rd Oct. 1940, Vol. 61, No. 40, p. 924.)

Although the examples given are mostly taken from the fields of medicine and biology, the book is of interest to engineers concerned in the testing of materials, mass production, etc : for the valuable application of statistical methods is often hindered by the rather laborious calculations involved.

625. Statistical Methods in Engineering Practice : No. III—Quality Control in Production Engineering.—Rissik. (*Engineer*, 13th Dec. 1940, Vol. 170, pp. 372–373.)

626. " The Theory of Group Characters and Matric Representations of Groups " [Book Review].—Littlewood. (*Nature*, 30th Nov. 1940, Vol. 146, p. 699.)

627. Technical Programme of the I.R.E.-R.M.A. Rochester Fall Meeting, Nov. 1940.—(*Communications*, Oct. 1940, Vol. 20, No. 10, p. 14.)

628. Fundamental Aspects of Radio Communication [Joint Meeting of I.R.E. and American Section of U.R.S.I., April 1940].—(*Nature*, 5th Oct. 1940, Vol. 146, pp. 450–451.)

629. Recent Developments in Electrical Engineering [including Insulation, Facsimile Telegraphy, Television, Broadcasting, etc : with German Literature References].—Verband Deutscher Elektrotechniker. (*E.T.Z.*, 4th July 1940, Vol. 61, No. 27, pp. 615–642.)

630. Report on the Work of the V.D.E. in 1939/40 [giving References to Standard Specifications].—Verband Deutscher Elektrotechniker. (*E.T.Z.*, 4th July 1940, Vol. 61, No. 27, pp. 604–611.)

631. " Jahrbuch des elektrischen Fernmeldewesens 1939 " [Year-Book of Electrical Communications : Book Review].—Gladenbeck (Edited by). (*E.T.Z.*, 4th July 1940, Vol. 61, No. 27, p. 643.)

632. Report on the Work of the Bartol Research Foundation, 1939/40 [chiefly Cosmic Rays (G-M Counters, Nature of Field in Magnetised Iron, etc.) : List of Publications, etc.].—Swann. (*Journ. Franklin Inst.*, Sept. 1940, Vol. 230, No. 3, pp. 281–354.)

633. Science and National Welfare.—Bragg. (*Nature*, 7th Dec. 1940, Vol. 146, pp. 731–732.) From the presidential address to the Royal Society.

634. Salvage : the Wireless Contribution [Editorial].—(*Wireless World*, Nov. 1940, Vol. 46, No. 13, p. 449.) *See* also pp. 466, 467.

635. The Purchase Tax : Applications to the Wireless Industry.—(*Wireless World*, Nov. 1940, Vol. 46, No. 13, p. 466.)

636. Decontamination of Electrical Equipment [Effects of Liquid Persistent Gases on Various Materials, etc.].—Electricity Commission. (*Sci. Abstracts*, Sec. B, 25th Oct. 1940, Vol. 43, No. 514, p. 418.)

637. Corrosion and Communications.—Richards. (*Inst. P.O. Elec. Eng., Printed Paper* No. 172, 12 pp.)

638. A Telephone Set for Explosive Atmospheres.—Beardsley. (*Bell Lab. Record*, Oct. 1940, Vol. 19, No. 2, pp. 42–45.)

639. Network Coupling by Means of Static Electronic Frequency Changers [Rectifier-Inverters].—Marti. (*Elec. Engineering*, Sept. 1940, Vol. 59, No. 9, Transactions pp. 495–503.)

640. Variable Speed through Electronic Control [Grid-Controlled Rectifier System controlling Engine Lathe].—(*Electronics*, July 1940, Vol. 13, No. 7, p. 65.) In operation since 1933 without the replacement of any parts.

641. An Electrical Engine Indicator for measuring Static and Dynamic Pressures.—Martin & others. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 429: summary only.)

642. "Elektrische Messung mechanischer Grössen" [Electrical Measurement of Mechanical Quantities: Book Review].—Pflier. (*Bull. Assoc. suisse des Élec.*, No. 21, Vol. 31, 1940, p. 501.) Based largely on Siemens & Halske activities.

643. Vibrometers having Metal Diaphragms.—Matudaira & others. (*Nippon Elec. Comm. Eng.*, July 1940, No. 21, pp. 35–38.) For the ordinary form *see* Kobayasi, 1931 Abstracts, p. 329.

644. The Electron Synchronous Coupling.—Goncharski. (*Automatics & Telemechanics* [in Russian], No. 1, 1940, pp. 117–121.)

For previous work *see* 3441 of 1940. A description is given of various circuits developed by the author for use with remote-control systems in which the rotation of a spindle is determined by the phase of an impulse with regard to a sinusoidal voltage. In the simplest case (Fig. 1) the impulses are produced by a disc (4) fitted on the rotor axis of the voltage generator and making one contact per revolution with a brush (5). At the receiving end the sinusoidal voltage is applied to the deflecting plates of a cathode-ray oscillograph while the impulses are used for modulating the electron beam. The phase angle is then observed by noting the position of a spot on the screen of the oscillograph. This observation can be utilised for manual control of a spindle by providing a pointer rotating about the centre of the screen and mechanically coupled to the spindle. By bringing the pointer (by hand) to the same position as the spot on the screen the spindle will be turned through the required angle.

In a modified circuit (Fig. 2) the cathode-ray oscillograph is replaced by a two-lamella electron commutator. The latter is mounted in a frame carrying three delta-connected coils fed from the a.c. generator at the sending end. The frame can be rotated in one or the other direction by means of two relays each connected through an amplifier valve to one of the lamellae. The electron beam is normally suppressed by a negative bias applied to the controlling electrode of the commutator, but is triggered by the impulses. If the beam passes through the slot between the lamellae the frame remains stationary; when however the beam falls on one of the lamellae, the frame (and the spindle which is mechanically coupled to it) is rotated automatically through an angle necessary to bring the beam to the original position (this angle is equal to the angular displacement of the brush on the disc.).

Two further circuits are described modified for operation from a.c. mains, without the a.c. generator. In one circuit (Fig. 3) an electron commutator is used with a single narrow, radially positioned, lamella. The commutator is mounted in a frame with coils similar to that fitted on the receiving commutator. These coils produce a rotating field, and in order to obtain the necessary phase angle of the impulses generated by the electron beam striking the lamella, the frame is rotated (by hand) through this angle about the commutator. In the other circuit (Fig. 4) a three-phase transformer is used with a rotating secondary coil. The voltage induced in this coil is employed for producing impulses and the phase angle of these is equal to that through which the coil has been rotated. The accuracy of the transmitted angle is discussed and it is pointed out that the only delay occurring in the systems described is that due to the inertia of the rotating mechanisms.

645. The Design Characteristics of Amplidyne Generators, and Other Papers on the Amplidyne.—Fisher, Alexanderson, & others. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 416: summaries only.) For previous work *see* 3700 of 1940 and back reference.

646. Amplidyne Generator System of Power Control [including for Boring Mills, Paper Machines, Constant-Load Control, Exciter for Synchronous Motor].—Butler. (*Sci. Abstracts*, Sec. B, 25th Sept. 1940, Vol. 43, No. 513, p. 386.) *See* also 3700 of 1940.

647. Vacuum-Tube Voltmeter: Application to Potentiometric Precipitation Titrations.—West, Robinson. (*Sci. Abstracts*, Sec. B, 25th Oct. 1940, Vol. 43, No. 514, p. 411.)

648. Characterisation of Mixtures of Isomers by the Measurement of Loss Angles.—Schupp. (Siemens paper referred to in Linder's article, 555, above.)

649. Car Radio Traffic Control: New Application in U.S.A. [George Washington Bridge, New York: Best Routes given by Induction Field from Cable].—(*Electronics*, Sept. 1940, Vol. 13, No. 9, p. 32: *Wireless World*, Nov. 1940, Vol. 46, No. 13, p. 466.)

650. Utilisation of Sun Power.—Abbot. (*Nature*, 7th Dec. 1940, Vol. 146, p. 744: summary only.)

"Even if we apply the corrective factor which is usually necessary in estimates by enthusiasts, and raise the farthing [per h.p.] to ½d. or ¾d., sun-power is obviously becoming a business for hot climates, and developments are worth watching." *See* also 291 of January.

651. Fundamental Problems of, and Some New Methods in, Geophysical Prospecting using Direct Current [including Study of Polarisation Phenomena : Suggested Methods applicable to Depths exceeding 300 m].—Horioka & Iwasa. (*Jap. Journ. of Eng., Abstracts*, Vol. 19, 1940, p. 110.)

652. " Klimaänderungen und Klimaschwankungen " [Climate Changes & Fluctuations : Book Review].—Wagner. (*Naturwiss.*, 4th Oct. 1940, Vol. 28, No. 40/41, pp. 646–648.)

The much-cited Brückner 35-year period is rejected. There is an 11-year temperature period (corresponding with the sunspot cycle) but all others, such as the 3-year and 16-year periods, are only found over certain stretches of time : they disappear suddenly.

653. Measurements of the Conductivity and Dielectric Constant of Water and of an Aqueous Solution of KCl at Ultra-High Frequencies.—Divilkovski & Mash. (*Journ. of Exp. & Theoret. Phys.* [in Russian], No. 5, Vol. 10, 1940, pp. 520–541.)

For Malov's work *see* 2682 of 1940. For a French version of the present paper see *Journ. of Physics* [of USSR], No. 5, Vol 2, 1940, pp. 385–407. In Part I, methods are described for measuring h.f. magnetic fields by a mercury thermometer placed between the two wires of a Lecher system : *cf.* 264 of 1936 and 1960 of 1940. The calibration of the thermometer is discussed and it is shown that on a wavelength of 450 cm this can be done within 1%. The effect of the thermal conductivity of the Lecher wires is considered and the distribution of the magnetic field in the system on a wavelength of 23.6 cm is investigated.

In Part II a detailed description is given of absolute measurements, based on these methods, of σ and ϵ' of liquids in h.f. magnetic and electric fields. The effects of various factors and corresponding corrections are discussed and the necessary formulae are derived. Results are given of measurements of σ and ϵ' of water and KCl solution (0.035 N). In Part III the results obtained are examined. It appears that in the case of water these are the same as obtained by other authors. ϵ' of KCl solution is the same as for water. The value of σ of KCl solution, excluding the " polar " conductivity of water, coincides with the static value of the ionic conductivity.

654. Uses of Electricity in Medicine [Historical Development : Survey of Recent Progress : Importance in Diagnosis rather than in Treatment].—Langworthy. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, pp. 389–394.)

655. Electricity in Medicine [especially the Need for Greater Cooperation between Electrical Engineers & Medical Men].—Woolf. (*Sci. Abstracts*, Sec. B, 25th Oct. 1940, Vol. 43, No. 514, p. 418.)

656. Short-Wave Diathermy Apparatus and Frequency-Control Possibilities [to avoid Frequency Departures due to Patient-Loading].—Gieringer. (*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, p. 429 : summary only.)

657. Total Energy Absorption in Biological Objects.—Mayneord. (*Sci. Abstracts*, Sec. A, 25th Sept. 1940, Vol. 43, No. 513, p. 674.) For a communication to *Nature* see 4131 of 1940.

658. H.F. Currents in Human Tissues [and the Dipole Theory of the Action].—Lay : Dalton. (*Wireless World*, Nov. 1940, Vol. 46, No. 13, p. 474.) Prompted by Dalton's article (277 of January), Lay refers to his own publications (1722 of 1935).

659. Bacteriophage, Its Nature and Behaviour as studied by the Electron Microscope [Short Note].—(*Sci. & Culture*, Calcutta, Oct. 1940, Vol. 6, No. 4, p. 239.) With particular reference to the work of Ruska and of Pfankuch & Kansche, *Naturwissenschaften*, No. 3, 1940, pp. 45 and 46.

660. " Elektronen-Übermikroskopie " [Book Review].—von Ardenne. (*See* 524.)

661. Integrating Circuit for Vapour-Type [Self-Quenching] Geiger-Müller Counters [suitable for Use as Radium or Gamma-Ray Exposure Meter or Warning Device].—Curtiss. (*Journ. of Res. of Nat. Bur. of Stds.*, Sept. 1940, Vol. 25, No. 3, pp. 369–377.)

662. Contents of 1940 Transactions Supplement of *Electrical Engineering*.—(*Elec. Engineering*, Oct. 1940, Vol. 59, No. 10, pp. 413–420.)

663. " The Subject Index to Periodicals, 1939 " [Book Review].—Library Association. (*Nature*, 16th Nov. 1940, Vol. 146, pp. 630–631.)

664. The Publication of Scientific Research [including the Functions of Microfilms, Desirability of Greater Degree of Specialisation in Periodicals and Abstract Journals, etc.].—Seidell. (*Science*, 18th Oct. 1940, Vol. 92, pp. 345–347.)

665. A New Photographic Film [wears Longer & stores Better : Linear Superpolymers or Polyamides].—Carothers. (*Science*, 18th Oct. 1940, Vol. 92, Supp. p. 11.) From the du Pont de Nemours laboratories.

666. Searching the Literature of Science.—Lancaster Jones. (*Journ. of Scient. Instr.*, Nov. 1940, Vol. 17, No. 11, pp. 253–257.)

667. " Notes on the Preparation of Papers for Publication in the *Journal of Hygiene* and *Parasitology* " [Book Review].—Nuttall. (*Proc. Phys. Soc.*, 1st Nov. 1940, Vol. 52, Part 6, p. 831.)

" Much good advice." The reviewer remarks that physicists and biologists apparently differ in their faults, since two of the commonest in MSS for the *Proceedings* are not mentioned : they are the incorrect use of hyphens and the misuse of " due to."

668. " The Irresponsibles " [Editorial Book Review].—MacLeish. (*Journ. Applied Phys.*, Oct. 1940, Vol. 11, No. 10, p. 625.)

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

526 503.—Aerial coupling circuit designed to prevent second-channel interference in a superhet receiver.

Ferranti and G. I. Thomas. Application date 18th March, 1939.

526 587.—Supporting means for the dipole and reflector of a television or other short-wave aerial.

Belling and Lee and F. R. W. Stafford. Application date 21st March, 1939.

526 621.—Construction of a suction-cup holder for attaching a wireless aerial to the roof of a motor car.

Ferranti and G. A. Hall. Application date 23rd March, 1939.

527 168.—Aerial coupling arrangement for a two-way relay station for short-wave working.

Marconi's W.T. Co. (assignees of C. W. Hansell). Convention date (U.S.A.) 1st April, 1938.

527 926.—V-shaped dipole arrangement for radiating or receiving, non-directionally, a wide band of signals, such as are used in television.

Marconi's W.T. Co. (assignees of P. S. Carter). Convention date (U.S.A.) 16th April, 1938.

DIRECTIONAL WIRELESS

526 412.—Direction finder with means for indicating, with equal sensitivity, equal deviation both on the " dot " or " dash " side of the middle-line of an overlapping-beam navigational course.

Marconi's W.T. Co. and C. S. Cockerell. Application date 8th February, 1939.

526 417.—Directive aerial system free from " night error " and comprising a pair of spaced frame aerials arranged to rotate about a common centre.

Marconi's W.T. Co. and S. W. H. W. Falloon. Application date 16th February, 1939.

526 481.—Automatic gyroscope or course-repeater for maintaining an aeroplane on the route marked out by a radio transmitter.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 6th April, 1938.

526 537.—Self-orientating radio compass which drives a control motor in one direction or the other according as the vessel to be steered yaws to port or starboard.

Marconi's W.T. Co. (assignees of D. S. Bond and W. L. Carlson). Convention date (U.S.A.) 19th March, 1938.

526 722.—Automatic " pilot " equipment for a direction-finding installation of the so-called " homing " type.

Marconi's W.T. Co. and J. Stewart. Application date 25th March, 1939.

526 859.—Means for more clearly defining the median line or true course to be followed in a direction finder of the equi-signal type.

Marconi's W.T. Co. (assignees of L. T. Wen). Convention date (U.S.A.) 14th September, 1938.

526 860.—Direction finder in which the bearing of a distant transmitter is indicated by the intersection of two luminous traces formed simultaneously on the fluorescent screen of a cathode-ray tube.

Soc. Francaise Radioelectrique. Convention date (France) 8th April, 1938.

527 380.—Stabilising device for the modulating circuits of a navigational or directional transmitter of the overlapping-beam type.

International Service Corporation. Convention date (U.S.A.) 14th April, 1938.

527 495.—Radio compass in which the signals from a directional and non-directional aerial are combined to give an alternating potential having a phase indicative of the bearing of the distant transmitter.

Marconi's W.T. Co.; C. S. Cockerell; and G. P. Parker. Application date 14th March, 1939.

527 841.—Radio-navigational system in which television signals are used to inform the pilot when his craft is on or off the correct course.

Marconi's W.T. Co. and R. J. Kemp. Application date 19th April, 1939.

527 937.—Radio-navigational system in which the positions of several frequency-modulated transmitters are shown continuously and simultaneously on the fluorescent screen of a cathode-ray receiver. (Addition to 525 393.)

M. Wallace. Convention date (U.S.A.) 26th April, 1938.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

526 239.—Wireless receiver adapted, on receipt of a predetermined signal, to operate an air-raid warning or other alarm.

H. L. Fletcher. Application date 8th February, 1939.

526 259.—Wireless receiver in which a multi-electrode piezo-electric crystal is used to convert a phase-modulated carrier-wave into an amplitude-modulated signal.

Marconi's W.T. Co. (assignees of M. G. Crosby). Convention date (U.S.A.) 10th March, 1938.

526 372.—Intermediate frequency coupling device

in which two coils wound on a common tube are tuned by two iron cores each capable of independent adjustment.

Johnson Laboratories Inc. (assignees of M. J. Kirk; W. H. James; and W. A. Schaper). Convention date (U.S.A.) 14th March, 1938.

526 424.—Stabilising circuits for amplifiers using negative feed-back.

C. G. Mayo and H. D. McD. Ellis. Application date 4th March, 1939.

526 464.—Means for ensuring correct "tracking" in a tuning device comprising movable powdered-iron cores, particularly for a superhet set.

Ferranti; N. H. Searby; and V. A. Neill. Application date 17th March, 1939.

526 472.—Automatic fine-tuning circuit in which the control valve is degeneratively coupled so as to develop a wide impedance variation.

Aga-Baltic Radio A-B. Convention date (Sweden) 4th May, 1938.

526 724.—Receiving circuit, or signal transmission system, with a so-called "regressive control" for suppressing signals below a given amplitude.

Hazeltine Corporation (assignees of L. M. Hershey). Convention date (U.S.A.) 16th April, 1938.

526 726.—Attenuator circuit for reducing the maximum amplitude, and the range of amplitude-variations, in a wireless receiver.

Hazeltine Corporation (assignees of H. M. Lewis). Convention date (U.S.A.) 7th April, 1938.

526 757.—Tuning gear for a wireless receiver adapted both for push-button control and for continuously variable operation by hand.

E. H. Roberts. Application date 14th March, 1939.

526 832.—Superhet receiver in which a low-pass filter-circuit couples the local oscillator to the mixing valve, in order to cut-out harmonic and other disturbing frequencies.

Kolster-Brandes and C. N. Smyth. Application date 24th March, 1939.

526 869.—Amplifier circuit comprising two tetrode valves cross coupled in such a way as to minimise the effect of fluctuations in filament emission.

J. C. M. Brentano. Application date 28th March, 1939.

526 886.—Push-button tuning system for a multi-band wireless receiver.

Philco Radio and Television Corporation (assignees of R. B. Albright). Convention date (U.S.A.) 13th April, 1938.

527 186.—Band-pass filter circuit comprising a wedge-shaped piezo-electric crystal so arranged that the effective length of one or both of its electrodes can be varied in order to adjust the selectivity of the circuit.

The General Electric Co. and R. F. Proctor. Application date 3rd April, 1939.

527 292.—Superhet receiver with a number of intermediate-frequency stages in which the effect of interfering signals is automatically balanced out.

E. P. Rudlim. Application date 21st March, 1939.

527 301.—Radio receiver in which two electron multipliers are coupled in cascade to amplify a selected band of frequencies.

F. J. G. van den Bosch and Vacuum-Science Products. Application date 30th March, 1939.

527 433.—Means for compensating for the inter-electrode capacity-changes that occur during the time when the cathode of a valve amplifier or oscillator is heating-up.

Marconi's W.T. Co. and G. B. Banks. Application date 1st April, 1939.

527 514.—Construction and arrangement of a permeability-tuned wave-trap for cutting out an interfering station.

Johnson Laboratories Inc. (assignees of M. J. Kirk). Convention date (U.S.A.) 14th April, 1938.

527 526.—Band-spreading device, with a single-knob control, for a short-wave receiver.

C. H. Dierks. Application date 14th April, 1939.

527 626.—Receiver in which a high quality of reproduction is attained by the use of input, coupling, and output circuits of constant impedance.

I. L. Maguire. Convention date (U.S.A.) 26th November, 1937.

527 628.—Screened-lead arrangement for the de-coupling condenser of a valve amplifier.

J. Hardwick. Application date 9th March, 1939.

527 649.—Variable-impedance or high-frequency tuning circuit in which the reactive element is constituted by the discharge path of an electron tube.

L. de Kramolin. Convention date (Germany) 30th April, 1938.

527 885.—Band-pass selector circuit with means for readily varying the width of the frequency band to be transmitted, particularly for a superhet set.

Hazeltine Corporation (assignees of J. F. Farrington). Convention date (U.S.A.) 27th April, 1938.

527 902.—Tuning circuit for a wireless receiver in which a feed-back network including a piezo-electric crystal is used to allow of a smooth and gradual widening of selectivity.

Marconi's W.T. Co.; N. M. Rust; and E. F. Goodenough. Application date 12th January, 1939.

527 915.—Automatically variable tone-correcting and interference-eliminating circuit for a wireless receiver.

Marconi's W.T. Co.; N. M. Rust; J. D. Brailsford; A. L. Oliver; and J. F. Ramsay. Application date 17th March, 1939.

527 968.—Variable feed-back circuit for adjusting the "sharpness" or efficiency of the automatic-selectivity control of a wireless receiver.

Marconi's W.T. Co.; N. M. Rust; and O. E. Keall. Application date 12th January, 1939.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

526 111.—Means for suppressing the cathode-ray stream during the back or idle traverse of the line and frame scanning periods in television.

C. L. Faudell. Application date 7th March, 1939.

526 211.—Television system in which a scanning device at the receiving end is governed from the

transmitting end without the use of synchronising signals.

Standard Telephones and Cables (assignees of T. T. Goldsmith, Jr.). Convention date (U.S.A.) 12th March, 1938.

526 226.—Television system in which the scanning voltages are derived from A.C. mains, common to the transmitter and receiver, through a condenser charged by a rectifier and discharged by a high-impedance leak.

Standard Telephones and Cables (communicated by A. B. Dumont). Application date 14th March, 1939.

526 437.—Means for ensuring straight-line modulation in a short-wave transmitter, particularly for television.

E. L. C. White. Application date 16th March, 1939.

526 875.—Light-modulating arrangement of the kind using a transparent medium in which mechanical waves of supersonic frequency are set up.

I.M.K. Syndicate; P. Nagy; and M. J. Goddard. Application dates 24th and 25th January, 1939.

526 954.—Means for preventing "rotary" and spiral distortion in a television receiver of the cathode-ray type.

M. Bowman-Manifold and H. Miller. Application date 22nd March, 1939.

526 982.—Transformer coupling for a selector circuit covering a wide band of frequencies, such as is used in a television receiver.

Hazeltine Corporation (assignees of M. Cawein). Convention date (U.S.A.) 14th April, 1938.

527 009.—Television light-modulator comprising a Kerr cell and a mosaic electrode in which modulating signals are produced by secondary emission.

I.M.K. Syndicate; P. Nagy; and M. J. Goddard. Application date 10th February, 1939.

527 104.—Transmission system designed to handle a wide band of signals, such as is used in television, without undue attenuation of the lower frequencies.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 23rd April, 1938.

527 188.—Amplifier circuit for handling a wide band of signal frequencies, as in television, with substantially no phase delay shift.

Marconi's W.T. Co. (assignees of A. Preisman). Convention date (U.S.A.) 1st April, 1938.

527 310.—Television system in which the synchronising impulses are also applied either to convey other intelligence, or to restore the D-C component which regulates the average illumination of the picture.

Kolster-Brandes; W. A. Beatty; and P. K. Chatterjea. Application date 3rd April, 1939.

527 602.—Receiving circuit in which the picture and associated sound signals are separated, after passing through one or more common stages, by a variable-impedance network.

The General Electric Co.; W. H. Aldous; and G. W. Edwards. Application date 17th April, 1939.

527 795.—Television receiver in which a subsidiary electrode in a valve of special design is used to separate the picture signals from their associated synchronising impulses.

The General Electric Co. and W. H. Aldous. Application date 20th April, 1939.

527 843.—Means for cooling the luminescent screen of a cathode-ray television transmitter in order to eliminate "after-glow."

Radio-Akt. D. S. Loewe. Convention date (Germany) 22nd April, 1938.

527 892.—Arrangement of magnetic poles for correcting trapezoidal and similar forms of distortion in the "raster" produced by a cathode-ray television tube.

Philips' Lamp Co. Convention date (Germany) 25th April, 1938.

527 904.—Pulse-modulating system for the sound signals associated with a television programme.

Kolster-Brandes and W. A. Beatty. Application date 31st January, 1939.

527 967.—Television scanning device in which thin sharp-edged plates are arranged in pairs over apertures of standard size formed in a pair of relatively-moving bands.

R. B. Poole. Application date 15th July, 1939.

528 070.—Transmission channel, particularly for a wide frequency-band of television signals, in which a valve with negative feed-back is used to effect selective attenuation of certain frequencies.

R. H. Tanner. Application date 26th April, 1939.

528 090.—Scanning system for the transmission or reception of television in natural colours.

The General Electric Co. and L. C. Jesty. Application date 27th April, 1939.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

526 719.—Means for separately receiving any one of a number of electromagnetic waves of the same frequency, but of different form, transmitted along a metallic hollow tube or "dielectric guide."

Telefunken Co. Convention date (Germany) 26th March, 1938.

526 827.—Low-loss high-frequency input and output circuits for a magnetron amplifier or generator of ultra-short waves.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 1st April, 1938.

527 099.—Circuit arrangements in which negative feed-back is used to apply volume-compression at the transmitting end and volume-expansion at the receiving end of a wave-transmission system.

Standard Telephones and Cables and R. A. Meers. Application date 31st March, 1939.

527 146.—Thermionic valve oscillation generator particularly for use with a piezo-electric crystal stabiliser, even when the structure of the latter has broken down.

The British Thomson-Houston Co. Convention date (U.S.A.) 31st March, 1938.

527 666.—Phase- or frequency-modulating system in which the carrier wave is wholly or partly suppressed.

Marconi's W.T. Co. (assignees of W. van B. Roberts.) Convention date (U.S.A.) 19th April, 1938.

528 041.—Generating ultra-short waves by controlling the flow of a stream of electrons through a hollow resonator in such a way as to cause them to " bunch " together periodically.

The Board of Trustees of the Leland Stanford Junior University. Convention date (U.S.A.) 22nd January, 1938.

528 105.—Resonant-line coupling for the input and output circuits of a pair of short-wave oscillation generators arranged in push-pull.

Marconi's W.T. Co. (assignees of A. M. Braaten. Convention date (U.S.A.) 28th April, 1938.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

527 096.—Electrode construction and assembly of a stabilised electron-discharge tube designed to handle frequencies of the order of 50 megacycles and more.

Marconi's W.T. Co. (assignees of W. G. Wagener). Convention date (Germany) 31st March, 1938.

527 097.—Electrode arrangement and supporting means for ensuring a constant spacing between the cathode and other elements of an electron-discharge tube.

Marconi's W.T. Co. (assignees of F. Elston). Convention date (U.S.A.) 31st March, 1938.

527 230.—Electron multiplier designed to deliver a large output current with a high degree of amplification.

G. Weiss. Convention date (Germany) 15th June, 1938.

527 567.—Focusing arrangement for a cathode-ray tube in which a velocity-modulated electron beam is converted into one modulated in charge-density. (Addition to 518 015.)

The British Thomson-Houston Co. Convention date (U.S.A.) 14th April, 1938.

527 870.—Construction and arrangement of the final output electrodes of an electron multiplier intended for handling comparatively large currents.

Marconi's W.T. Co. (assignees of R. L. Snyder, Jr.). Convention date (U.S.A.) 30th April, 1938.

527 871.—Construction and arrangement of the electrodes of a cathode-ray tube used for high-powered television work and fitted with a constantly operated exhausting pump.

Marconi's W.T. Co. and N. Levin. Application date 21st April, 1939.

527 980.—Means for ensuring the adequate insulation of the high-potential electrodes of a cathode-ray tube.

A. F. Pearce. Application date 18th April, 1939.

527 996.—Electron-multiplier tube in which the shape and disposition of the electrodes are designed to give the effect of a photo-electric cathode of large area.

Marconi's W.T. Co. (assignees of E. W. Pike ; R. L. Snyder, Jr. ; and J. A. Rajchman). Convention date (U.S.A.) 3rd May, 1938.

528 425.—Valve amplifier in which a control grid of constant pitch is combined with a suppressor grid of variable pitch so as to eliminate undesirable space-charge effects.

The Mullard Radio Valve Co. Convention date (Germany) 9th May, 1938.

SUBSIDIARY APPARATUS AND MATERIALS

527 101.—Construction and arrangement of the bearing surfaces of a variable condenser of the " precision " type.

Standard Telephones and Cables ; R. M. Barnard ; and F. L. J. Jarvis. Application date 31st March, 1939.

527 103.—Circuit arrangement for converting the non-directional current-impulses derived from a photo-electric cell into an alternating current free from undesirable transients.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique, Soc. Anon.). Convention date (France) 17th May, 1938.

527 353.—Hydrogen bombardment process for making, sensitising, and stabilising photo-electric cells.

Board of Trustees of the University of Illinois. Convention date (U.S.A.) 5th January, 1938.

527 547.—Means for producing an intense " spot " on the fluorescent screen of a cathode-ray tube and of controlling it so that it does not burn the screen yet remains fixed in space.

The General Electric Co. and L. C. Jesty. Application date 14th April, 1939.

528 296.—Construction of the sensitized selenium surfaces of photo-electric cells and disc rectifiers.

Suddeutsche Apparate-Fabrik G.M.B.H. Convention date (Germany) 4th May. 1938.