2/6

WIRELESS ENGINEER

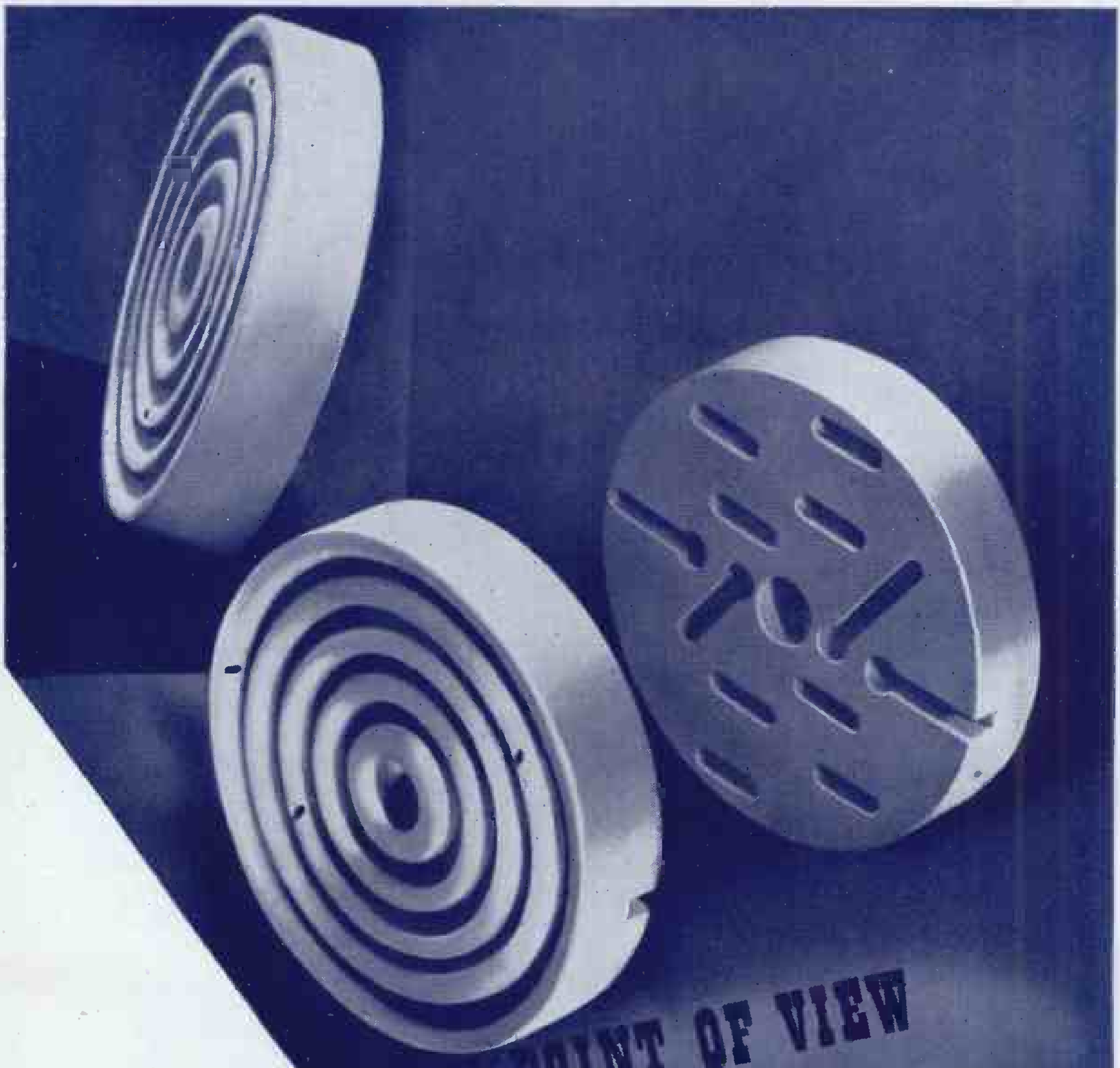
The Journal of Radio Research & Progress

Vol. XXI JULY 1944 No. 250

CONTENTS

Published on the sixth of each month
SUBSCRIPTIONS (Home and Abroad)
One Year 32/- 6 months 16/-
Telephone: WATerloo 3333 (35 lines)
Telegrams: Experiwyr Sedist London

ILIFFE & SONS LTD. DORSET HOUSE STAMFORD ST. LONDON S.E.1



FROM EVERY POINT OF VIEW

Frequentite is the most suitable insulating material for all high frequency applications. Ten years ago we introduced the first British-made low-loss ceramic, and consultation with us before finalising the design of new components is a wise precaution.

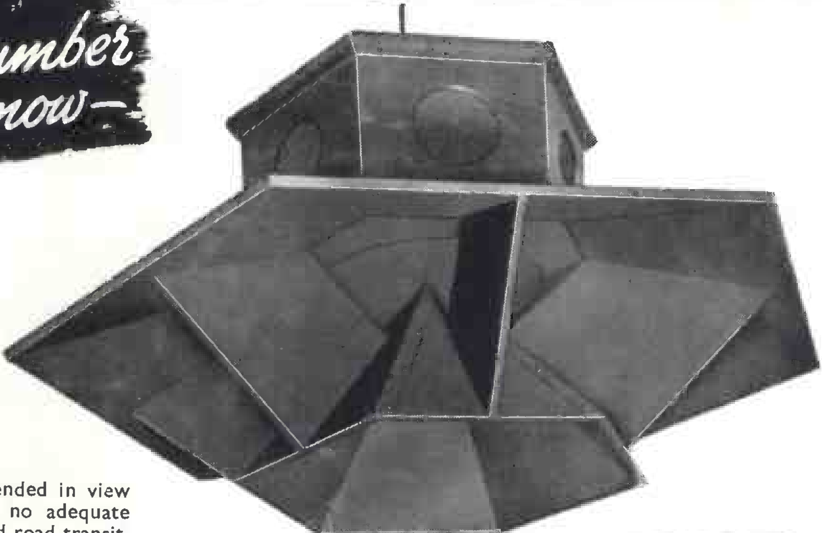
STEATITE & PORCELAIN PRODUCTS LTD.

Head Office: Stourport-on-Severn, Worcester. Telephone: Stourport 111. Telegrams: Steatain, Stourport.

R.P.33

Concentric Diffuser Loudspeakers for P.A.

Limited number available now—



EX WORKS

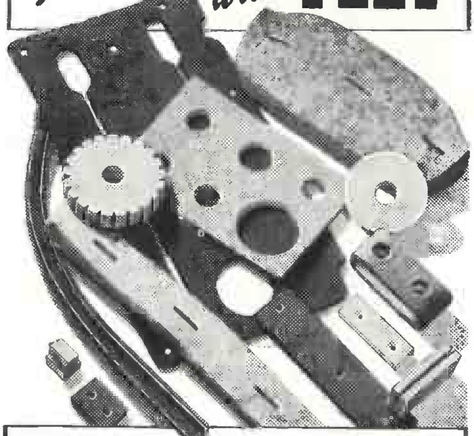
Designed for high power handling capacity, they meet present - day requirements in large halls and workshops, giving consistently high fidelity reproduction with full volume.

Early application is recommended in view of restricted quantity. As no adequate packing is available for rail and road transit, we are obliged to offer these speakers to those who can collect ex works unpacked.

Quality & Performance as before

GOODMANS INDUSTRIES LIMITED LANCELOT ROAD, WEMBLEY, MIDDX.

Into Battle with **FELT**

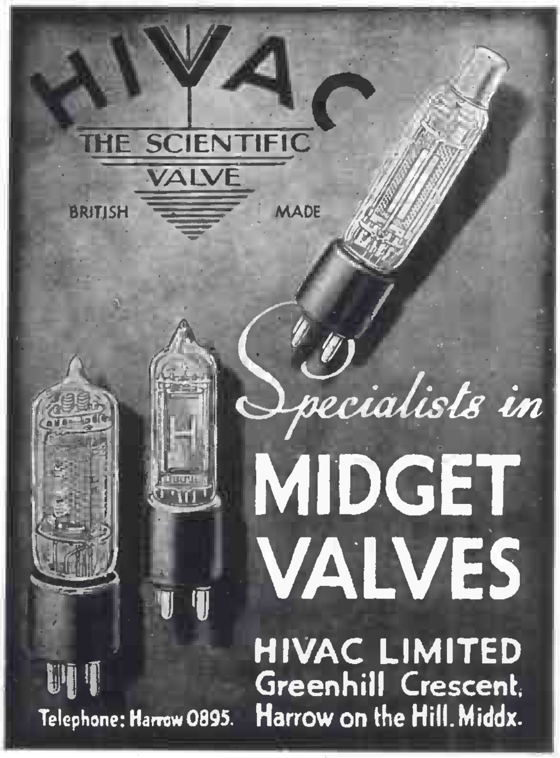


Woollen & Hair Felts, Cloths. Furnishing, Mechanical, Surgical. Washers, Strips and Gaskets. Gas Meter Washers. Felt Cut and Turned. Waterproofing.

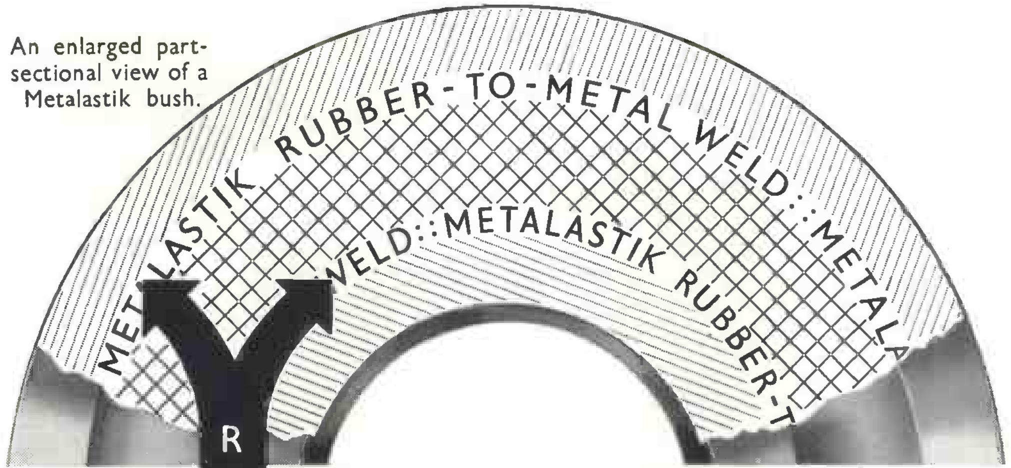
STERLING TEXTILE INDUSTRIES LTD.

STERLING WORKS, ALEXANDRA ROAD, PONDERS END MIDDLESEX

'Phone: HOWARD 2214-5, 1755 'Grams: STERTEX, ENFIELD



An enlarged part-sectional view of a Metalastik bush.



METALASTIK BUSHES

A triple advantage
that can't be seen!

A Metalastik bush is very different from an ordinary rubber-in-compression bush.

Instead of relying on compression-plus-friction, the rubber in the Metalastik bush is firmly 'welded' to the inner and outer metal sleeves, and functions in three ideal ways:—

(1) Deflection and frequency are controllable in shear, both axial and torsional.

(2) The rubber-to-metal-weld resists separation of the rubber from the metal under tension stress.

(3) In compression, as well as in shear and tension.

We design these bushes to meet required frequencies or damping, using natural or synthetic rubber, welded to all metals in ordinary use.

Our technique and experience enable us to provide bushes for many fresh applications where rubber could never be entertained before.

Metalastik Ltd., Leicester.

METALASTIK

WIRELESS ENGINEER

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

VOL. XXI JULY, 1944 No. 250

Editorial

The Angle of the Inverted Cone Transmission Line which Simulates the Radio Waves

IN a Paper entitled "The nature of the electromagnetic waves employed in radio-telegraphy, and the mode of their propagation," read before the British Association at Birmingham* in 1913, it was shown that the field in the neighbourhood of the earth was the same as it would be if the waves were transmitted outwardly in all directions between the earth and an inverted conducting cone. The question then arises as to the angle which the cone should have in order that the relation between the field strength and the total radiated power should be the same as in the absence of the cone. In the Paper referred to this was calculated, and it was found that the cone should have an angle of 55°, or that the angle between the cone and the earth should be 35°, as shown in Fig. 1.

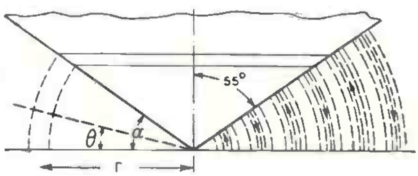


Fig. 1.

An American scientist has recently written suggesting that this value is not quite correct. It is true that in making the calculation an approximation was made; in finding the capacitance of the transmission line per unit length, the fact was ignored that the electric flux leaving unit area of the earth becomes more concentrated as it approaches the cone and ends on a surface somewhat less than unity. The calculated capacitance and inductance were therefore not strictly correct, the error depending upon the angle of the cone. The accurate value is easily found as follows. Taking a ring of unit width at a distance r from the apex and assuming it to have a charge q e.s. units, the electric force $\mathcal{E}$ near the ground will be $4\pi q/2\pi r$, but at an angle θ (see Fig. 1) the area will be reduced and $\mathcal{E}$ increased to $\frac{4\pi q}{2\pi r \cos\theta}$.

For the $P.D.$ between the cone and the earth we have

$$V = \int_0^\alpha \mathcal{E}\, r\, d\theta = 2q \int_0^\alpha \frac{d\theta}{\cos\theta}$$

$$= 2q \log_e \tan\left(\frac{\alpha}{2} + \frac{\pi}{4}\right) \text{ e.s. units.}$$

Hence for the capacitance of unit length of the line we have

$$C = \frac{q}{P.D.} = \frac{1}{2 \log_e \tan\left(\frac{\alpha}{2}+\frac{\pi}{4}\right) \times 9.10^{11}} \text{ farad.}$$

Since with air as the dielectric $\frac{1}{LC} = c^2 = 9 \times 10^{20}$

$$L = 2 \log_e \tan\left(\frac{\alpha}{2} + \frac{\pi}{4}\right) \times 10^{-9} \text{ henry.}$$

Both C and L are thus independent of the distance r.

For small values of the angle α these for-

* *Electrical Review*, 26th September, 1913.

mulae approximate to the values used in the original paper, viz. $\frac{1}{2\alpha \times 9.10^{11}}$ F and $2\alpha \times 10^{-9}$ H. For the characteristic impedance of the line we have

$$Z_o = \sqrt{\frac{L}{C}} = 60 \log_e \tan\left(\frac{\alpha}{2} + \frac{\pi}{4}\right) \text{ ohms.}$$

As the angle α increases, the percentage error of the approximation increases as shown in Fig. 2, the

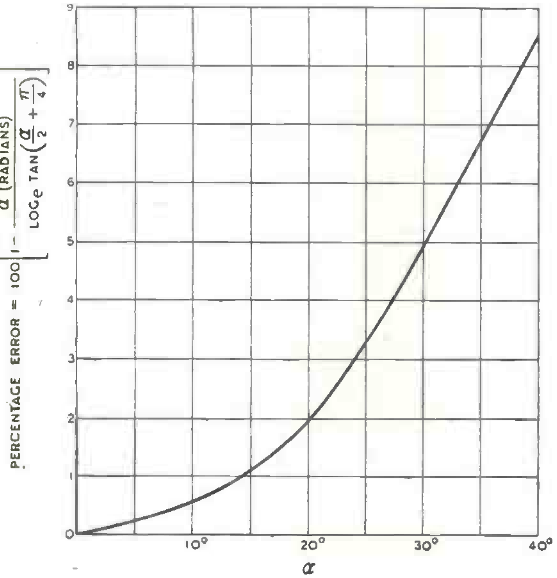


Fig. 2.

calculated value of L being too small and that of C too large. The calculated value of Z_o will be too small by the same percentage.

If the voltage between the cone and the earth be V the transmitted power P will be $\frac{V^2}{Z_o}$ or $\frac{\hat{v}^2}{2Z_o}$. Now the strength of the electric field at the earth's surface will not be exactly $\frac{V}{r\alpha}$ as assumed in the original paper, but $\frac{V}{r \log_e \tan\left(\frac{\alpha}{2} + \frac{\pi}{4}\right)}$.

Hence $$\frac{P}{\mathcal{E}_v^2} = \frac{r^2 \log_e \tan\left(\frac{\alpha}{2} + \frac{\pi}{4}\right)}{60}$$

where $\mathcal{E}_v$ is the field strength at the earth's surface in r.m.s volts per cm.

If the conical line is to simulate the freely radiated wave, this relation between the radiated power and the field strength at the earth's surface should be the same in both cases.

An element of uncertainty is now introduced into the problem because in the radio case this relation depends upon the ratio of the effective height of the aerial to the wavelength employed. In calculating the field strength at the earth's surface, the effect due to each element of the aerial can obviously be added, but in other directions the effects arrive with a phase difference which lessens the resultant field and therefore lessens the power radiated. In the original paper the aerial was assumed to be a plain vertical wire of height h operating at its fundamental frequency, i.e. with $\lambda = 4h$. In this case the phase effect is a maximum and the radiated power in watts is equal to $36.6\, I^2$ where I is the r.m.s current at the foot of the aerial. The mean value of the current along the aerial is $\frac{2}{\pi} I$ and the field strength at a distance r will be given by the formula

$$\mathcal{E}_v = \frac{2}{10} \cdot \frac{4\pi}{10} \cdot \frac{h}{\lambda} \cdot \frac{I}{r} \times 300 \text{ volts/cm}$$

$$= 60 \frac{I}{r} \text{ since } \lambda \times 4h.$$

Hence $$\frac{P}{\mathcal{E}_v^2} = \frac{36.6}{3600} r^2 = \frac{r^2}{60} \times 0.61$$

If, however, the antenna be operated at a wavelength much greater than $4h$, either by the addition of a large upper capacitance or by a tuning

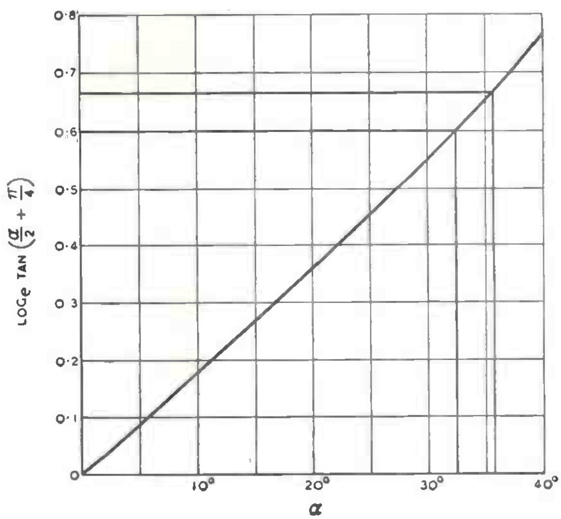


Fig. 3.

inductance, the phase effect will be reduced and the radiated power will approximate to

$$P = 1584 \left(\frac{h}{\lambda}\right)^2 I^2 \text{ watts.}$$

where h is the effective height. For $\mathcal{E}_v$ we have

$$\mathcal{E}_v = \frac{4\pi}{10}\frac{h}{\lambda}\frac{I}{r} \times 300 \text{ volts/cm.}$$

and therefore

$$\frac{P}{\mathcal{E}_v^2} = \frac{1584}{\frac{16 . \pi^2}{100} \times 9 \times 10^4} r^2 = \frac{r^2}{60} \times \frac{2}{3}$$

Hence $P/\mathcal{E}_v^2$ varies between $\frac{r^2}{60} \times 0.61$ and $\frac{r^2}{60} \times 0.67$, depending on the value of h/λ, and in order that the conical line may simulate the various aerials, the value of $\log_e \tan\left(\frac{\alpha}{2}+\frac{\pi}{4}\right)$ must vary over the range 0.61 to 0.67. From Fig. 3 it is seen that this corresponds to a range of the angle α from 32.5 to 35.5 degrees. The error due to the approximation made in the original paper gave 35 degrees instead of 32.5 degrees, that is, it gave the correct angle for an aerial with a value of h/λ differing from that assumed in the paper.

G. W. O. H.

Specific Resistance, Volume Resistivity, and Mass Resistivity

IN an interesting letter published in this number (see p. 328) C. F. Brockelsby points out that Roget's Dictionary of Electrical Terms gives a definition of mass resistivity which differs from that given in the May Editorial. Our definition was, however, that of the British Standards Institution, which simply says that it is the product of the specific resistance and the density of the substance. Roget's definition, viz. " the resistance per unit length of unit mass of a substance," is however, merely the same thing expressed in a different way, for if δ be the density of the substance, the volume of unit mass will be $1/\delta$ and this must be the cross-section if it be of unit length. The resistance of unit mass 1 cm long will therefore be $\rho\delta$, that is, it is the product of the specific resistance and the density.

Mr. Brockelsby also quotes Roget as saying that the mass resistivity is convenient when dealing with wire and that the definition makes the term apply to the column " ohms/lb. " often found in wire tables. Now is this so ? If we wish to find the resistance per unit weight of a wire of a given gauge or diameter, we proceed as follows :—

$$\text{weight} = W = l \times A \times \delta \qquad \therefore\ l = W/A\delta$$

where A = area of cross-section.

$$\text{Then}\quad R = \rho l/A = \frac{\rho}{\delta} \times \frac{W}{A^2} = \frac{\rho}{\delta} \times \frac{16W}{\pi^2 d^4}$$

As an example take copper wire 0.04in. diameter (= 0.1016 cm) ; putting $\rho = 1.7 \times 10^{-6}$, $\delta = 8.9$ and $W = 1$ lb. = 454 gm. Substituting these values in the above formula gives R = 1.325 ohms per lb. ; the wire tables give 1.3146 at 60 deg. F. Surely this calculation proves conclusively that in determining the ohms per lb. what is required is not the product of the specific resistance and the density but their quotient. The application of the so-called mass resistivity must lie in some other direction.

Another correspondent wrote privately saying that he did not see anything wrong in writing " ohms per cm³ " as one could interpret it as " ohms per cm. cube." It is not a matter of private interpretation, however, as cm³ has been officially adopted as an abbreviation for cubic centimetre ; apart from this cm³ has obviously the dimensions of the cube of a length.

One sometimes sees the specific resistance of a material referred to as being ρ ohms per cm per cm². This is an ambiguous and dangerous use of the word " per," for if the resistance of unit length is so much per cm² it should be twice as much for 2 cm² and ten times as much for 10 cm², whereas it is inversely proportional to the cross-section. It is doubtful if the " per " is fully justified even when stating that the specific resistance is so much per cm cube, since it involves the assumption that the cubes are arranged in series and not in parallel. It is correctly defined as the resistance between the opposite faces of a cm cube, and correctly stated as being so many ohm-cm or so many microhm-cm, because, since $R = \rho l/A$, $\rho = RA/l$ and consequently is correctly given as the product of a resistance and a length.

G. W. O. H.

A New Treatment of the WHEATSTONE BRIDGE NETWORK*

By Raymond J. Wey, A.M.I.E.E.

SUMMARY.—The normal methods employed for the determination of galvanometer current in a Wheatstone bridge network become very laborious when it is necessary to calculate a number of values, or to design a network having any desired characteristic curve of galvanometer current and variable arm resistance. To facilitate such calculations, a new mathematical treatment has been evolved, and it is shown that the characteristics of all Wheatstone bridge networks, either with or without appreciable battery internal resistance, can be represented by a single curve of the form $f = \frac{g}{1 + g}$, it being merely necessary to choose appropriate scales for galvanometer current (f) and variable arm resistance (g). Variation in the bridge constants has the effect of varying the position of the apparent point of balance on the curve.

Furthermore, the characteristics of any bridge may be specified completely by two constants, the "null point sensitivity" S, and the "equivalent null point" a_e. Simple formulae are derived for calculating these constants from the bridge resistance values.

To facilitate the calculation of characteristic curves, particularly when the range and hence the curvature, is small, the results are expressed in terms of deviation from a straight line tangential to the curve at the null point.

1. Introduction

THE simple Wheatstone bridge network is of considerable importance in electrical and electro-physical measurement; for instance, in resistance thermometry, temperature is determined in terms of the resistance of a temperature-sensitive resistor forming the variable arm of a bridge. The bridge may be balanced to zero galvanometer current in the usual way, thus measuring the resistance of the variable arm, or alternatively, the bridge is not adjusted in any way, the out-of-balance galvanometer current being used as a measure of the temperature.

In general, when a Wheatstone bridge network is used, it is necessary to be able to calculate the sensitivity in terms of galvanometer current caused by a given departure from the balance point of the variable arm. In many cases, furthermore, it is necessary to predict the characteristic curve of galvanometer current against variable arm resistance over any given range, for, as is well known, this is not a linear relationship.

The determination of the scale shape by calculation is normally a very laborious process, involving the determination of the galvanometer current for a series of values of variable arm resistance, to give a characteristic curve. If the curve obtained is not of the required shape, the whole process must be repeated with new values of bridge constants. Since, in addition to the variable arm, there are five possible constants, variation of each of which will affect the scale shape, the labour involved in calculating may be prohibitive.

In an effort to overcome this, a new treatment of the problem was evolved, which, as far as the author is aware, is novel, and which greatly reduces the labour required to design a Wheatstone bridge network to fulfil any desired requirements. The method is of general use in any problem involving such a network.

2. Earlier Work

In the solution of network problems in general, it is customary to apply Kirchhoff's Laws, or Maxwell's Principle of Circulating Currents, but it does not seem to be widely appreciated that considerable simplification results in many cases by the use of the "make and break" theorem. The "Make and Break" Theorem of Helmholtz is usually incorrectly attributed to Thévenin, but it has been shown recently by Prof. G. W. O. Howe[1] that it was in fact anticipated by Helmholtz in 1853, or thirty years before Thévenin's publication. The application of the theorem to the Wheatstone bridge has been dealt with by F. Wenner[2], and it is desirable at this stage briefly to give the results of this earlier work.

Fig. 1 shows in the conventional manner a Wheatstone bridge network supplied from a battery of e.m.f. V and internal resistance R_8. Let the switch X be opened; then a p.d. will exist across the break, which can be calculated quite simply from the voltage drops along the two current paths 1, 2, 3 and 1, 4, 3. Taking the

* MS. accepted by the Editor, April, 1944.

[1] *Wireless Engineer*, Vol. 20, pp. 319–322 (1943).
[2] *Proc. Phys. Soc.*, Vol. 39, pp. 124–144 (1927).

positive direction of current in the mesh 2, 3, 4 as being anticlockwise.

$$-i_5R_5 - e_2 + e_4 + e_0 = 0$$

where e_2 = voltage drop across R_2

e_4 = voltage drop across R_4

As X is open $i_5 = 0$,

and $$e_0 = e_2 - e_4 = E\left(\frac{R_2}{R_1+R_2} - \frac{R_4}{R_3+R_4}\right)$$

By the "make and break" theorem, if an e.m.f. equal to $-e_0$ be introduced across the break, and all the other e.m.f.s (i.e. V) be suppressed, then the current produced in the branch in which the break is made will be equal to that which would be produced when the e.m.f. V is present and the switch X is closed. Referring to Fig. 2; it will be seen that the equivalent resistance of the bridge, viewed from the e.m.f. $-e_0$, is

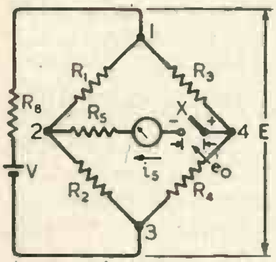


Fig. 1.

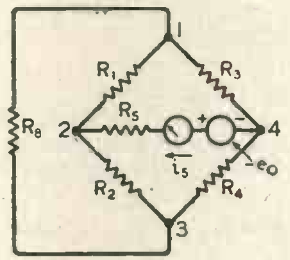


Fig. 2.

$$R_0 = R_5 + \frac{R_1R_2}{R_1+R_2} + \frac{R_3R_4}{R_3+R_4}$$

and $$i_5 = -\frac{e_0}{R_0}$$

Note that this assumes R_8 to be negligible compared with the resistance of the bridge viewed from the terminals 1 and 3, or alternatively, that the bridge is very nearly balanced, in which case very little p.d. would exist across terminals 1 and 3 as a result of the presence of $-e_0$. This is equivalent to stating that in Fig. 1, only a negligible alteration in E is produced by closing switch X.

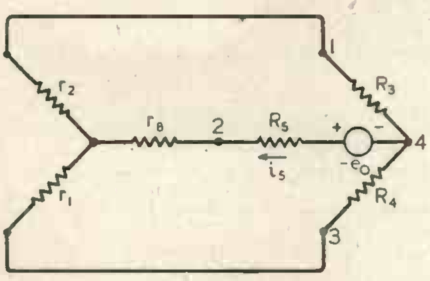


Fig. 3.

When this is not the case, Wenner recommends that the Kennelly delta-star transformation be applied to the arms R_1, R_2 and R_8, giving an equivalent circuit as shown in Fig. 3, where

$$r_1 = \frac{R_2R_8}{R_1+R_2+R_8}, \quad r_2 = \frac{R_1R_8}{R_1+R_2+R_8}$$

and $$r_8 = \frac{R_1R_2}{R_1+R_2+R_8}$$

It will be evident that the equivalent resistance of the network viewed from $-e_0$ is

$$r_0 = R_5 + r_8 + \frac{(r_2+R_3)(r_1+R_4)}{r_1+r_2+R_3+R_4}$$

and $$i_5 = -\frac{e_0}{r_0}$$

Whilst the use of Helmholtz's Make and Break Theorem in conjunction with the Kennelly transformation leads to considerable simplification, when compared with the standard methods of network treatment, there is still much tedious arithmetic when the effects of varying the constants of the bridge are to be determined. Furthermore, no general idea can be obtained of the effect upon the characteristics caused by variation of the bridge arms, galvanometer resistance or battery resistance.

3. The New Treatment

An alternative manner of representing the equivalent circuit of a bridge network is shown

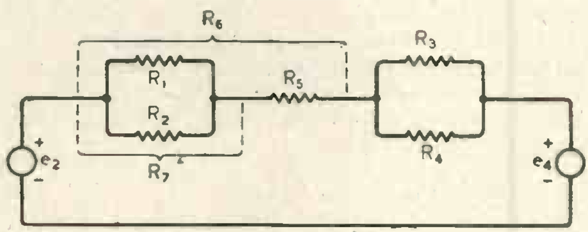


Fig. 4.

in Fig. 4, and follows from a consideration of Helmholtz's Theorem. The single e.m.f. e_0 of Fig. 1 is replaced by two e.m.f.'s e_2 and e_4, which are equal respectively to the voltage drops across R_2 and R_4 when X is open. The e.m.f. e_2 is constant, provided that E is constant, and hence R_1 and R_2 may be represented as a source of potential e_2 having an internal resistance equal to the parallel resistance of R_1 and R_2. Similarly, R_3 and R_4 may be represented as a variable source of e.m.f. e_4 having a variable internal resistance equal to the parallel resistance of R_3

and R_4. These two e.m.f.'s act in opposition through the load R_5

Thus $e_4 = E\left(\frac{R_4}{R_3 + R_4}\right)$

$$e_2 = E\left(\frac{R_1}{R_1 + R_2}\right) = \text{constant.}$$

and $e_0 = e_4 - e_2$

Hence the e.m.f. e_0 can be represented by a curve AZQ, as shown in Fig. 5. If the point A is the origin, then the curve represents e_4 against R_4.

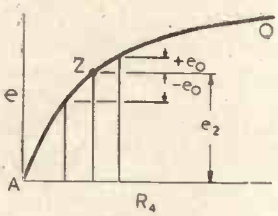


Fig. 5.

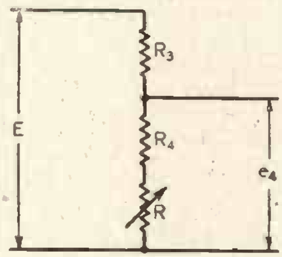


Fig. 6.

When the effect of e_2 is considered the datum shifts up to a value equal to e_2, and e_0 is measured above and below this datum as positive and negative potentials. Since R_5 has no effect upon the curve, and R_1 and R_2 merely determine the zero datum, this single curve may be called the "fundamental" law or scale shape of any Wheatstone bridge network.

In practice, the increase in resistance of the arm R_4 is measured from a certain minimum value. In what follows, R_4 is assumed to be the minimum or fixed value of the arm, whilst the variation in resistance is represented by the addition of a variable resistance R (*see* Fig. 6). It has been found convenient to represent the values of the bridge arms in terms of a fixed arm, in this case R_3. Thus

$$k = \frac{R}{R_3}, \quad a = \frac{R_4}{R_3}$$

and $g = \frac{R + R_4}{R_3} = a + k$

Also, e_4 will be represented as a fraction of E, thus $e_4 = f E$

or $$f = \frac{e_4}{E} = \frac{R_4 + R}{R + R_3 + R_4} = \frac{g}{1 + g} \quad \ldots \quad (1)$$

The curve of f against g is, naturally, of the same shape as AZQ in Fig. 5, i.e. it is the "fundamental" scale shape. It is shown by the curve AZB in Fig. 7, in which the null point Z is determined by the value of

$$b = \frac{R_2}{R_1 + R_2} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

At this point $R = 0$, and hence

$$\frac{R_4}{R_3 + R_4} = \frac{R_2}{R_1 + R_2}$$

If now R has any positive value, the working point on the curve is moved up from Z to H, corresponding to an increase in g from a to $a + k$. There is now a p.d. corresponding to

$$e_4 - e_2 = E\,(q - b)$$
$$= f_2\, E$$

across the break in the galvanometer circuit.

With this circuit closed, the characteristic curve of galvanometer current will have substantially the same shape as the p.d. curve AZH only when R_5 is very high compared with the effective resistance of the two sources of e.m.f. e_2 and e_4 in series (*see* Fig. 4). With normal values for the bridge arms, there will be a deviation from the curve AZH, due to the variation in equivalent resistance of the source e_4, giving a curve FZJ, Fig. 7. Since over the working range, the curvature of these characteristics may be small, it is difficult to depict or compare them accurately when plotted in the conventional manner. This difficulty has been overcome by representing the scale shape in

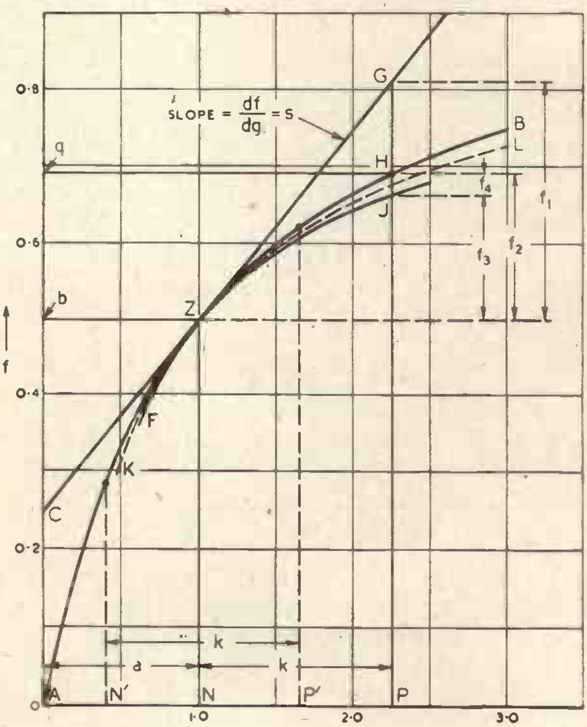


Fig. 7.

terms of deviation from a straight line. The deviation can be plotted to any desired scale, and enables accurate comparison to be made between different characteristic curves.

4. Fundamental Deviation

Referring to Fig. 7, the straight line *CZG* is tangential to the curve *AZB* at *Z*, and has a slope equal to *s*.

Now $f = \frac{g}{1+g}$ (eqn. 1)

$$\therefore \quad \frac{df}{dg} = \frac{1}{(1+g)^2}$$

When $g = a$, $\frac{df}{dg} = s$

$$\therefore \quad s = \frac{1}{(1+a)^2} \qquad \ldots \qquad (3)$$

At point *G*, $\quad f_1 = sk \qquad \ldots \qquad (4)$

Also at point *H*, $\quad f_2 = q - b$

$\therefore$ from eqns. (1) and (2),

$$f_2 = \frac{a+k}{1+a+k} - \frac{a}{1+a} \qquad \ldots \qquad (5)$$

Let the "fundamental" deviation, or fraction by which the fundamental curve *AZB* deviates from the linear law *CZG*, at any particular value of *k*, be D_1.

Then $$D_1 = \frac{f_1 - f_2}{f_1} \qquad \ldots \qquad (6)$$

Substituting for f_1 and f_2 by eqns. (4) and (5),

$$D_1 = \frac{sk - \frac{a+k}{1+a+k} + \frac{a}{1+a}}{sk}$$

Substituting for *s*, eqn. (3)

$$D_1 = \frac{\frac{k}{(1+a)^2} - \frac{a+k}{1+a+k} + \frac{a}{1+a}}{\frac{k}{(1+a)^2}}$$

which simplifies to

$$D_1 = \frac{k}{k+a+1} \qquad \ldots \qquad (7)$$

5. Load Deviation

The effect of the passage of current through the galvanometer or "load" must now be determined. The equivalent circuit with the galvanometer switch closed is as shown in Fig. 8, where the resistance R_5 of Fig. 4 has been "lumped" with the parallel resistance of R_1 and R_2 to give R_6 or $k_6 R_3$.

Now, the parallel resistance of R_3 and R_4 is

$$\frac{R_3 R_4}{R_3 + R_4} = \frac{a}{(a+1)} R_3 = bR_3$$

and the parallel resistance of R_3 and $(R_4 + R)$ is

$$\frac{(R + R_4)R_3}{R + R_3 + R_4} = \left(\frac{a+k}{a+k+1}\right) R_3 = qR_3$$

$\therefore$ the initial total circuit resistance $(R = 0)$ is

$$R_3\,(b + k_6) = \beta R_3 \qquad \ldots \qquad (8)$$

and the total circuit resistance when $R \neq 0$ is

$$R_3\,(q + k_6) = \lambda R_3 \qquad \ldots \qquad (9)$$

It is evident that the current through R_6 (the galvanometer current) would be proportional to f_2 if the total circuit resistance remained constant, but since it increases from βR_3 to λR_3 the current will not be proportional to f_2, but will have a deviation increasing with *k*, as shown by the curve *FZJ*. This deviation f_4, expressed as fraction of f_2, will be termed the "load deviation," D_2'. If the initial resistance βR_3 were maintained, the current would have the "fundamental" value $\frac{f_2 E}{\beta R_3}$ but actually the current has the value $\frac{f_2 E}{\lambda R_3}$.

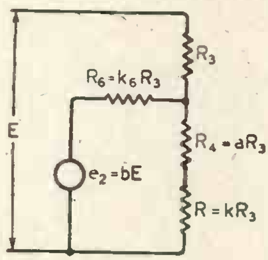


Fig. 8.

Hence: $$\frac{\text{actual current}}{\text{"fundamental" current}} = \frac{\beta}{\lambda} = \frac{f_3}{f_2}$$

The load deviation D_2' is hence $\frac{f_2 - f_3}{f_2} = 1 - \frac{\beta}{\lambda}$

Substituting for β and λ (*see* eqns. (8) and (9)).

$$D_2' = 1 - \left(\frac{b + k_6}{q + k_6}\right) = \frac{(q + k_6) - (b + k_6)}{q + k_6}$$

$$= \frac{q - b}{q + k_6} = \frac{f_2}{q + k_6} \qquad \ldots \qquad (10)$$

Now f_4 can be expressed as a fraction D_2 of the linear law value f_1 given by the straight line *CZG*, thus

$$D_2 = \frac{f_4}{f_1} = \frac{f_2 - f_3}{f_1} = \frac{f_2 - f_3}{f_2} \cdot \frac{f_2}{f_1}$$

$$= D_2'\,(1 - D_1)$$

Hence the total deviation of the curve *FZJ* with respect to *CZG* will be

$$D_3 = D_1 + D_2'\,(1 - D_1)$$

Substituting for D_2', eqn. (10),

$$D_3 = D_1 + \left(\frac{q-b}{q+k_6}\right)\left(1 - D_1\right)$$
$$= \frac{D_1(k_6+b) + (q-b)}{q+k_6}$$

Substituting for D_1, eqn. (7) ; for q and b, eqn. (5),

$$D_3 = \frac{\frac{k}{k+a+1}\left(k_6 + \frac{a}{a+1}\right) + \left(\frac{a+k}{k+a+1} - \frac{a}{a+1}\right)}{\frac{a+k}{k+a+1} + k_6}$$

$$= \frac{\frac{k}{k+a+1}\left(k_6 + \frac{a}{a+1}\right) + \frac{k}{(k+a+1)(a+1)}}{\frac{a+k+k_6(k+a+1)}{k+a+1}}$$

$$= \frac{k\left(k_6 + \frac{a}{a+1} + \frac{1}{a+1}\right)}{a+k+k_6(k+a+1)} = \frac{k(k_6+1)}{k(k_6+1)+a(k_6+1)+k_6}$$

$$= \frac{k}{k+a+\frac{k_6}{k_6+1}} = \frac{k}{k+1+\left(a - \frac{1}{1+k_6}\right)} \quad \ldots \quad \ldots \quad (11)$$

This result shows that effect of the load deviation in altering the scale shape is the same as an alteration in the value of 'a' in eqn. (7) to $\left(a - \frac{1}{1+k_6}\right)$ Thus *the same curve can be used to represent the characteristics*, it being merely necessary to reduce all values of g in eqn. (1) by $\frac{1}{1+k_6}$, i.e. the working range is shifted from $N - P$ to $N' - P'$, Fig. 7. Note also that any values of bridge arms can be used, since R_1 and R_2 determine 'a', whilst R_5 + (R_1 and R_2 in parallel) determines k_6.

6. Equivalent Null Point

It has been shown in the foregoing that the effect of varying the galvanometer resistance R_5 can be represented by an alteration in the value of 'a', and since 'a' is really a means of expressing the position on the curve of the null or balance point, the conception of "*equivalent a*" or "*equivalent null point*" can be introduced. Let a_e = equivalent null point. Then it follows from the previous section that

$$a_e = a - \frac{1}{1+k_6} \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

All bridge networks having the same value of a_e will give the same relationship between i_5 and k, although the actual *magnitude* of i_5 at any value of k will depend upon other factors. The actual value of i_5 can be easily calculated, however, as shown in the following section.

7. Actual Value of Galvanometer Current

When the galvanometer resistance R_5 is infinite, the e.m.f. across R_5 will be

$$e_5 = f_2 E$$
$$= f_1(1 - D_1)E$$
$$= Eks(1 - D_1)$$

When R_5 is finite, the current through it will have the value $i_5 = \frac{e_5}{\lambda R_3}$, where λR_3 is the total equivalent circuit resistance, as given by eqn. (9). But λ varies with k, and it has been shown that the effect of this variation can be represented by replacing D_1 by D_3, whilst the total circuit resistance is assumed to remain at its initial (constant) value βR_3 eqn. (8) ; thus

$$i_5 = \frac{Eks(1 - D_3)}{\beta R_3}$$
$$= \frac{E}{R_3}\,\frac{ks(1 - D_3)}{(k_6 + b)} \quad \ldots \quad \ldots \quad \ldots \quad (13)$$

8. Null Point Sensitivity

Let S = null point sensitivity in terms of variation of galvanometer current with k and S' = null point sensitivity in terms of variation of galvanometer current with R.

When at the null point, $D_3 = 0$,

$$\text{and} \quad i_5 = \frac{E}{R_3}\,\frac{ks}{(k_6+b)} = \frac{E}{R_3^2}\,\frac{Rs}{(k_6+b)}$$

$$\therefore \quad S = \frac{di_5}{dk} = \frac{E}{R_3}\,\frac{s}{(k_6+b} \quad \ldots \quad \ldots \quad (14)$$

$$\text{also } S' = \frac{di_5}{dR} = \frac{E}{R_3^2}\,\frac{s}{(k_6+b)} = \frac{S}{R_3} \quad \ldots \quad \ldots \quad (15)$$

It should be noted that provided the null point sensitivity S is constant, then the actual value of the current at any value of k will be constant for all Wheatstone bridge networks having the same value of a_e (and hence the same relationship of D_3 and k). Thus, *to specify completely the characteristics of the bridge, only two constants are required, i.e. the null point sensitivity and the equivalent null point.* From these values may be determined the variation of galvanometer current in terms of k or R. Combining equations (13) and (14)

$$i_5 = Sk(1 - D_3) \quad \ldots \quad \ldots \quad \ldots \quad (16)$$

So far, it has been assumed that the potential E across the bridge remains constant for all values of R or k. In some cases, this is true enough for practical purposes, but in other cases, e.g. where a rectifier unit is used as the source of supply, or a variable resistance is included for voltage adjustment, this assumption is not justified, and it becomes necessary to determine the effect of this resistance (R_8 in Fig. 1). This will be done indirectly, by first considering the variation in battery current I which the bridge would take with constant applied e.m.f. E.

9. Variation in Battery Current

Referring to Fig. 9, let

I = total battery current when the bridge is at the null point.

I' = decrease in I when bridge is unbalanced.

e_y = rise in potential of point y when bridge is unbalanced.

e_x = rise in potential of point x when bridge is unbalanced.

It will be evident that e_y will be the rise in potential caused by a current i_5 flowing into R_1 and R_2 in parallel, thus

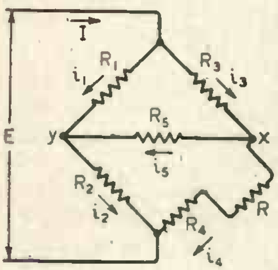


Fig. 9.

$$e_y = i_5\left(\frac{R_1R_2}{R_1 + R_2}\right)$$

Also

$$e_x = e_y + i_5R_5$$

As the potential of point y increases, the current through R_1 decreases by $i_1' = \frac{e_y}{R_1}$, and similarly, the current through R_3 decreases by $i_3' = \frac{e_x}{R_3}$.

Hence the total fall in battery current is

$$I' = i_1' + i_3'$$

$$= \frac{i_5}{R_1}\left(\frac{R_1R_2}{R_1 + R_2}\right) + \frac{i_5}{R_3}\left(\frac{R_1R_2}{R_1 + R_2} + R_5\right)$$

By definition, section (5),

$$\left(\frac{R_1R_2}{R_1 + R_2} + R_5\right) = R_6 = k_6R_3$$

and from eqn. (2)

$$\left(\frac{R_2}{R_1 + R_2}\right) = b$$

Hence $\quad I' = i_5(b + k_6) \quad \quad$ .. .. .. (17)

Substituting for i_5, eqn. (13), and simplifying

$$I' = \frac{E}{R_3}ks(1 - D_3) \quad .. \quad .. \quad .. \quad (18)$$

It will be observed from eqn. (17) that the reduction in battery current is proportional to the galvanometer current, when E is constant.

10. Effect of Battery Resistance

Let $R_e = k_eR_3$ = effective resistance of bridge to supply E, when balanced.

$$= \frac{(R_1 + R_2)(R_3 + R_4)}{R_1 + R_2 + R_3 + R_4} \quad .. \quad .. \quad (19)$$

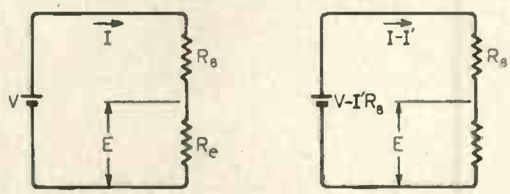
$R_8 = k_8R_3$ = equivalent internal resistance of battery.

$V = k_9E$ = open circuit e.m.f. of battery.

Referring to Fig. 10a, the equivalent circuit, as far as the load upon the battery is concerned, may be represented by R_e and R_8 in series. The bridge is assumed to be balanced, and the battery current is hence

$$I = \frac{E}{R_e} = \frac{E}{k_eR_3}$$

Assume now that the bridge is unbalanced, and that the voltage E is maintained constant. The bridge current and hence current through R_8 will fall to $I - I'$, and thus to maintain E constant, V must be reduced by $I'R_8$ (*see* Fig. 10b). In the practical case, however, V remains constant, and therefore E increases in the ratio of $\frac{V}{V - I'R_8}$. This is equivalent to a positive deviation from the curve FZJ, Fig. 7, giving a new curve KZL. Since $V - I'R_8$ is the value of battery voltage which would have to be applied through the resistance R_8 to obtain the curve FZJ, it is



(a) (b)

Fig. 10.

evident that the deviation of the new curve from this (i.e. the fraction by which any vertical ordinate on KZL, exceeds a corresponding ordinate on FZJ) is given by

$$D_4' = \frac{I'R_8}{V - I'R_8} = \frac{I'k_8R_3}{k_9E - I'k_8R_3}$$

Substituting for I', eqn. (18), and simplifying, the resultant "battery resistance deviation" is

$$D_4' = \frac{k_8ks(1 - D_3)}{k_9 - k_8ks(1 - D_3)} \quad .. \quad .. \quad (20)$$

Now D_4' is in terms of the characteristic curve FZJ, which itself is given by the deviation D_3 from the linear law, CZG. Hence if D_4 is the "battery resistance deviation" referred to the linear law, $D_4 = D_4'(1 - D_3)$

and the total deviation is

$$D_5 = D_3 - D_4 = D_3 - D_4'(1 - D_3)$$

It should be noted that D_4 is subtracted from D_3, since it is a deviation in the opposite sense. Substituting for D_4', eqn. (20),

$$D_5 = D_3 - \frac{k_8 ks(1 - D_3)^2}{k_9 - k_8 ks(1 - D_3)}$$

$$= \frac{D_3\{k_9 - k_8 ks(1 - D_3)\} - k_8 ks(1 - D_3)^2}{k_9 - k_8 ks(1 - D_3)}$$

$$= \frac{D_3 k_9 - k_8 ks + k_8 ks D_3}{k_9 - k_8 ks(1 - D_3)}$$

$$= \frac{D_3 k_9 - k_8 ks(1 - D_3)}{k_9 - k_8 ks(1 - D_3)}$$

$$= \frac{D_3 - k_{10} ks(1 - D_3)}{1 - k_{10} ks(1 - D_3)} \quad \ldots \ldots \quad (21)$$

where $k_{10} = k_8/k_9$

By definition

$$k_9 = \frac{V}{E} = \frac{R_8 + R_e}{R_e} = \frac{k_8 + k_e}{k_e} \quad \ldots \quad (22)$$

$$\therefore \quad k_{10} = \frac{k_8 k_e}{k_8 + k_e} \quad \ldots \quad \ldots \quad \ldots \quad (23)$$

Now from eqn. (11),

$$D_3 = \frac{k}{k + 1 + \left(a - \frac{1}{1 + k_6}\right)} = \frac{k}{k + 1 + x}$$

where $x = a - \frac{1}{1 + k_6}$

from which $(1 - D_3) = \frac{1 + x}{k + 1 + x}$

Substituting for D_3 and $(1 - D_3)$ in eqn. (21),

$$D_5 = \frac{\frac{k}{k + 1 + x} - k_{10} ks\left(\frac{1 + x}{k + 1 + x}\right)}{1 - k_{10} ks\left(\frac{1 + x}{k + 1 + x}\right)}$$

$$= \frac{k - k_{10} ks(1 + x)}{k + 1 + x - k_{10} ks(1 + x)}$$

$$= \frac{k\{1 - k_{10} s(1 + x)\}}{1 + x + k\{1 - k_{10} s(1 + x)\}}$$

$$= \frac{k}{k + \frac{1 + x}{1 - k_{10} s(1 + x)}}$$

$$= \frac{k}{k + \frac{1}{\frac{1}{1 + x} - k_{10} s}} \quad \ldots \ldots \quad (24)$$

Thus it will be seen that the general form of the equation is identical with that derived for D_1 eqn. (17), and D_3 eqn. (11), i.e. $D = \frac{k}{k + \text{constant}}$ where the constant is $a_e + 1$.

Hence to obtain identical scale shapes, it is merely necessary to ensure that the constant has the same value in each case, or

$$\frac{1}{\frac{1}{1 + x} - k_{10} s} = \text{constant}$$

or $$\frac{1}{1 + x} - k_{10} s = \text{constant}$$

or $$\frac{1}{1 + a - \frac{1}{1 + k_6}} - k_{10} s = \text{constant}$$

The corresponding value of a_e is, of course,

$$a_e = \frac{1}{\frac{1}{1 + a - \frac{1}{1 + k_6}} - k_{10} s} - 1 \quad \ldots \quad (25)$$

The relatively simple result given by eqn. (25), enables all the factors in a Wheatstone bridge network to be taken into account, and enables the effect of variation in one or more factors to be readily determined. In all cases, the result may be expressed in terms of variation in a_e and/or

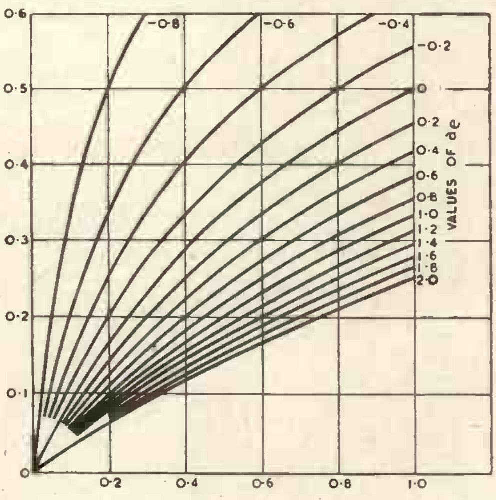


Fig. 11.

variation in S. From eqn. (16) it will be apparent that when R_8 is not zero (i.e. deviation $= D_5$ instead of D_3).

$$i_5 = Sk(1 - D_5) \quad \ldots \quad \ldots \quad \ldots \quad (26)$$

or more generally

$$i_5 = Sk(1 - D) \quad \ldots \quad \ldots \quad \ldots \quad (27)$$

where D can be either D_1, D_3 or D_5, according to

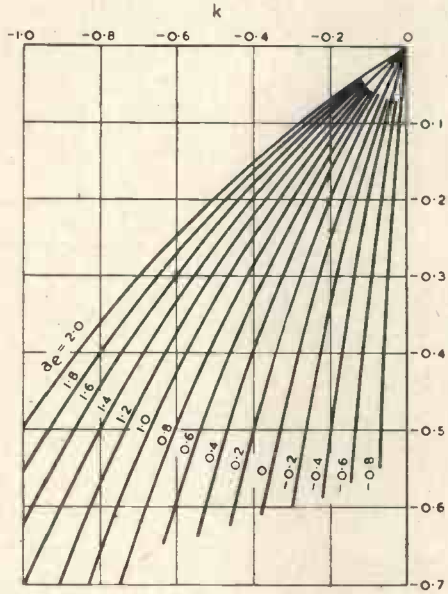


Fig. 12.

the factors which have been taken into account and in any case, has the value

$$D = \frac{k}{k + 1 + a_e} \quad \ldots \quad \ldots \quad \ldots \quad (28)$$

A series of curves connecting D and k, with a_e as parameter, is given in Fig. 11 and 12, and are of value when a number of calculations are being made, e.g. in the design of a network having any desired scale shape.

It should be noted that k may have a positive or a negative value. To give a negative value, R must become negative, which in practice means that with $R = 0$, R_4 is reduced below its normal value, or alternatively, that R_4 includes a part of R. This will be the case with a resistance thermometer in which R_b (the bulb resistance) obviously has a finite value at the null point. This value should be included in R_4, and any increase or decrease in R_b due to temperature variation is then equivalent to positive and negative values of R.

11. Conclusion

The most important results of the foregoing analysis may be stated as follows :—

(*a*) The characteristics of any Wheatstone bridge network, in terms of the variation of galvanometer current with variation in resistance of one arm, may be represented by a single curve of the form $f = \frac{g}{1 + g}$ (eqn. (1)). It is simply necessary to choose an appropriate position for the null point and suitable scales for the co-ordinates.

(*b*) The characteristics may furthermore be specified completely by two factors only

(1) the equivalent null point on the curve $= a_e$

(2) the null point sensitivity $= S$.

The value of a_e is found from eqn. (12) when the battery resistance is effectively zero, or eqn. (25) when the battery resistance is not zero.

The value of S is calculated according to eqn. (14) in both cases, bearing in mind that E is the value of applied e.m.f. across the bridge diagonal, at the null point $= \frac{V}{k_9}$ (see eqn. (22)).

(*c*) The characteristics may be calculated conveniently in terms of deviation from a straight line tangential to the actual characteristic curve at the null point. The fractional deviation is calculated according to eqn. (11) when the battery resistance is zero, or eqn. (24) when the battery resistance is not zero. By expressing the characteristics in this way, the attainment of accuracy in calculation, graphical representation and comparison, is greatly facilitated, particularly when the deviation is small (say less than 0.1).

(*d*) The magnitude of the galvanometer current at any value of arm resistance is calculated by means of eqns. (27) and (28).

APPENDIX

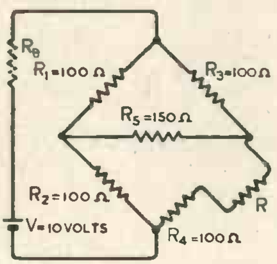


Fig. 13.

Examples

(a) Consider the simple network shown in Fig. 13. It is assumed that battery resistance is zero. Find the value of galvanometer current i_5 when $R = 100\Omega$.

First, the necessary factors to be used in this and succeeding examples will be found as follows :—

$a = \frac{R_4}{R_3} = 1.00$ .. by definition, Section 3.

$b = \frac{R_4}{R_3 + R_4} = 0.50$ .. eqn. (2).

$k = \frac{R}{R_3} = 1.00$ .. by definition, Section 3.

$s = \frac{1}{(1 + a)^2} = 0.25$ .. eqn. (3).

$k_5 = \frac{R_5}{R_3} = 1.50$ .. by definition, Section 5.

$k_7 = \frac{R_1 R_2}{R_3(R_1 + R_2)} = 0.50$ .. by definition, Section 5.

$k_6 = k_5 + k_7 = 2.00$ .. by definition, Section 5.

Next the values of a_e, D and S are found :—

$$a_e = a - \frac{1}{1 + k_6} = 0.666 \quad \text{eqn. (12).}$$

$$D = \frac{k}{k + 1 + a_e} = 0.375 \quad \text{eqn. (28).}$$

$$S = \frac{E}{R_3} \frac{s}{(k_6 + b)} = 0.010 \quad \text{eqn. (14).}$$

The galvanometer current i_5 may then be calculated from eqn. (27) :—

$$i_5 = Sk(1 - D) = \underline{\underline{0.00625\text{A}}}.$$

(b) Find the value of i_5 in the above example when $R = -50$ ohms.

The only factors altered by this change are k and D :—

$$k = \frac{R}{R_3} = -0.50.$$

$$\therefore \quad D = -0.428.$$

and $i_5 = 0.01 \times -0.50(1 + 0.428) = \underline{\underline{-0.00714\text{A}}}.$

(c) Plot the curve i_5 and R for values of R between -50 and $+50$ ohms.

When moderate accuracy only is required, the curves Figs. 11 and 12 may be used to determine D, for the appropriate values of k, with $a_e = 0.666$. Table I gives the figures obtained in this way, and values of i_5 calculated from them (the actual curve has been omitted from this example).

TABLE I.

R (ohms)	k	D	$(1 - D)$	$i_5 = Sk(1 - D)$ (amps)
−50	−0.50	−0.430	1.43	−0.00715
−40	−0.40	−0.320	1.32	−0.00528
−30	−0.30	−0.220	1.22	−0.00366
−20	−0.20	−0.138	1.138	−0.00228
−10	−0.10	−0.066	1.066	−0.00107
0	0.00	0.00	1.000	0.00
10	0.10	0.055	0.945	0.00095
20	0.20	0.108	0.892	0.00178
30	0.30	0.155	0.845	0.00254
40	0.40	0.195	0.805	0.00322
50	0.50	0.232	0.768	0.00384

(d) What is the null point sensitivity in terms of variation of galvanometer current with variation in R? From eqn. (15)

$$S' = \frac{S}{R_3} = \frac{0.01}{100} = 10^{-4}\ \text{A}/\Omega$$

$$= \underline{\underline{0.10/\text{mA}\Omega}}$$

(e) What is the battery current when $R = 50\Omega$? With the bridge balanced, the battery current is obviously $\frac{E}{R_e}$, where R_e is given by eqn. (19),

i.e. $I = \frac{10}{100} = 0.10$ A.

It has been shown in Section 9, eqn. (18), that the reduction in battery current is given by

$$I' = \frac{E}{R_3} ks(1 - D_3)$$

$$= \frac{10 \times 0.5 \times 0.25}{100}(1 - 0.233) = 0.0096\ \text{A}.$$

Hence the battery current when $R = 50\Omega$ is $I - I'$ $\underline{\underline{= 0.0904\ \text{A}}}$.

(f) It is desired to feed the network of Fig. 13 from a source having an internal resistance of 50 ohms. What alterations are necessary to the network to maintain the same scale shape and what e.m.f. must be applied to maintain the galvanometer current at its original value? From section 10, eqn. (28), it is known that to satisfy these conditions, a_e must be constant, and from example (a), it is known to be 0.666. Using eqn. (25), it will be seen that

$$a_e = \frac{1}{\dfrac{1}{1 + a - \dfrac{1}{1 + k_6}} - k_{10}s} - 1 = 0.666$$

$$\therefore \quad \frac{1}{1 + a - \dfrac{1}{1 + k_6}} - k_{10}s = 0.600$$

It will be assumed that the values of R_3 and R_4 are unaltered, i.e. a = constant = 1.0, and that any variation required is to be made to R_5.

Now by definition $k_8 = \frac{R_8}{R_3} = \frac{50}{100} = 0.50$

and $k_e = \frac{R_e}{R_3} = \frac{100}{100} = 1.00$

$$\therefore \quad k_{10} = \frac{k_e k_8}{k_e + k_8} = 0.333 \quad \therefore \text{eqn. (23)}$$

Substituting

$$\frac{1}{1 + 1 - \dfrac{1}{1 + k_6}} - 0.333 \times 0.25 = 0.600$$

or $k_6 = 0.864$.

Now $k_5 = k_6 - k_7$

$$= 0.864 - 0.500 = 0.364$$

$$\therefore \quad R_5 = k_5 R_3 = 0.364 \times 100 = \underline{36.4\Omega}$$

Since the scale shapes are now identical, to obtain the same value of galvanometer current, it is merely necessary to ensure that S is constant. From eqn. (14), it is seen that

$$E = \frac{SR_3(k_6 + b)}{s}$$

Only k_6 is changed, hence

$$E = \frac{0.01 \times 100\ (0.864 + 0.500)}{0.25} = 5.456\ \text{V}$$

From eqn. (22)

$$V = E\left(\frac{k_8 + k_e}{k_e}\right)$$

$$= 5.456\left(\frac{0.50 + 1.00}{1.00}\right) = \underline{\underline{8.184\ \text{V.}}}$$

(g) What error will be introduced in the scale shape, due to an increase in the battery resistance from 0 to 25 ohms, assuming that no variation is made in the other bridge resistance values?

This example illustrates the value of the deviation method in obtaining accurate comparisons between two closely similar characteristics. The values of D for the first case (case A) have already been found in example (c) using the curves, but to obtain higher accuracy, it is desirable to calculate the values using eqn. (28). This should be done for both cases, using the appropriate values of a_e. For case B, (when $R_8 = 25\Omega$), by substituting numerical values in eqn. (23), k_{10} is found to be 0.2, which, when put into eqn. (25) (the other values being unaltered from example (a) gives $a_e = 0.8182$.

The corresponding values of deviation for a range of k can be calculated, giving D_A and D_B for the two cases, as shown in Table II, cols. 2 and 3. Bearing in mind that a lower value of deviation corresponds to a higher value of current, it will be seen that the current in case B *exceeds* that of case A by the difference $D_A - D_B$. For convenience this is given as a percentage (of the linear law value) col. 4. To obtain the difference in terms of the actual value, the figures must be multiplied by the factor $\frac{1}{1 - D_A}$, giving column 5.

In practice, if it were required to match the two characteristics as nearly as possible, the null point sensitivity S of one could be altered to equalise the errors. Thus, in case B, the value of S could be reduced by 0.75% which would reduce the actual value of current by 0.75% at all points on the characteristics. The resulting differences would now be as shown in column 6. As the differences in the two characteristics are small, it is sufficiently accurate to make the last correction by simple subtraction of a constant percentage.

TABLE II

1	2	3	4	5	6
k	D_A	D_B	$D_C = 100(D_A - D_B)$ (per cent.)	$D_D = \frac{D_C}{1 - D_A}$	$D_E = D_D - 0.75$
0.00	0.0000	0.0000	0.00	0.00	− 0.75
0.05	0.0292	0.0268	0.24	0.25	− 0.50
0.10	0.0567	0.0521	0.46	0.49	− 0.26
0.15	0.0827	0.0762	0.65	0.71	− 0.04
0.20	0.1071	0.0990	0.81	0.91	+ 0.16
0.25	0.1304	0.1208	0.96	1.10	+ 0.35

NEW VALVE-OSCILLATOR CIRCUIT*

By F. Butler, B.Sc., A.M.I.E.E.

SUMMARY.—The properties of a half-wave artificial line are employed in the design of a valve oscillator of high frequency stability and low harmonic content. There are no critical adjustments and the circuit is capable of operation over a wide range of frequencies. Balanced or unbalanced loads can be supplied and any normal method of frequency stabilisation may be employed to supplement the inherent high stability. The circuit is readily converted to a neutralised amplifier and the network also provides an output which is in quadrature with the voltage across the load resistance. The addition of simple circuit elements provides further attenuation of harmonic voltages.

1. Introduction

A VALVE oscillator may be regarded as an amplifier feeding a four-terminal network in which, at the operating frequency, the input and output voltages are in phase-opposition and in which the attenuation is equal to the stage-gain of the amplifier.

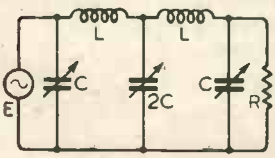


Fig. 1.

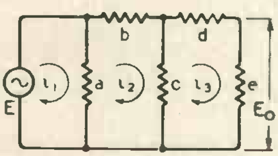


Fig. 2.

Many frequency-selective networks possess these properties, and almost all have been applied to the design of audio- or radio-frequency oscillators. The half-wave transmission line is one such network which has been employed with particular advantage at high frequencies. The oscillator to be described employs an equivalent half-wave artificial line with lumped inductance and capacitance.

2. Analysis of the Artificial Half-Wave Line

The basic circuit to be discussed is shown in Fig. 1.

The circuit is best analysed in the more general form shown in Fig. 2.

Let E = input voltage.

E_0 = output voltage.

Z_i = input impedance $= \frac{E}{i_1}$

Z_t = transfer impedance $= \frac{E}{i_3}$

i_1, i_2, i_3 = mesh currents shown.

Writing down and solving Kirchhoff's equations for the several meshes, it can be shown that :—

$$Z_i = \frac{E}{i_1} = \frac{a\{b(c+d+e) + c(d+e)\}}{(a+b)(c+d+e) + c(d+e)} \quad \ldots \quad (1)$$

$$Z_t = \frac{E}{i_3} = b + d + e + \frac{b}{c}(d+e) \quad \ldots \quad (2)$$

* MS. accepted by the Editor, April, 1944.

$$\frac{E_0}{E} = \frac{e}{Z_t} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

For the particular case shown in Fig. 1 :—

$$a = \frac{1}{j\omega C}; \quad b = d = j\omega L; \quad c = \frac{1}{2j\omega C};$$

$$e = \frac{R/j\omega C}{R + \frac{1}{j\omega C}}$$

Substituting these values in eqn. (1) and setting $\omega^2 = \frac{1}{LC}$ we have :—

$$Z_i = R; \quad Z_t = \frac{j\omega LR}{R + \frac{1}{j\omega C}} = -\frac{R/j\omega C}{R + \frac{1}{j\omega C}};$$

$$E_0 = -E \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

If $E_q = P.D.$ across the mid-shunt condenser $2C$, then :—

$$E_q = j\frac{E}{\omega CR} = jE\frac{\omega L}{R} \quad \ldots \quad \ldots \quad (5)$$

These results may be summarised as follows :—

When a network is proportioned as shown in Fig. 1 and operated at the frequency given by $\omega^2 = \frac{1}{LC}$:—

(a) The input impedance is non-reactive and equal in value to the terminating load.

(b) The output voltage is equal to the input but is reversed in phase.

(c) A quadrature voltage is available across the mid-shunt element. If the terminating load resistance is so chosen that $R^2 = L/C$ the quadrature voltage is equal in magnitude to both input and output voltages.

At a given frequency, the quadrature voltage is inversely proportional to the terminating resistance. The circuit is thus seen to be a phase-shift network of zero loss and differs in this respect from the resistance-capacitance circuits commonly employed in audio-frequency oscillators which introduce serious attenuation.

3. Practical Oscillator Circuit

Using these principles, the simplest circuit which it is possible to devise is shown in Fig. 3.

The component values are selected in accordance with normal practice, none of them being critical. The main tuning capacitances are conveniently provided by a four-gang condenser with two elements paralleled to give the mid-shunt capacitance. The inductances should be accurately matched and so arranged that there is a minimum of inductance coupling between them. Grid leak and condenser bias is provided by C_2R_2, while cathode bias and negative feedback are obtained by the introduction of R_1. A blocking condenser C_1 isolates the load resistance from the D.C. power supply. The H.T. feed is taken through a R.F. choke to the junction of the two inductances. Equation (5) shows that if the load resistance $R \gg \sqrt{L/C}$, the radio frequency voltage developed between the feed-point and earth is very much less than the input or output voltages.

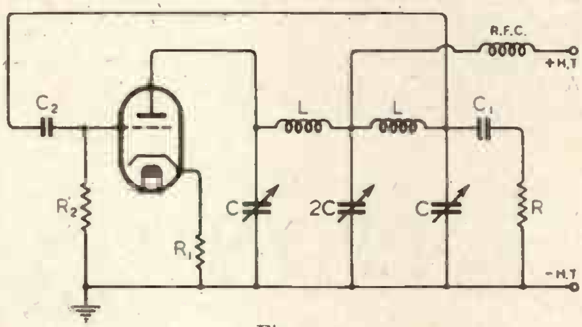


Fig. 3.

The special properties of the oscillator may be summarised as follows :—

(a) The grid driving voltage is equal in magnitude to the alternating anode voltage and is large enough to give reliable oscillation even at very high frequencies.

(b) Valve input and output capacitances are readily absorbed by the terminating condensers of the network.

(c) The line acts as a low-pass filter and gives strong attenuation of harmonic voltages.

(d) Push-pull voltages, balanced to earth, are available for driving a succeeding amplifier stage.

(e) The circuit is convertible to a push-pull disposition by adding a second valve symmetrically connected to the output terminals of the network.

(f) The rotors of the tuning condensers are all at earth potential.

(g) Using a triode valve as shown, the oscillator is well adapted to anode modulation.

(h) The quadrature voltage developed across the mid-shunt condenser can be applied to drive the reactance modulator of a F.M. transmitter. Wide-band modulation is obtained by using three reactance valves shunting the three variable condensers.

(j) A neutralised amplifier is obtained by making C_2 variable and setting it equal to the anode-grid capacitance of the valve.

4. Circuit Refinements to give High Frequency-Stability

Neglecting the variation of frequency caused by temperature changes of circuit elements, constant-frequency operation is secured if the following requirements are met :—

(a) Rigid limitation of the amplitude of oscillation.

(b) Rapid change of phase of the grid driving voltage with respect to the alternating anode voltage when a slight change of frequency takes place.

Amplitude limitation is easily provided, either by use of a stabilising resistance joined in series with the anode circuit between valve and load, or by means of a delayed diode automatic gain control for producing the grid bias. The reduction of harmonics caused by this artifice can be supplemented by the use of a parallel-tuned circuit to replace the normal load resistance, and by the use of negative feedback.

The tuned output circuit increases the frequency stability by causing a more rapid change of phase between input and output voltages, than would be provided by the network alone, due to small variations in the operating frequency.

Fig. 4 shows a circuit which incorporates the devices necessary to secure constant-frequency operation. Stabilised power supplies and temperature-compensated networks are assumed to be employed.

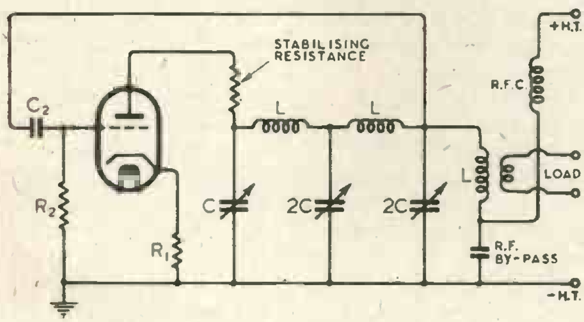


Fig. 4.

There are a number of laboratory applications for such an oscillator. It can be made the basis of a stable heterodyne frequency meter, or may be employed in a beat-frequency oscillator in which one of the radio-frequency sources is required to be free from harmonics. A particularly useful application to the production of a circular time-base of variable frequency, making use of the fact that the mid-shunt and terminal voltages are in phase-quadrature. Further sections of artificial line may be added at the output end of the circuit for the purpose of impedance matching or additional filtering.

As an example, a low impedance aerial may be energised by causing it to terminate an extra section of quarter-wave line in tandem with the main oscillator network.

At high frequencies the artificial line may be replaced by a section of actual transmission line having distributed constants, but in this case the electrical performance is largely modified and controlled by the interelectrode capacitances of the valve. This is particularly so if a triode is used.

Birthday Honours

IN the Birthday Honours Prof. J. D. Cockcroft, Ph.D., Chief Superintendent, Air Defence Research and Development Establishment, Ministry of Supply, is created a C.B.E.

W. A. Duncan, Deputy Director of Signals, Air Ministry, and Dr. S. E. A. Landale, Superintending Experimental Officer, Admiralty Signal Establishment, are among those who become O.B.E.s.

Among a number of executives in the wireless industry who receive honours are: R. H. Hacker, managing director, Dynatron Radio; T. H. Kinman, head of the radio section, research laboratory, British Thomson-Houston Co.; M. I. Lipman, manager, E. K. Cole; H. L. Oura, assistant superintendent, Designs and Development Department, Gramophone Company; F. C. Robinson, manager, A. C. Cossor; W. C. Tingey, general manager, Dispersal Factories, Dubilier Condenser Co.; and S. S. West, development physicist, Cinema-Television, who become Members of the Order of the British Empire.

The Ionosphere

"RADIO Waves and the Ionosphere" is the title of a new book which is issued from the offices of *Wireless World* and is believed to be the only publication of its kind. The author, T. W. Bennington, of the Engineering Division of the B.B.C., states in the preface "It is not a text-book. It contains no mathematics. It merely aims to explain the phenomena [of propagation] in as simple language as is possible."

In the foreword Sir Edward Appleton says "Although it is primarily written for the professional radio technician who wishes to understand more about his own subject, I recommend it as a friendly and well-informed guide to anyone interested in long-distance radio communication."

The chapter headings of this 81-page book, which is illustrated by 27 figures, gives some idea of its scope. They are :—Ground Waves and Sky Waves; The Sun and the Ionosphere; How the Ionosphere is Sounded; Ionosphere Variations; Long-distance Transmission; Ionosphere Disturbances and other Abnormalities.

"Radio Waves and the Ionosphere" is issued by our Publishers, Iliffe and Sons Ltd., Dorset House, Stamford Street, London, S.E.1, at 6s. net; by post 6s. 4d.

The Energy and Permittivity of ELECTRON SPACE CHARGES *

By W. E. Benham

(P. R. T. Laboratories)

THE general question as to the energy may be framed as follows. The work done in charging an empty condenser being W_0, how much energy is stored when the condenser is taking part in a pure electron discharge? Owing merely to the need for simplicity at the outset, we restrict attention to the simple case for which the condenser is a parallel plane diode and the electron discharge space-charge limited. Fringing will likewise be ignored. The results can nevertheless be regarded as having practical application in connection with the study of the cathode-grid space of any hard thermionic polyode the geometry of which does not depart too markedly from plane parallel. By polyode is meant a valve comprising anode and cathode and at least one grid. The majority of indirectly heated cathode valves have clearances sufficiently small compared with cathode radius to enable us to assume a plane geometry.

While the results of this paper apply at most practical frequencies it can be shown that they break down for ωT much greater than unity, where T = electron transit time, and $\omega = 2\pi f$. As the permittivity, or dielectric constant, of the electron space charge in an idealised diode satisfying Child-Langmuir conditions (that is satisfying the 3/2 power relationship between current and voltage), and operating with small or negligible anode load is already known to be 3/5, the main reason for including an account of this quantity here is to set forth an attempt to establish this result without resort to the use of transit time dynamics. The result $\epsilon = 3/5$ has been so much quoted as to give the impression to the uninitiated that it is much the most important conclusion reached by the writer in his first papers. This is a one-sided view, the behaviour of the conductance being probably of greater interest, particularly in cases where it may become negative. However, the question of input capacitance variations is one of prime practical importance, and an ingenious device[1] which gives substantially zero capacitance and conductance variations has been proposed; with the theory of this we shall not deal here.

Considering the energy first, let us regard the potential of the diode-anode as held constant at the value $V(d) = V$, while the electrons are supposed brought up from the cathode and constrained to occupy positions in the intervening space such that at any plane intermediate between cathode and anode the potential and space charge distributions become, ignoring initial velocity distribution

$$V(x) \propto x^{4/3},\ \rho(x) \propto x^{-2/3} \quad \ldots \quad \ldots \quad (1)$$

where x is to be thought of as measured from the potential minimum as zero.

The energy associated with any slice dx of unit area is

$$dW = V(x)\,\rho(x)\,dx \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

If we integrate for all such slices we obtain for the space on the anode side of the potential minimum

$$W = \int_{x=0}^{x=d} V(x)\,\rho(x)\,dx = \tfrac{3}{5}\,V(d)\,\rho(d)\,d \quad \ldots \quad (3)$$

Owing to the proximity of the potential minimum to the cathode, d is sensibly the inter-electrode clearance and $V(d)$, $\rho(d)$ refer respectively to the anode potential and the space charge density just in front of the anode. The energy contained between cathode and potential minimum is usually small in view of the small volume comprised. We shall ignore it in the sequel. Now we may express (3) in terms of the surface density of charge, σ_0, of the empty condenser. The space potential in a plane diode being proportional to the 4/3 power of the distance x from the cathode, the field under space charge conditions, E_0 referring to empty condenser, is

$$E(d) = \tfrac{4}{3}E_0,\ E(o) = 0 \quad \ldots \quad \ldots \quad (4)$$

and, since $E(x) \propto x^{1/3}$,

$$4\pi\,\rho(x) = \frac{d\,E(x)}{dx} = \frac{E(x)}{3x} \quad \ldots \quad \ldots \quad (5)$$

Thus, remembering that V is kept the same as in the empty condenser,

$$\rho(d) = \frac{E(d)}{4\pi}\,\frac{1}{3d} = \frac{E_0}{4\pi}\,\frac{4}{9d} = \frac{-4\sigma_0}{9d} \quad \ldots \quad (6)$$

(the minus because the field at the positive anode is negative). Equations (6) and (3) give

$$W = \tfrac{3}{5}\,V(d)\left(\frac{-4\sigma_0}{9d}\right) = \frac{-4}{15}\,V(d)\,\sigma_0 \quad \ldots \quad (7)$$

* MS. accepted by the Editor, April, 1944.

Defining W_0 as $\frac{1}{2} V(d)\,\sigma_0$, (7) becomes $W = \frac{-8}{15} W_0$ .. .. (8)

The negative value of W arises from the fact that ρ and V have opposite signs, a state of affairs which applies at all points of our idealised distribution. The rate of change of W can be shown to be the same as the (scalar) product of the "polarisation current" and the electromotive force. In order to show this let us anticipate the later-to-be-proved result

$$\epsilon = \tfrac{3}{5} \quad .. \quad .. \quad .. \quad .. \quad (9)$$

In electron theory the displacement and field are identical to a factor of 4π. The polarisation is $(\epsilon - 1)E/4\pi$ and the polarisation current is the rate of change of this quantity. Our statement above is equivalent to the equation

$$4\pi \frac{dW}{dt} = (\epsilon - 1)\frac{dE}{dt} \cdot E_0 d$$

since $(\epsilon - 1)$ is $-2/5$ and $E = (4/3)E_0$ we obtain

$$4\pi \frac{dW}{dt} = \frac{-8}{15}\frac{dE_0}{dt}E_0 d$$

Integrating

$$W = \frac{-1}{4\pi}\frac{8}{15}\frac{E_0^2}{2}d = -\tfrac{4}{15}V(d)\sigma_0$$

in agreement with (7), thus proving the proposition.

In regard to the excess of $E(d)$ over E_0, as given by (4), this corresponds to an excess surface density of charge $\sigma_0/3$. But since the anode was charged to potential V before we filled the space with electrons, the excess induced charge $\sigma_0/3$ must be regarded as having been conferred on the anode at constant potential V. The work involved in doing this is

$$W' = \tfrac{1}{3}\sigma_0 V = \tfrac{2}{3}W_0 \quad .. \quad .. \quad .. \quad (10)$$

We must, therefore, for the gross work done in charging the condenser,

$$W_\sigma = W_0 + W' = \tfrac{1}{2}V\sigma_0 + \tfrac{1}{3}V\sigma_0 = \tfrac{5}{3}W_0 \quad (11)$$

It is to be noted that the work W' involved in placing the induced charge on the anode is not all realisable as kinetic energy of the electron stream, only $(8/15)W_0$ as against $(10/15)W_0$ being available for this purpose—that is the quantity $(-W)$. Of the difference, only one half, namely $W_0/15$, appears as energy stored in the diode condenser, the remaining half being stored as mutual electrostatic energy of the space charge electrons. This means that, were the electrons to scatter under the influence of their mutual repulsions alone they would acquire a total kinetic energy $W_0/15$. The energy stored in the diode *condenser* is thus the original energy W_0 plus the energy $W_0/15$ mentioned above, or W_1, where

$$W_1 = \tfrac{16}{15}W_0 \quad .. \quad .. \quad .. \quad .. \quad (12)$$

a result which was first derived by Hartshorn[2] in 1931 by another method and interpreted by him to mean that the apparent dielectric constant of the space charge is 16/15. This interpretation was criticised by the writer at the time on the basis that a dynamical method was alone capable of giving an uncontradictable value for the apparent permittivity[3]. It is to-day seen to be more accurate to say that one can indeed obtain a correct value for the permittivity on quasi-statical considerations especially when guided by the knowledge that the dynamical method gives this value; namely the assumed value under equation (9). For, by writing W_1 as the difference between W_σ (the gross energy required to charge the condenser) and $\frac{9}{15}W_0$ (the energy which is to be regarded as stored, or potential energy, $(8/15)W_0$ of which is immediately realised as kinetic energy of the electron stream and $\frac{1}{15}W_0$ is realisable only if the cloud is permitted to scatter to great distances), we see that instead of the single step represented by (12) we should have the double step

$$W_1 = (\tfrac{5}{3} - \tfrac{3}{5})W_0 = \tfrac{16}{15}W_0 \quad .. \quad .. \quad (12a)$$

We infer from (12a) that ϵ has the value 3/5, the value it has hitherto been with certainty known to possess only by a dynamical analysis involving transit time considerations. For, since the term $W_0 = (5/3)W_0$ is an affair of the surface charges we should expect it to take the form

$$W_\sigma = \frac{2\pi\sigma_0^2}{\epsilon}\cdot d = \frac{W_0}{\epsilon} \quad .. \quad .. \quad .. \quad (13)$$

requiring $\epsilon = 3/5$, while the second term, which has to do with a volume distribution, evidently requires the same value of ϵ, as may also be seen as follows.

When the electrons, as here, obey a Child-Langmuir distribution all lines of force from the anode terminate on electrons, none reaching the cathode. Defining capacitance as follows

$$\text{capacitance} = \frac{\text{twice the electronic energy stored per electron transit.}}{\text{square of anode potential.}} \quad .. \quad .. \quad (14)$$

we obtain $C = (3/5)C_0$ by considering $\frac{1}{2}CV^2$ to be the potential energy stored in all the electrons present simultaneously between the electrodes (to replace which would require the time of one complete transit from cathode to anode). The difference between this definition and that of (15) (*q.v.*) is to be carefully noted. The part played by the electrons is now seen to be of paramount importance. Since in other space charge distributions some of the lines of force reach the cathode, or else emanate from the cathode to the intervening space charge, we cannot from the foregoing reach any very general conclusions as to the trend of ϵ when space charge departs from the simple conditions assumed above.

Since the anode charge is 4/3 of the cold value, it may be asked how it is we are justified in regarding $(5/3)W_0$ rather than $(4/3)W_0$ as the energy corresponding to the anode charge. True, we have already shown that this may, from one point of view, be explained as due to the induced charge being conferred on the anode at constant potential V and not at an average potential $V/2$. But, on the usual definition of electrostatic energy as (half charge times potential), a definition having such general acceptance that any exception might seem impertinent, we should certainly expect to obtain $(4/3)W_0$. In order to throw light on this paradox, we offer some further energy considerations. Let us work out the destruction of kinetic energy consequent upon the collection of electrons by the anode during the time of one complete transit. The details, which are simple but uninteresting, yield the result that $8W_0/3$ (or five times the realised kinetic energy of the space electrons) is so destroyed. The additional energy of the anode charge $(W_0/3)$ is one-fifth of the whole energy of the charging, so that the ratio of accumulated to destroyed kinetic energy would seem to give the clue to the additional anode charging energy, namely that one-fifth of the work may be regarded as energy storage, only four-fifths of the work being performed continuously. For although $(8W_0/3)$ is destroyed $(8W_0/15)$ simultaneously comes into being, so that the nett destruction of kinetic energy of electrons during the time of a single transit is $32W_0/15$ or twice the stored potential energy W_1 of the condenser. This result is reminiscent of a proposition in electrostatics to the effect that[4] "when the potentials (of charged conductors) are kept constant, the batteries which maintain the potentials of the conductors at their constant value will be called upon to furnish twice the amount of mechanical work done by the electric forces. For they will have to furnish energy equal to the sum of the mechanical work done and the increase in the electric energy of the system ; the latter is . . . equal to the decrease in the electric energy of the system while the charges are kept constant, and this is equal by the principle of the conservation of energy to the mechanical work done." It is possible for this double quantity of work to be negative, so that the battery gets charged. If you forcibly increase the distance between the plates of a condenser while connected to a battery, you do an amount of work, but the energy stored in the electrostatic field of the assembly has decreased by the same amount. They have both gone to charge the battery[5].

It is admitted that in the absence of independent knowledge or from dynamical considerations one might never have been led to the intermediate equation of (12a), for one is still apt to think in terms of classical electricity which would give $\epsilon = 16/15$ on the basis that

$$\text{capacitance} = \frac{\text{twice energy stored in condenser}}{\text{square of anode potential}} \quad \ldots \quad (15)$$

The present article must be regarded as fulfilling a dual purpose. First, to show that the result (9) may be rationally derived on low frequency considerations, albeit that such "rationale" is at least in part based on the new definition (14), and secondly to draw attention to this new definition of capacitance as applied to the Langmuir diode. The work would, however, lay itself open to a charge of isolationism were it to imply that only in dealing with thermionic systems need we revise our definitions. There are other, more primordial examples (such, for example, as the collection, from a state of infinite dispersal, of the parts of a homogeneous sphere of electricity) where the expression $QV^2/_2$ fails to give the whole energy, but in all these cases this expression truly gives the work performed by some external agency in *transferring* the charge, any work additional to this representing work done in overcoming mutual forces between individual parts of the said charge which may arise as a result of the transfer.

REFERENCES

[1] *Electronic Engineering*, "The Pentode-Heptode," July, 1941, pp. 304, 5.
[2] Hartshorn, *Wireless Engineer*, August, 1931, p. 413.
[3] *Wireless Engineer*, Sept. and Nov., 1931, pp. 488 and 601.
[4] Thomson, J. J., "Elements of Electricity and Magnetism," 5th Edition, pp. 39, 40.
[5] I am indebted to Prof. G. W. O. Howe for this last example.

A Method of Solving Certain NON-LINEAR CIRCUIT PROBLEMS

By W. H. B. Cooper, A.M.I.E.E.

SUMMARY.—A method of solving problems associated with certain types of non-linear, non-reactive circuits, is presented. The solution, which is in series form, is a numerical one, and as such has certain disadvantages; it is, however, particularly useful, when specific products of distortion need to be ascertained.

Introduction

THE types of circuits considered, are those possessing one or more discontinuities in characteristics, which can otherwise be represented by very simple "Artificial" functions; e.g., a perfectly linear rectifier. The method applies only to circuits containing non-reactive elements.

When the law of a non-linear device, can be expressed in the form of a simple "Analytic" function over its entire range, then there is, generally speaking, no difficulty in obtaining a solution to the problem.

In practice, however, the problem cannot often be solved in this simple way, but the law of the device in question can usually be represented by taking a sufficient number of terms of a power series. In those cases where the law can be expressed by means of say two "Artificial" functions, then these two functions can be combined by a Fourier Series, resulting in one expression which will hold over a limited, but controllable, range. An answer is produced in a form which is particularly useful for ascertaining the magnitudes of specific distortion (modulation) products.

Various applications of this method of solution are given below in cases I to IV inclusive.

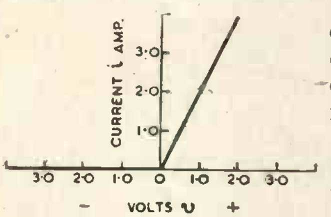


Fig. 1.

The basic circuits chosen are frequently employed in telecommunication engineering.

Approached from the mathematical, rather than the engineering point of view, it appears that this method has been anticipated, with others, in an article entitled "New Results in the Calculation of Modulation Products."—*B.S.T.J.*, Vol. XII, April, 1933.

Case I

Non-linear device with characteristic as shown in Fig. 1.

In this case it is convenient to consider the voltage/current characteristic, the device being assumed to possess two terminals only. In this case

$$i = Kv \text{ for values of } v > 0 \quad \ldots \quad (1)$$

and

$$i = 0 \text{ for values of } v < 0 \quad \ldots \quad (2)$$

These two conditions can be combined by writing

$$i = Kv[1.] \quad \ldots \quad (3)$$

Where [1.] is a function of v as shown in Fig. 2(a) and has a value of zero for $v < 0$ and unity for $v > 0$. This is similar to the "Heaviside Unit Function" but with "v" as the independent variable.

Normally this "Unit Step" function would be represented by a Fourier Integral, but if we are prepared to impose limits to the range of "v", the independent variable,

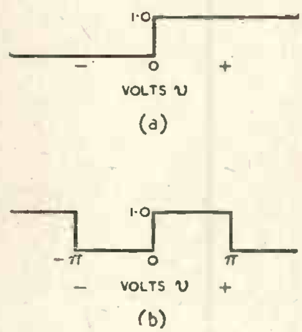


Fig. 2.

there appears to be no reason why a Fourier Series should not be used as indicated in Fig. 2(b). Under these particular conditions $|v| \not> \pi$, Fig. 2(b) is represented by

$$f(v) = \tfrac{1}{2} + \frac{2}{\pi}\{\sin v + \tfrac{1}{3}\sin 3v + \ldots\}$$

$$= \tfrac{1}{2} + \frac{2}{\pi}\sum_{m=1}^{\infty}\frac{1}{m}\sin mv. \quad (m \text{ is odd}) \quad (4)$$

From (3) and (4)

$$i = \frac{Kv}{2} + \frac{2Kv}{\pi}\sum_{m=1}^{\infty}\frac{1}{m}\sin mv \ldots \quad (5)$$

Where m is an odd integer and $|v| \not> \pi$.

Instead of using $\sin mv$ in eqn. (4) with the restriction that $|v| \not> \pi$, the expression $\sin \frac{mv\pi}{V_0}$ where $|v| \not> V_0$ might equally well be employed.

Within the restrictions indicated, eqn. (5)

expresses the law given graphically in Fig. 1. K in this case is numerically equal to 2, it is the forward conductance.

If now a zero impedance generator of E.M.F. $e = E \sin \omega t$ is applied to the terminals of this device then the resulting current will be

$$i = \frac{KE}{2} \sin \omega t + \frac{2KE}{\pi} \sin \omega t \sum_{m=1}^{\infty} \frac{1}{m} \sin (mE \sin \omega t) \quad \ldots \quad (6)$$

Now $\sin(mE \sin \omega t)$

$$= 2\{J_1(mE) \sin \omega t + J_3(mE) \sin 3\omega t + \ldots\}$$

and

$$\sin \omega t \sin(mE \sin \omega t) = 2\{J_1(mE) \sin \omega t \sin \omega t + J_3(mE) \sin \omega t \sin 3\omega t + \ldots\}$$

$$= J_1(mE) + \{J_3(mE) - J_1(mE)\} \cos 2\omega t. + \{J_5(mE) - J_3(mE)\} \cos 4\omega t + \ldots$$

the final current is therefore

$$i = \frac{2KE}{\pi} \sum_{m=1}^{\infty} \frac{1}{m} J_1(mE) + \frac{KE}{2} \sin \omega t$$

$$+ \frac{2KE}{\pi} \sum_{m=1}^{\infty} \frac{1}{m} \{J_3(mE) - J_1(mE)\} \cos 2\omega t.$$

$$+ \frac{2KE}{\pi} \sum_{m=1}^{\infty} \frac{1}{m} \{J_5(mE) - J_3(mE)\} \cos 4\omega t.$$

$$+ \ldots \quad \ldots \quad (7)$$

(m is odd)

By giving a particular value to E, eqn. (7) can be evaluated provided that E is less than π.

The first three terms of eqn. (7) are evaluated below when $E = 1.0$ volt.

$$\text{the first term} = \frac{2KE}{\pi} \sum_{m=1}^{\infty} \frac{1}{m} J_1(mE)$$

$$= \frac{2K}{\pi} \{J_1(1) + \tfrac{1}{3} J_1(3) + \ldots\}$$

$$\doteqdot \frac{2K}{\pi} (0.5083) \quad \ldots \quad (8)$$

(*See* Table I).

TABLE I

m	$J_1(m)$	$\frac{J_1(m)}{m}$ +	$\frac{J_1(m)}{m}$ −
1	0.440	0.440	—
3	0.339	0.113	—
5	−0.327	—	0.0650
7	−0.005	—	0.0007
9	+0.245	0.027	—
11	−0.177	—	0.0160
13	−0.070	—	0.0050
15	+0.205	0.014	—
		0.594	0.0867
		Total = 0.5083	

$$\text{the second term} = \frac{K}{2} \sin \omega t \quad \ldots \quad (9)$$

$$\text{The third term} = \frac{2K}{\pi} \Big[\{J_3(1) - J_1(1)\} + \tfrac{1}{3}\{J_3(3) - J_1(3)\} + \ldots\Big] \cos 2\omega t$$

$$\doteqdot -\frac{2K}{\pi} (0.337) \cos 2\omega t \quad \ldots \quad (10)$$

(*See* Table II).

TABLE II

m	$-J_1(m)$	$J_3(m)$	$J_3(m) - J_1(m)$	$\frac{1}{m}\{J_3(m) - J_1(m)\}$ +	$\frac{1}{m}\{J_3(m) - J_1(m)\}$ −
1	−0.440	+0.019	−0.421	—	0.4210
3	−0.339	+0.309	−0.030	—	0.0100
5	+0.327	+0.365	+0.692	0.1380	—
7	+0.005	−0.167	−0.162	—	0.0230
9	−0.245	−0.181	−0.426	—	0.0470
11	+0.177	+0.227	+0.404	0.0360	—
13	+0.070	+0.003	+0.073	0.0056	—
15	−0.205	−0.194	−0.399	—	0.0266
17	+0.098	+0.135	+0.233	0.0137	—
19	+0.106	+0.073	+0.179	0.0094	—
21	−0.170	−0.175	−0.345	—	0.0164
23	+0.039	+0.067	+0.106	0.0046	—
				0.2073	0.5440
				Total = − 0.337	

And so from eqns. (8) to (10) we get the first three terms of the series for i.

$$i \doteqdot \frac{2K}{\pi} (0.508) + \frac{K}{2} \sin \omega t - \frac{2K}{\pi} (0.337) \cos 2\omega t \quad \ldots \quad (11)$$

This particular example could, of course, be readily solved in a much simpler manner, since by inspection the resulting current waveform is as shown in Fig. 3, and represented by the well-known series form of—

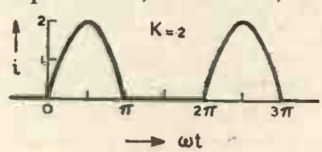


Fig. 3.

$$i = \frac{K}{\pi} + \frac{K}{2} \sin \omega t - \frac{2K}{\pi} \left\{ \frac{\cos 2\omega t}{1.3} + \frac{\cos 4\omega t}{3.5} + \right\} \quad \ldots \quad (12)$$

Comparing eqns. (11) and (12) it is seen that the numerical coefficients for terms one and three agree to within one or two per cent.

Whilst an upper limit to the value of v has been set, nothing has been mentioned of its minimum value. In obtaining a numerical solution, v should be chosen as large as possible in order to limit the number of terms of the series which are required for a given percentage accuracy.

Case II

Two generators of zero impedance applied in series with the device of Fig. 1.

Let the resultant generator voltage due to the two in series be given by

$$v = E_1 \sin \omega t + E_2 \sin pt \qquad \ldots \quad \ldots \quad (13)$$

Reference to eqn. (5) gives the current i as

$$i = \frac{K}{2}(E_1 \sin \omega t + E_2 \sin pt)$$
$$+ \frac{2K}{\pi} E_1 \sin \omega t \sum_{m=1}^{\infty} \frac{1}{m} \sin(mE_1 \sin \omega t + mE_2 \sin pt)$$
$$+ \frac{2K}{\pi} E_2 \sin pt \sum_{m=1}^{\infty} \frac{1}{m} \sin(mE_1 \sin \omega t + mE_2 \sin pt) \qquad \ldots \quad \ldots \quad (14)$$

Now

$$\sin(mE_1 \sin \omega t + mE_2 \sin pt) = [J_0(mE_2) + 2\{J_2(mE_2) \cos 2pt + J_4(mE_2) \cos 4pt + \ldots\}] \times 2\{J_1(mE_1) \sin \omega t + J_3(mE_1) \sin 3\omega t + \ldots\}$$
$$+ [J_0(mE_1) + 2\{J_2(mE_1) \cos 2\omega t + J_4(mE_1) \cos 4\omega t + \ldots\}] \times 2\{J_1(mE_2) \sin pt + J_3(mE_2) \sin 3pt + \ldots\} \qquad \ldots \quad \ldots \quad (15)$$

At this stage it is well to decide upon the components of interest in order that the expressions may be simplified.

As an example, the amplitude of the side band $(\omega - p)$ will be investigated.

From eqns. (14) and (15) the only terms required are

$$\frac{2K}{\pi} \cdot \sum_{m=1}^{\infty} 2E_1 \sin \omega t \{J_1(mE_2) \sin pt\} \{J_0(mE_1) + 2J_2(mE_1) \cos 2\omega t\}$$

and
$$\frac{2K}{\pi} \sum_{m=1}^{\infty} 2E_2 \sin pt \{J_1(mE_1) \sin \omega t\} \{J_0(mE_2) + 2J_2(mE_2) \cos 2pt\}$$

and again selecting only the $(\omega - p)$ terms we get

$$\frac{2K}{\pi} \sum_{m=1}^{\infty} [E_1 J_1(mE_2)\{J_0(mE_1) - J_2(mE_1)\} + E_2 J_1(mE_1)\{J_0(mE_2) - J_2(mE_2)\}] \times \cos(\omega - p)t \qquad \ldots \quad \ldots \quad (16)$$

where m is odd and $|E_1 + E_2| \not> \pi$.

Case III

Two generators feeding the non-linear device in parallel. Fig. 4(a).

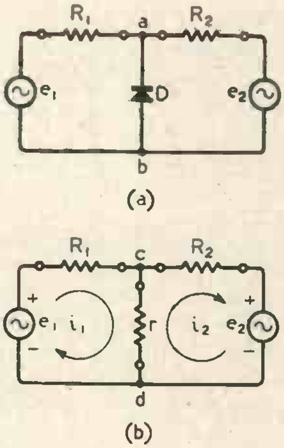


Fig. 4.

The voltage waveform appearing across terminals a b will be analysed. The rectifier "D" will be assumed perfect in that its conducting resistance is zero and non-conducting resistance infinite.

Referring to Fig. 4(b) where "D" is replaced by a linear resistor of r ohms, then the voltage v_{cd} appearing across terminals $c\,d$ is

$$v_{cd} = \frac{(e_1 R_2 + e_2 R_1) r}{r(R_1 + R_2) + R_1 R_2} \qquad \ldots \quad \ldots \quad (17)$$

It will be observed from eqn. (17) that the sign of v_{cd} is unaffected by the magnitude of r.

Returning now to Fig. 4(a) it follows that when terminal "a" is positive with respect to "b" i.e. $(e_1R_2 + e_2R_1)$ is positive, then "D" is non-conducting so that r in eqn. (17) is infinite.

And so:

$$v_{ab} = \frac{e_1 R_2 + e_2 R_1}{R_1 + R_2} \quad \text{for positive values of } (e_1R_2 + e_2R_1) \qquad \ldots \quad \ldots \quad (18)$$

and similarly

$$v_{ab} = 0 \text{ for negative values of } (e_1R_2 + e_2R_1) \qquad \ldots \quad \ldots \quad (19)$$

By comparison with eqn. (5) the solution of the circuit of Fig. 4(a) is therefore

$$v_{ab} = \frac{e_1 R_2 + e_2 R_1}{2(R_1 + R_2)} + \frac{2}{\pi} \frac{(e_1 R_2 + e_2 R_1)}{(R_1 + R_2)} \sum_{m=1}^{\infty} \frac{1}{m} \sin(mR_2 e_1 + mR_1 e_2) \qquad \ldots \quad \ldots \quad (20)$$

provided $|(R_2 e_1 + R_1 e_2)| \not> \pi$.

If now $e_1 = E_1 \sin \omega t$

and $e_2 = E_2 \sin pt$

then eqn. (20) is really the same as eqn. (14), which has already been considered in some detail.

Case IV

The series solution applied to the case of a voltage limiter.

A representative circuit is shown in Fig. 5 where the rectifiers D_1 and D_2 are again assumed perfect as in Case III.

The two bias batteries, each of E.M.F. E volts, prevent any load being imposed upon the generator until the magnitude of its terminal voltage exceeds E. At this point either D_1 or D_2 become conducting (zero resistance) and prevent any further increase of output voltage e_2.

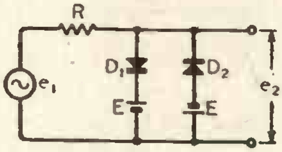


Fig. 5.

The law connecting the input voltage " e_1 " with that of the output " e_2 " is shown graphically in Fig. 6(a). Passing now from the Integral to the Fourier Series form we get in a similar manner to Fig. 2 the Fourier Series representing the periodic function of Fig. 6(b) as :

$$e_2 = \frac{4}{\pi} \sum_{m=1}^{\infty} \frac{\sin mE}{m^2} . \sin me_1 \quad .. \quad .. \quad (21)$$

where m is odd.

This series will therefore represent the law of Fig. 6(a), so long as e_1 does not exceed $(\pi - E)$.

Now assume an input signal of $e_1 = 1 \sin \omega t$. Then the output e_2 will be

$$e_2 = \frac{4}{\pi} \sum_{m=1}^{\infty} \frac{\sin mE}{m^2} \sin (m \sin \omega t)$$

$$= \frac{8}{\pi} \sum \frac{\sin mE}{m^2} \{ J_1(m) \sin \omega t + J_3(m) \sin 3\omega t + . \} \quad .. \quad (22)$$

Firstly, taking E as 1.0 when there will be no " limiting " action.

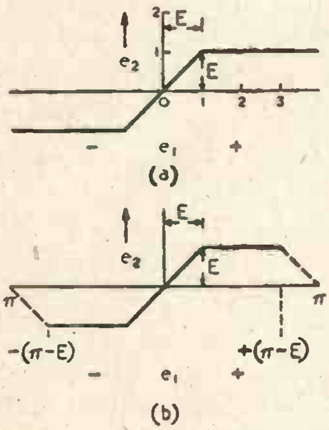


Fig. 6.

Computing eqn. (22) to three terms only, gives the amplitude of the fundamental as 0.985, and when the first six terms are taken the fundamental amplitude is 0.994.

It will be appreciated that over this region the device is linear, so that a fundamental amplitude of unity should have been obtained, and no harmonics.

To consider now the operation under conditions of " Limiting." The input signal $e_1 \doteq 1 \sin \omega t$ remains unchanged, whilst E is varied (always being less than unity) in accordance with the degree of limiting. A value of E of 0.01, for instance, will cause the output waveform to assume a virtually square-topped appearance, in which the various components follow the well-known Fourier series—at least this is true for the lower order harmonics.

Considering the third harmonic in such a case, its value computed from eqn. (22), taking six terms, differs from the square wave value by only 5 per cent. It will be appreciated that this method of solution is of real value when two or more sinusoidal input signals are applied simultaneously; this has not been worked out in detail, however, since the result follows closely on the lines of Case No. II. Eqn. (12) can be obtained from eqn. (7) by a direct analytical process, but the numerical method given can be used for an applied voltage waveform which is complex, in which case the analytical solution becomes very involved.

The late Dr. N. Partridge

It is with deep regret we record the death, as a result of enemy action, of Dr. Norman Partridge, Ph.D., B.Sc.(Eng.). He will be known to readers of this journal as an authority on transformer design, on which subject he has contributed a number of articles. Dr. Partridge was a member of the I.E.E. and Brit. I.R.E. and served on the Council and Parliamentary and Technical Committees of the latter.

Books Received

Elements of Radio. By Abraham and William Marcus. The first half of this book, which is said to be the result of " many years' experience of teaching radio," is devoted entirely to the receiver and aims at explaining progressively the functions of each stage. It does not contain a single formula. The second half of the book is devoted to electrical theory, transmitters, and more advanced aspects of radio. It is illustrated by over 500 drawings and includes a glossary and questions at the end of each chapter. George Allen and Unwin, Ltd., 40, Museum Street, London, W.C.1. Price 27s. 6d.

Introductory Magnetism and Electricity. By T. M. Yarwood. An attempt has been made in this little book to present the fundamental facts of magnetism and electricity in a logical sequence for the student with no previous knowledge of the subject. Many suggestions for experimental work are included and a set of questions on each of the twelve chapters, together with the answers, is given at the end of the book. A great deal of ground has been covered for a small book and, as the author points out in the preface, much of the work, therefore, is very incomplete. Pp. 159, Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2. Price 2s. 6d.

Correspondence

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

"Deflected Electron Beams"

To the Editor, "Wireless Engineer."

SIR,—In the first part of his paper in the June issue, Mr. Owen Harries calculates the equivalent circuit constants of a portion of an infinitely long deflecting condenser. He goes on to state, that his equation (4.1) does *not* mean that if the plates are of finite length the real part $1/R_d$ of the admittance has the meaning of an equivalent resistance across the deflecting plates. But, in fact, Mr. Harries' calculation amounts to an admirably concise derivation of Recknagel's formula. This can be seen as follows :—

Mr. Harries starts from Ramo's formula for the current induced by a moving electron, and from this he calculates, quite correctly, the current induced by the electron beam in the circuit connecting the deflector plates. The part of this current which is in phase with the deflecting potential is the same as would flow through a resistance R_d shunting the deflector plates. I have proved in my paper on "Energy Conversion in Electronic Devices" that the input connected with this current is the same as the volume integral which I have called "transit power".* An independent proof was given recently by Mr. Rodda.† Hence what Mr. Harries calculates is in fact the transit power.

I will try once more to explain why in a calculation which is based on the transit power (or its equivalent), it is not necessary to take account of the exit field, provided that it is short against the plate length and against the length traversed by an electron in a cycle. The work done on an electron in a potential field ϕ in a time interval dt is equal to the increase of its kinetic energy, and can be written as follows :

$$d\left(\tfrac{1}{2}mv^2\right)=e\left(v_x\frac{\partial\phi}{\partial x}+v_y\frac{\partial\phi}{\partial y}+v_z\frac{\partial\phi}{\partial z}\right)dt=e\left(d\phi-\frac{\partial\phi}{\partial t}\,dt\right) \qquad (1)$$

The first term depends only on the potential difference traversed by the electron, whilst the second term corresponds to the local change of potential during dt. Let us now imagine a heavy ball, representing an electron climbing up a hill shaken by an earthquake, and down again, to the same level. In this case the energy which it has lost or gained in the end is due to the earthquake which represents the alternating field. By restricting the calculation to the second term alone, that is to say, to the "transit power" we take this into account from the start. But if we do this it would be obviously wrong to take separately into account the energy gained in descending the hill, as we have not included in the calculation the energy which is lost in climbing it. Finally, if the hill terminates in a steep slope or a precipice, even the earthquake on the slope does not matter, provided that the electron falls down the slope in a time which is short enough, in the sense above defined. All that matters is that we follow the electron correctly to the edge of the precipice. This is what Mr. Harries has done in the calculation which led to his eqn. (4.1).

In the second part of his paper, Mr. Harries assumes a sine-shaped deflecting field in the middle plane, terminating with zero intensity at both ends, and assumes that "end effects are then non-existent". This is not strictly correct. Outside the middle plane, where the electron leaves the system there will be in general an x-directed field, and this cannot be neglected in the method employed by Mr. Harries. This method consists in solving the dynamical problem and calculating directly the kinetic energy with which the beam leaves the system. This would be correct, if Mr. Harries would not restrict it to the calculation of the kinetic energy connected with the y-directed motion only. Though (on p. 274) he mentions x-directed fields and their effects, he thinks that he can exclude them from the analysis. He is, of course, free to do so, but in this case he is not justified in calling the quantity which he calculates "the power used to deflect the beam". In fact, x-directed fields will necessarily arise in the case of the sine-shaped electric field assumed by him. Let this be, in the middle plane $y = 0$

$$E_x(x, 0) = 0,\ E_y(x, 0) = E_0 \sin(2\eta x/L)\cos\omega t \qquad (2)$$

It is not difficult to calculate the extension of this field in the whole x,y plane. The extension is unique if the field is assumed independent of the z-coordinate.

We introduce a length Λ defined by

$$\left|\frac{1}{L^2}-\frac{1}{\lambda^2}\right|=\frac{1}{\Lambda^2} \qquad (3)$$

where λ is the vacuum wavelength $\lambda = 2\pi c/\omega$. Two cases must be distinguished :—

(a) $\lambda > L$. (Low frequencies.) The solution is, in Gaussian units

$$E_x = E_0\,(L/\Lambda)\cos(2\pi x/L)\sinh(2\pi y/\Lambda)\cos\omega t$$
$$E_y = E_0\sin(2\pi x/L)\cosh(2\pi y/\Lambda)\cos\omega t$$
$$H_z = -E_0\,(L/\lambda)\cos(2\pi x/L)\cosh(2\pi y/\Lambda)\sin\omega t \qquad (4a)$$

H_z is the magnetic field at right angles to the plane of the drawing in Fig. 1, which shows the field lines in the special

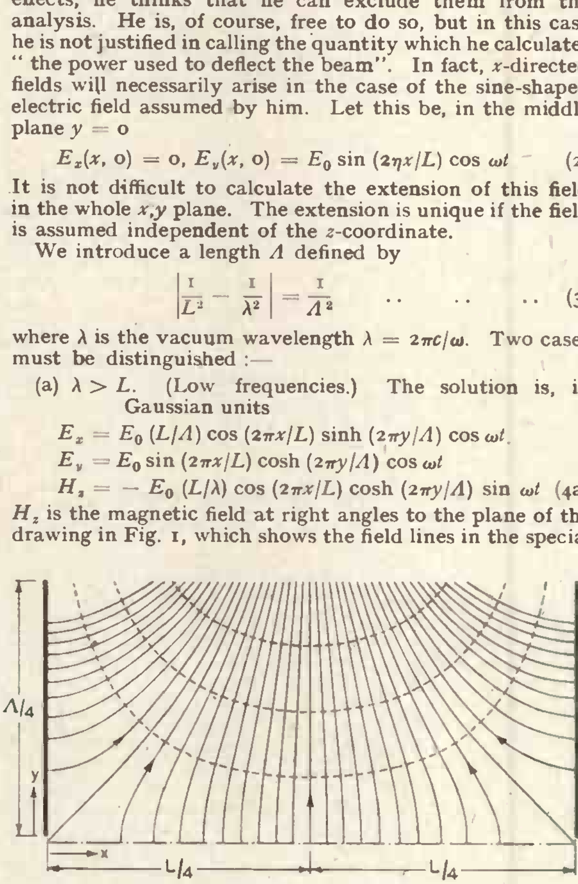


Fig. 1. *Sine-shaped deflecting field at low frequencies.*

case $\Lambda = L$, i.e. for very low frequencies. The electrode system consists of two deflector plates (any of the dotted lines at right angles to the field lines) and two end-plates.

(b) $\lambda < L$. (High frequencies.) The solution is

$$E_x = -E_0(L/\Lambda)\cos(2\pi x/L)\sin(2\pi y/\Lambda)\cos\omega t$$
$$E_y = E_0\sin(2\pi x/L)\cos(2\pi y/\Lambda)\cos\omega t$$
$$H_z = -E_0\,(L/\lambda)\cos(2\pi xL)\cos(2\pi y/\Lambda)\sin\omega t \qquad (4b)$$

This field is shown in Fig. 2, again in the special case

* D. Gabor, *Wireless Engineer*, March, 1944, p. 115.
† S. Rodda, *Wireless Engineer*, May, 1944, p. 207.

$\Lambda = L$ which now means $L^2 = 2\lambda^2$. This field can be realised with two end plates only, without deflecting electrodes of the usual kind. Though the figures illustrate only two special cases, the field for any other frequency can be obtained from them simply by changing the length Λ, i.e. by changing the y-scale.

It can be seen that at the exit of the beam, off the middle plane, there is always an x-directed field, except in the

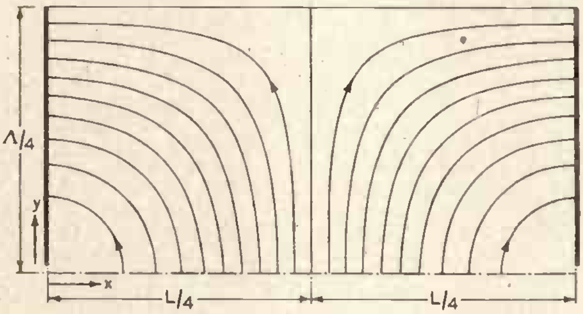


Fig. 2. *Sine-shaped deflecting field at very high frequencies.*

interesting special case $\lambda = L$. In this case the electric field is parallel to the y-axis. It can be realised by two parallel deflecting plates of length $\lambda/2$. But even in this case it would be wrong to infer that there is no change in the x-directed velocity, as the magnetic field which is now

$$H_z = -E_0 \cos(2\pi x/L) \sin \omega t$$

will bend the electron trajectories and convert some of the transversal velocity into longitudinal, and *vice versa*.

It remains, therefore, to be seen in what relation the quantity calculated by Mr. Harries stands to the real power necessary to deflect an electron beam.

Rugby D. GABOR.

Nomenclature of Dielectric Properties

To the Editor, "Wireless Engineer"

SIR,—Your Editorial "Specific Resistance, Volume Resistivity and Mass Resistivity" (May, 1944, p. 206) prompts me to raise a related topic. May I point out in passing that Roget's "Dictionary of Electrical Terms" (4th ed. 1943) gives a definition of mass resistivity which differs from yours? It is defined as "The resistance per unit length of unit mass of a substance," and is said to be convenient when dealing with wire.

In work on dielectrics, I have found it convenient to have names for some quantities which arise as follows. From the practical point of view, the properties of a dielectric under A.C. stress are expressed in terms of the capacitance and power factor of a condenser containing the dielectric compared with those of the same condenser in vacuo. In the usual case in which a sinusoidal e.m.f. produces a sinusoidal current* the admittance of the condenser with dielectric can be written—

$$Y_d = L\,(\sigma + j\omega K/3.6\pi.10^{12}) \text{ mho.}$$

L = a constant of the geometry (cm.).

σ = specific a.c. conductance (mho/cm.).

K = permittivity (o).

In vacuo $Y_o = L\,(0 + j\omega/3.6\pi.10^{12})$ mho.

The behaviour of the dielectric (at ω) is specified by the dimensionless quantity—

$$y = Y_d/Y_o = K - j3.6\pi \times 10^{12}\sigma/\omega$$
$$= K - jK'$$

or in polar form

$$y = |y|\epsilon^{-\delta} = (K^2 + K'^2)^{\frac{1}{2}} \,\underline{/-\delta}\,;\ \tan\delta = K'/K.$$

The quantities for which names seem to be needed are K, K', y, $|y|$ and δ. Roget gives at least six synonyms for K, viz., permittivity = permittance = dielectric constant = dielectric coefficient = inductivity = S.I.C. His definition of a related term, elastivity (derived from elastance = $1/C$) appears to suffer from a printer's error; it reads "A name sometimes used in permittivity." Roget prefers "permittivity." Hartshorn (*J.I.E.E.* 64, 1153, 1926) also prefers permittivity to dielectric constant because K is not generally constant for a given material, e.g. at various frequencies. An unusual meaning is attached to the term by Whitehead (*E.R.A. Rep.* L/T 34, 1929) who uses it for $|y| = \sqrt{K^2 + K'^2}$.

K' involves σ (which must be distinguished from the specific conductance measured with d.c.). There seems to be no accepted name for K'; Whitehead (*loc. cit.*) defines the "specific power loss" as $\omega K'$, but Hartshorn (*loc. cit.*) says this name may be applied to σ. The symbols Q and $\tan\delta$, where $1/Q = \tan\delta = K'/K$, are used so widely that they seem to need no special names.

y is sometimes called the "complete" or "complex" permittivity. I have been using the terms "complex admittivity" for y, and "admittivity" for $|y|$. These names are by no means unambiguous: confusion between them, or with "specific admittance" (units mho/cm.) is obviously possible. Reference to K' can be avoided by using instead the specific a.c. conductance, but this is often inconvenient.

The nomenclature in this field is far from satisfactory; since many of the quantities have no names at present, it does not seem unreasonable to hope that a discussion of suitable terms may prove fruitful.

Redbourn, Herts. C. F. BROCKELSBY.

* This is not always the case, *see* e.g. Thornton on glass (*Proc. Phys. Soc.* 24, 301, 1912).

I.E.E. Awards

DR. D. GABOR has been awarded the I.E.E. Duddell Premium for his paper "Energy Conversion in Electron Valves." The Ambrose Fleming Premium is awarded to Prof. Willis Jackson, D.Sc., and Dr. L. G. H. Huxley for their joint paper "The Solution of Transmission Line Problems by use of the Circle Diagram of Impedance." For his paper on "Wave Guides in Electrical Communication" J. Kemp receives the Extra Premium. These papers were read before the Wireless Section during the 1943/44 Session.

I.E.E. Students' Section

WE are advised of the election of the following officers of the London Students' Section of the I.E.E. for the 1944–45 Session: Chairman, C. C. Barnes; Vice-Chairman, H. Shorland; Hon. Sec., R. G. F. Stefanelli; Hon. Asst. Sec., R. V. Darton.

Institute of Physics

AT the Annual General Meeting of the Institute of Physics, the following were elected to take office on October 1st: President, Sir Frank Smith; Vice-Presidents, Prof. J. D. Cockcroft, T. Smith and Dr. F. C. Toy; Hon. Treas., Major C. E. S. Phillips; Hon. Sec., Prof. J. A. Crowther.

POST-WAR DEVELOPMENT

Reports on the Industry and Radio Engineering

TWO recently issued reports survey probable trends of progress in radio engineering and the industry. The first is the annual report of the Radio Manufacturers' Association.

In putting forward its definition of the problems with which the industry will be faced in the post-war years the R.M.A. Post-War Committee has previously expressed the view that, if there is to be any hope of a solution, these problems must be dealt with on an industry basis. Consideration has been given to the necessity of remoulding the existing organisations in the industry to form a more efficient and representative machine to deal with the increased responsibilities which organised industry must inevitably carry in the post-war years.

The report states that although there have been different views as to the means whereby this could be obtained the R.M.A. Council was agreed as to the objective, namely, that there should be " an organisation representative of the various sections of the radio industry, and empowered by those sections to speak for the industry as a whole on matters of common interest." Recognising, however, on the one hand, the difficulties which would have to be surmounted before the legal establishment of such an organisation became possible, and, on the other, the urgent necessity for the work to proceed without delay, it was thought that a first useful step might be the formation of the Radio Industry Council.

A draft constitution has been prepared, and it is proposed that the R.I.C. should, when legally constituted, take over such of the assets of the R.M.A. as may be legally transferred to it.

The Radio Industry Council held its first meeting in July 1943, and has submitted many recommendations to the Government on such matters as the post-war employment of technical personnel and the reinstatement of television. The Council's evidence to the Government Television Committee was based on the following three basic points :

(1) The television service existing when war broke out to be restarted as soon as possible after hostilities with Germany cease.

(2) The resumption to be followed by an extension of the system over the rest of the country at the greatest possible speed.

(3) Research and development to be carried out concurrently with the resumption and extension of the old system : The research work to be so planned that any resulting improved system may be begun and run concurrently with the existing transmissions.

Another problem being considered by the Council is that of the organisation of research in the industry.

Development of Radio Engineering

The first part of a report on " Post-war Development in Radio Engineering," issued by the British Institution of Radio Engineers, opens with a plea that the Government, after considering the various reports on post-war planning, should give immediate encouragement to those industries offering the greatest prospects of national well-being.

Part I of the report is confined to expressing views on the development of radio engineering. In order that fundamental research may be prosecuted on a far more vigorous scale than has been possible under the pre-war system, which was largely financed by individual private enterprise and often resulted in duplication of effort, the Institution has proposed the formation of a British Radio Research Institute. It is claimed that such an organisation will bring the universities and the individual industrial research laboratories into direct association with the Government and thereby provide the facilities which have hitherto not been fully available.

The need for a television service, broadly of a pre-war character, that is, having the following characteristics in common with 1939 standards, is stressed in the report :

(1) That the service be " broadcast," i.e. there shall be a (generally) non-directional transmission without wires.

(2) That the vision and sound transmissions be of the same order of carrier frequency as pre-war. With regard to the assignment of any new frequencies required, a conservative policy is advocated having regard to the possibility of echo trouble at higher carrier frequencies.

(3) That the bandwidth for vision transmission be of the same order as pre-war, viz. 4 Mc/s approximately.

It is pointed out that serious consideration should be given to better utilisation of the above-mentioned bandwidth by making use of vestigial side-band transmission and also to increasing the number of lines to that which is optimum for the increased modulation bandwidth.

Tentative figures proposed are :

525 lines (gross, interlaced).

3.25 Mc/s, maximum modulation frequency.

The view is expressed that in the field of communication more effort has been expended in research during the war years than in any other period of the industry's history.

It is suggested the establishment of relay chains on a single carrier frequency offers a solution which will contribute very materially to alleviation of the congestion of the ether.

The extent to which standardisation is desirable is dealt with in the report, and the conclusion is reached that " although standardisation of fully developed components and equipment is without question of paramount importance in the electronic, as in many other, industries, considerable care must be exercised to ensure that it is not pressed so far as to stifle the initiative of skilled designers".

United Nations Standards

AS a temporary measure, pending the return of full international co-operation, it has been decided to establish a United Nations Standards Co-ordinating Committee to provide for the immediate co-ordination of standards in, among others, the field of telecommunications. These standards will provide agreed methods of expressing and testing the properties of materials, appliances, symbols, terms and definitions, and will include dimensional standardisation to secure interchangeability where the replacement of parts is an important consideration.

The object of the Committee will be the promotion of the maximum possible co-ordination and unification of standards necessary for the war effort and the immediate post-war period. The promulgation of the standards will be the responsibility of the national standards organisations. Membership of the Committee will be open to national standardising bodies of the United Nations.

Offices have been set up in London and New York, and approval of the scheme has been received from Australia, Canada, South Africa and the United States. The London Office, at 19, Palace Street, S.W.1, will be run by C. le Maistre, C.B.E., who was, until his retirement, Director of the British Standards Institution.

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

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

559 417.—Preventing distortion in a push-pull A.F. amplifier when supplied with operating voltages from a power.

Standard Telephones and Cables (assignees of H. Romander). Convention date (U.S.A.) 5th February, 1942.

560 055.—Low-frequency transmission line on which the insulation leakage from both conductors to earth is automatically balanced by the use of non-linear resistances.

Rediffusion; P. Adorjan; and R. V. Roscoe. Application date 15th September, 1942.

560 219.—Construction and arrangement of the moving-coil system of a loudspeaker, microphone, or like instrument to ensure maximum magnetic flux at the boundary of the gap.

W. H. Allan. Application date 4th May, 1943.

AERIALS AND AERIAL SYSTEMS

559 424.—Short-wave "indoor" aerial with transmission-line coupling which is adjustable both in tuning and directivity for receiving television signals.

Philco Radio and Television Corporation (assignees of W. H. Newbold). Convention date (U.S.A.) 14th December, 1940.

559 471.—Wide-band short-wave aerial comprising a number of turnstile units mounted on a common vertical axis (addition to No. 528 817).

Marconi's W.T. Co. (assignees of N. E. Lindenblad). Convention date (U.S.A.) 20th December, 1941.

559 886.—Short-wave aerials of the "vee" or "double-vee" (rhombic) type in which the diameter of the conductors is varied in order to stabilise the surge impedance of the system.

Standard Telephones and Cables (assignees of C. R. Burrows). Convention date (U.S.A.) 2nd July, 1941.

DIRECTIONAL WIRELESS

559 583.—Radio goniometer for ultra-high frequencies in which the rotor and stator are coupled through dipole elements.

A. C. Cossor and F. R. W. Strafford. Application date 13th November, 1940.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

559 259.—Receiver with cyclically-varied tuning for co-operation with an aircraft radiating signals indicative of height and direction (divided out of No. 559 243).

Square D. Co. Convention date (U.S.A.) 5th February, 1941.

559 290.—Receiver for frequency-modulated signals in which the usual limiter stage is replaced by a method of balancing-out amplitude variations.

Marconi's W.T. Co. (assignees of H. O. Petersen). Convention date (U.S.A.) 27th November, 1941.

559 330.—Variable tuning device comprising a coil which is wound over, and is movable relatively to, a powdered-iron core of helical shape.

Marconi's W.T. Co. (assignees of R. L. Harvey). Convention date (U.S.A.) 31st May, 1941.

559 535.—Automatic volume control system for frequency-modulated receivers, particularly those not provided with an amplitude-limiting stage.

Philco Radio and Television Corporation (assignees of C. T. McCoy). Convention date (U.S.A.) 17th October, 1941.

559 555.—Method of using a local amplitude-modulated signal for accurately tuning a receiver of frequency-modulated signals.

Philco Radio and Television Corporation (assignees of C. T. McCov and P. McF. Craig). Convention date (U.S.A.) 21st October, 1941.

559 673.—Combined switch and volume control for changing over from radio to disc reproduction in a radio-gramophone.

A. A. Thornton (communicated by Philco Radio and Television Corporation). Application date 16th December, 1942.

559 705.—Receiver for frequency-modulated signals in which the cathodes of the discriminator valves are earthed so that the set can be operated by batteries.

Marconi's W.T. Co. (assignees of W. R. Koch). Convention date (U.S.A.) 31st July, 1941.

559 717.—Receiver in which the permeability tuning control of one circuit is ganged with the capacitance tuning control of another circuit.

Marconi's W.T. Co. (assignees of W. F. Sands and G. M. Daly). Convention date (U.S.A.) 1st July, 1941.

559 718.—Permeability tuning system with provision for the simultaneous adjustment of a capacitance across the coil in order to increase the band-width covered.

Marconi's W.T. Co. (assignees of W. van B. Roberts). Convention date (U.S.A.) 30th July, 1941.

559 780.—Muting or Q.A.V.C. system which automatically adjusts itself to different noise levels, for instance as between urban and rural reception areas.

Marconi's W.T. Co. (assignees of L. E. Thompson). Convention date (U.S.A.) 26th June, 1941.

559 841.—R.F. amplifier in which damping is deliberately applied to a tuned input circuit, in order to cover a wider band of signals, by means of a negative reaction device. (addition to No. 554 371).

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 24th February, 1943.

559 877.—Rectangular chassis which is divided by an internal member of cruciform shape to afford easy access to the component parts of a radio set.

Stratton and Co. and H. A. J. Laughton. Application date 5th September, 1942.

559 967.—Set for receiving amplitude-modulated signals at one frequency, and frequency-modulated signals at a substantially different frequency, without requiring a switching circuit.

Philco Radio and Television Corporation (assignees of C. T. McCoy). Convention date (U.S.A.) 14th November, 1941.

560 001.—Radio receiver with a pilot or indicator light which is initially energised by a reduced voltage, and thereafter by the full mains voltage.

Philco Radio and Television Corporation (assignees of A. C. Miller). Convention date (U.S.A.) 22nd November, 1941.

560 013.—Amplifier with muting circuit in which the threshold of signal reception is determined by a thermally-sensitive resistance element.

Standard Telephones and Cables; P. K. Chatterjea; L. W. Houghton; and C. T. Scully. Application date 12th September, 1942.

560 017.—Tuning indicator of the magic-eye type combined with a thermally-sensitive resistance element to increase the range of response (divided from No. 560 013).

Standard Telephones and Cables; P. K. Chatterjea; L. W. Houghton; and C. T. Scully. Application date 12th September, 1942.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

559 549.—Processing tank for television films, provided with variable-speed gear and a stroboscopic viewing device.

J. L. Baird. Application date 18th August, 1942.

560 030.—Cathode-ray tube with means for intensifying the television signals developed by the scanning stream from a photo-sensitive screen of the mosaic type.

The British Thomson-Houston Co. (communicated by the General Electric Co.). Application date 17th July, 1942.

560 092.—Preparation and mounting of a striated luminescent screen used in a cathode-ray tube for the reception of television signals in natural colour.

Marconi's W.T. Co. (assignees of H. W. Leverenz). Convention date (U.S.A.) 25th January, 1941.

560 122.—Television receiver in which A.V.C. is applied both to the picture and speech signal channels by means of thermally-sensitive resistance elements.

Standard Telephones and Cables; P. K. Chatterjea; L. W. Houghton; C. T. Scully; and D. M. Ambrose. Application date 17th September, 1942.

560 150.—Optical system, corrected for spherical aberration, for a cathode-ray television projector or camera.

Marconi's W.T. Co. (assignees of F. H. Nicoll). Convention date (U.S.A.) 1st July, 1941.

TRANSMITTING CIRCUITS AND APPARATUS

(*See also under Television*)

559 245.—Method of shielding multi-circuit cables, particularly for multiplex-carrier-wave working.

Standard Telephones and Cables (assignees of W. E. Mougey). Convention date (U.S.A.) 30th October, 1941.

559 258.—Arrangement for replacing or testing repeater or relay valves, without creating transient surges, in a multi-channel carrier signalling system.

Standard Telephones and Cables (assignees of C. H. Bidwell and P. V. Koos). Convention date (U.S.A.) 17th September, 1941.

559 289.—Frequency modulating system in which a variable resistance serves to control the frequency of a resistance-capacity-coupled oscillator.

Marconi's W.T. Co. (assignees of M. Artzt). Convention date (U.S.A.) 21st November, 1941.

559 377.—Automatically regulating both the L.T. and H.T. voltages taken from A.C. mains for energising the repeater valves of a carrier-wave signalling system.

Standard Telephones and Cables and R. Kelly. Application date 14th August, 1942.

559 484.—Automatic gain-control system in which two power-driven switches make variable contact with a closed ring of resistances in a carrier-wave signalling system.

Automatic Telephone and Electric Co. (communicated by A. C. Corner). Application date 18th August, 1942.

559 518.—High-frequency cable designed to reduce resistance losses in the outer of two coaxial lines, or in the common surrounding screen.

Telegraph Construction and Maintenance Co.; J. Dean; E. W. Smith; and R. Sear. Application date 12th May, 1942.

559 545.—Metal-foil wrapping arranged to reduce resistance losses in a high-frequency cable comprising two coaxial or balanced lines (divided out of No. 559 518).

Telegraph Construction and Maintenance Co.; J. N. Dean; E. W. Smith; and R. Sear. Application date 12th May, 1942.

559 585.—Construction of tubular wave-guide designed to allow for a gradual change in the direction of transmission.

British Insulated Cables and J. C. Quale. Application date 10th July, 1941.

559 907.—Two-way signalling system in which secondary emission in a multi-electrode discharge device is utilised to control the direction of the signal path.

Western Electric Co., Inc. Convention date (U.S.A.) 9th December, 1941.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

560 230.—Space-discharge device and circuit for regulating the voltage supply to a multi-channel carrier-wave signalling system.

Standard Telephones and Cables and R. Kelly. Application date 7th August, 1942.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

559 515.—Method of "processing" or preparing the anodes of glow-discharge tubes in order to prevent undesirable back-ignition or flash-over.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date 14th October, 1941.

559 753.—Process for exhausting and sealing the bulb of a thermionic valve.
Marconi's W.T. Co. (assignees of N. R. Smith). Convention date (U.S.A.) 31st January, 1941.

559 591.—Method of processing secondary-emission electrodes utilising a thin film of beryllium or magnesium oxide.
Standard Telephones and Cables (communicated by International Standard Electric Corporation). Application date 17th July, 1942.

559 800.—Apparatus for forming the stem, and sealing the lead-in conductors, of a thermionic valve.
The British Thomson-Houston Co. Convention date (U.S.A.) 21st January, 1942.

559 806.—Apparatus for making metal-to-glass seals, say, for thermionic valves.
Standard Telephones and Cables (assignees of C. V. Litton). Convention date (U.S.A.) 31st January, 1942.

559 824.—Method of sealing and supporting the re-entrant stub of a gas-filled electron discharge tube.
The British Thomson-Houston Co.; E. J. G. Beeson; and J. G. Brett. Application date 27th October, 1942.

560 057.—Construction and arrangement of a helical-coil thermionic cathode suitable for a gas-filled electron discharge tube.
The British Thomson-Houston Co. Convention date (U.S.A.) 17th September, 1941.

560 140.—Short-wave oscillation-generator, of the demountable type, in which provision is made for relative rotation of the grid and cathode elements, whilst the tube is under vacuum.
"Patelhold" Patentverwertungs, etc., A-G. Convention date (Switzerland) 23rd May, 1941.

450 155.—Arrangement and process for gettering electron discharge tubes.
The Mullard Radio Valve Co. and R. A. Stephen. Application date 19th August, 1942.

SUBSIDIARY APPARATUS AND MATERIALS

559 021.—Stabilising the mutual conductance of a multi-stage tube of the secondary-emission type, in shunt with a potentiometer, for supplying constant voltages to a load circuit.
H. S. Molyneux-Ffennell; F. J. G. van den Bosch; and Vacuum-Science Products. Application date 28th January, 1942.

559 181.—Method of sealing a very thin "window" into an evacuated tube containing a thermo-couple for the detection of infra-red radiation.
A. Graves; Alltools, Ltd.; G. A. R. Tones; and Cinema-Television, Ltd. Application date 19th August, 1942.

559 303.—Arrangement for amplifying a direct current by "transductor" action, i.e. the use of D.C. magnetised inductances traversed by alternating current.
Allmanna Svenska Elektriska Akt. Convention date (Sweden) 25th July, 1941.

559 376.—Clamping arrangement for the interleaved conducting and insulating layers of the "stacked" type of condenser.
Dubilier Condenser Co. (1925)*; A. E. Bennett; and R. J. Tungay. Application date 14th August, 1942.*

559 473.—Watertight construction and assembly of a stack of selenium rectifiers.
Standard Telephones and Cables (assignees of C. A. Kotterman). Convention date (U.S.A.) 3rd April, 1942.

559 502.—Grinding and assembly of the contact electrodes used for mounting a piezo-electric oscillator.
S. J. Smith. Application date 1st October, 1942.

559 513.—Glow-lamp device for indicating when a high-tension battery is at the end of its useful life.
Akt Elektrod. Convention date (Sweden) 15th November, 1938.

559 562.—Contact reinforcing device for the terminals of a thermionic valve and holder.
Carr Fastener Co. and G. Wagstaff. Application date 27th August, 1942.

559 579.—Construction of central screening-contact for a thermionic valve holder.
Carr Fastener Co. and G. Wagstaff. Application date 14th October, 1942.

559 627.—Variable condenser in the form of an outer cylinder surrounding two inner coaxial tubes which can be telescoped together.
A. Faber. Application date 26th August, 1942.

559 902.—Means for initiating the operation of a gas-filled discharge tube of the kind that normally works with a cold cathode.
Standard Telephones and Cables (assignees of W. H. Martin). Convention date (U.S.A.) 4th October, 1941.

559 920.—Rotary condenser of the trimmer type with means for preventing capacitance variations due to moisture.
United Insulator Co. and N. G. Westcombe. Application date 8th September, 1942.

559 973.—Photo-sensitive device responsive to the change of pressure created by the incidence of light on certain gases, such as nitrogen peroxide or a nitrosyl halide.
Venner Time Switches and R. G. W. Norrish. Application date 15th September, 1942.

560 181.—Suppressing parasitic radiation from D.C. to A.C. converters, of the vibrating-contact type, by a combination of filtering and screening.
H. M. Harmer. Application date 21st September, 1942.

560 236.—Variable tuning inductance comprising two series-connected coaxially-wound coils, and an auxiliary short-circuited winding or collar, arranged to slide one within the other.
The Mullard Radio Valve Co. and R. G. Clark. Application date 23rd September, 1942.

559 978.—Arrangement including a condenser in parallel with a non-linear resistance for reducing surge voltages when switching a highly-inductive circuit.
Igranic Electric Co. and C. E. Randall. Application date 8th October, 1942.

GOODS FOR EXPORT

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

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 not necessarily an indication of the importance attached to the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

PROPAGATION OF WAVES

2113. WAVE-GUIDE TERMINOLOGY [and the Danger of Confusing the "Phase Velocity" of the Interference Pattern (Kemp, 3249 of 1943) with the Phase Velocity of the Wave].—K. R. Sturley: G. W. O. H: Smith-Rose. (*Wireless Engineer*, Jan. 1944, Vol. 21, No. 244, p. 24.)

2114. RANGES OF 112 Mc/s SIGNALS: THE DETROIT/EAST-COAST WERS-SIGNALS RUMOUR [394 of February: Further News].—E. P. Tilton. (*QST*, Feb. 1944, Vol. 28, No. 2, p. 43.)

2115. THE RÔLE OF ULTRA-HIGH FREQUENCIES IN POST-WAR BROADCASTING, *and* FREQUENCIES FOR TELEVISION: FACTORS AFFECTING THE CHOICE OF CARRIER.—(*See* 2344 & 2249.)

2116. TOPOGRAPHY AND V.H.F. WAVE PROPAGATION: CONTOUR MAPS AS GUIDES IN SELECTING TRANSMITTER SITES.—H. M. French. (*QST*, Feb. 1944, Vol. 28, No. 2, pp. 15–19 and 96, 98.)

Among points discussed are :—" the highest possibilities of a good location may be lost through inability to adjust antenna height to local conditions" (illustrated by a personal experience of bad results on an apparently ideal 2624 ft summit): and standing waves in air currents, illustrated by the so-called "Moazagotl condition" behind a mountain range (Fig. 4). For other articles in this series *see* 1104 of April and back reference.

2117. WIRELESS AND WEATHER: EXPLORATION BY ULTRA-SHORT-WAVE REFLECTIONS [U.S.W. Propagation: Bending of the Direct Wave: Reflection from Atmospheric Discontinuities: Air Masses: Fronts & Occlusions: the Possibilities Visualised].—T. W. Bennington. (*Wireless World*, May 1944, Vol. 50, No. 5, pp. 146–149.)

2118. PHASE AND GROUP VELOCITY IN THE IONOSPHERE: CORRECTION TO DETAIL IN FIG. 3 [1494 of May].—G. W. O. H: Kirke. (*Wireless Engineer*, Feb. 1944, Vol. 21, No. 245, p. 57.)

2119. THE EFFECT OF THE EARTH'S MAGNETIC FIELD IN THE IONOSPHERE [Editorial, following on 1494 of May].—G. W. O. H. (*Wireless Engineer*, Jan. 1944, Vol. 21, No. 244, pp. 1–3.) "This subject has been discussed more or less fully in numerous articles and textbooks, but usually in a manner more calculated to appeal to the mathematical physicist than to the radio engineer who wishes to form a clear mental picture of the various phenomena . . ."

2120. EQUATORIAL RADIO GIRDLE: AVOIDING ZONES OF IONOSPHERE DISTURBANCE [Discussion of American Plan].—(*See* 2345.)

2121. GROUND AND CLOUD SCATTER OF ELECTROMAGNETIC RADIATION [Experimental Confirmation of Original Theory (1352 of 1939 & 2881 of 1940) giving E-Region Ionic Clouds, and Not the Ground, as Cause of Long-Delayed Diffuse Echoes reflected obliquely from Region F].—T. L. Eckersley, G. Millington, & J. W. Cox. (*Nature*, 18th March 1944, Vol. 153, No. 3881, p. 341.)

"It is not proved that ground-scatter does not exist, because it would be mixed in with the cloud-scatter from lower-angle transmission; but the fact that there is no noticeable increase of amplitude at the delay corresponding to the ground-scatter shows that the cloud-scatter is predominant. The cloud-scatter will be less at higher frequencies, so that eventually the ground-scatter will predominate; but this is not likely to be the case until frequencies greater than about 30 Mc/s are used, where ionic scatter becomes unimportant because of the lack of F-region transmission." The present tests were on frequencies from about 6.5 to 20 Mc/s.

2122. THE PROPAGATION OF ELECTROMAGNETIC WAVES OVER INHOMOGENEOUS GROUND [where the Ground Constants vary at Different Points along the Path: Incorrectness of the Usual Treatment: Use of a New Numerical Distance].—J. Grosskopf. (*Hochf: tech. u. Elek:akus.*, Oct. 1943, Vol. 62, No. 4, pp. 103–110.)

The rotating-dipole technique, with its "effective" ground constants σ_{eff} and ϵ_{eff}, was first dealt with in 1833 of 1941 and 376 & 964 of 1942. Measurement of the frequency-dependence of these "effective" constants not only enabled an exact analysis of the electrical properties of the individual strata to be carried out, but also provided information as to the suitability of a proposed site for a transmitter, over the whole frequency range contemplated.

In order, however, to apply the measured "effective" constants to the problem of wave propagation, two questions required answering. The first, the question of the attenuation over stratified ground, was answered in the paper dealt with in 1361 of 1943, where it was shown that the well-known Sommerfeld propagation function must have the homogeneous-ground constants (for which the function was derived) replaced by the "effective" constants of the stratified ground. The second question, with which the present paper is concerned, relates to the nature of the propagation process over ground with locally varying constants, that is, constants dependent on r, the distance from the transmitter, and on the azimuth ϕ.

"Hitherto, an erroneous method has generally been employed in the answering of this question. What has happened is that in connection with the first propagation formulae of Austin, Watson, and others the exponential attenuation factor $F = e^{-\alpha r}$, arising from the bending at the curved earth's surface which only occurs at large distances ("shading factor"), has been transferred to smaller distances, for which the propagation process is given by the entirely different Sommerfeld function." Thus the propagation function has been expressed in the form $\mathfrak{E} = (300\sqrt{N}/r) . e^{-\alpha r}$ mv/m, the attenuation exponent α being taken as dependent only on the ground constants and the wavelength. Similarly, where the ground constants are locally variable, the value $e^{-\alpha r}$ for F has been replaced by $e^{\int_0^r \alpha dr}$.

But the locally variable attenuation exponent is *not* dependent only on the ground constants and the wavelength; it varies also with the distance r from the transmitter, or (better) with the Sommerfeld numerical distance w_o. This point is discussed on p. 104 (eqns. 3–6), and illustrated by Fig. 1. Even for a fixed frequency and uniform ground conductivity α is dependent on r; it is therefore no constant, and the exponential form of the attenuation factor is therefore unsuitable to describe the propagation process. Incidentally, the often-used determination of α from two values taken from the field-strength decay curve ($e^{-\alpha \Delta r} = E_2/E_1$) is equally without physical meaning unless the numerical distance is also stated. Such calculations of α have already led to the apparently remarkable result that the mean attenuation coefficient calculated from measurements over a long distance was always smaller than that similarly derived from measurements over part of the distance only: energy radiating in from above has been dragged in to explain this result, which however is elucidated directly by the decrease in α with increasing distance, shown in Fig. 1.

If the representation of the attenuation in the form of an exponential factor is unsuitable for homogeneous ground, it is not to be expected that it will be any more suitable in the case of locally varying ground properties. How, then, is the propagation process to be represented correctly for such inhomogeneous ground? "An exact reply to this question by a strict solution of the wave equation $\Delta\pi + k^2\pi = 0$ is naturally not to be expected. The sensible thing to do is to build up, on the basis of the existing results of experimental propagation research, an approximate solution whose correctness will then have to be tested by further experiment. Such results are given by measurements of field-strength decay curves over inhomogeneous ground, measurements of the height-dependence of field strength, and more recently by numerous measurements of the Zenneck rotating field of the electric vector": the problem has indeed been partly solved, and the solution confirmed by measurements, in a previous paper (739 of March) where a new expression was evolved to replace the simple Sommerfeld numerical distance.

Author's summary:—"The behaviour of the attenuation in the propagation of electromagnetic waves over inhomogeneous ground is investigated, and it is found that the Sommerfeld propagation law still holds good, and gives agreement with measured field-strength curves, if a new, more generally defined numerical distance is employed. On the basis of empirical results and theoretical considerations, an expression is found for the Hertzian potential for propagation over inhomogeneous ground which, at not too great heights, satisfies the wave equation [eqn. 16] to a first approximation. With this expression for the Hertzian potential as a basis, an investigation is made into the anomalous behaviour of the Zenneck rotating field, the formation of bearing-disturbing components, and the distortions of the phase surfaces, in the neighbourhood of discontinuities in ground properties": *see* also 1605 of May and 2958 of 1943.

2123. AN EQUIVALENT CIRCUIT FOR THE UNIVERSE? [Leading Article on Kron's Recent Work].—S. Ramo: Kron. (*Gen. Elec. Review*, March 1944, Vol. 47, No. 3, p. 7.)

See McAllister, 2124, below. "When a simple electromagnetic wave, guided by a two-conductor transmission line, passes a discontinuity in the line, it is true that a myriad of complex electromagnetic waves are formed at the break. The easy, continuous, distributed network of impedances that would have represented the transmission line is no longer sufficient to depict the over-all characteristics of the complete system. However, when the new field problem is solved and the waves started at the discontinuity are all accounted for, their over-all effect on the otherwise smooth-line equivalent circuit can be represented by adding one or more lumped impedances of proper magnitude to the circuit at the discontinuity.

"And now Kron shows that the space itself inside, say, a hollow-pipe wave-guide may be properly conceived of as filled with blocks of little impedance networks . . . Never before has the breadth of circuit concepts and impedance networks been so clear as now. Never have circuits and fields and waves been so clearly and intimately related. But Kron tells us that this is only the beginning of the art of equivalent-circuit representations. A chat with him and one comes away almost convinced that one day the universe will all be clear: there will be an equivalent circuit for it."

2124. EQUIVALENT CIRCUITS OF THE ELECTROMAGNETIC FIELD.—J. F. McAllister, Jr: Kron. (*Gen. Elec. Review*, March 1944, Vol. 47, No. 3, pp. 9–14.)

A summary of three papers, Kron's "Equivalent Circuit of the Field Equations of Maxwell" [*cf.* 2 of January], "A New Approach to the Solution of High-Frequency Field Problems," by Ramo & Whinnery, and "A.C. Network Analyser Studies of Electromagnetic Cavity Resonators", by Whinnery, Concordia, Ridgway, & Kron. Whinnery & Jamieson's paper (2125, below) is also mentioned. *See* also Ramo, 2123, above.

2125. EQUIVALENT CIRCUITS FOR DISCONTINUITIES IN TRANSMISSION LINES.—J. R. Whinnery & H. W. Jamieson. (*Proc. I.R.E.*, Feb. 1944, Vol. 32, No. 2, pp. 98–114.)

Referred to in 2124, above. Authors' summary:—

"Exact equivalent circuits for several types of discontinuities in parallel-plane transmission lines are obtained by Hahn's method of matching electromagnetic-wave solutions (1336 of 1941, on cavity resonators). Values of lumped elements to be used in these are given in curve form, with rules for using results in the corresponding coaxial-line problems. Experimental checks are reported, which verify results of the calculations and stress the importance of the discontinuity capacitances appearing in the equivalent circuits."

2126. REMARKS ON THE REPORT OF F. W. PAUL GÖTZ ON "A NEW RADIATION IN THE AURORA OF 18TH/19TH SEPT. 1941" [Götz's Bright Line at 5190 A.U. (369 of 1942) identified with the Writer's "Second Green Line", investigated since 1926].—L. Vegard: F. W. P. Götz. (*Physik. Berichte*, 1st April 1943, Vol. 24, No. 7, p. 549.) From *Naturwiss.*, No. 50/51, Vol. 30, 1942. For Götz's reply, and a counter by Vegard, *see* p. 550.

2127. COSMIC RAYS AND MAGNETIC STORMS.—A. Duperier. (*Physik. Berichte*, 1st April 1943, Vol. 24, No. 7, pp. 550–551: summary, from *Observatory* [London], April 1942.) On the work dealt with in 2279 of 1942: for a later note *see* 1374 of 1943.

2128. SOLAR FLARES AND MAGNETIC STORMS [Statistical Discussion of Recent Spectrohelioscopic Observations & Older Spectroscopic Records].—H. W. Newton. (*Sci. Abstracts*, Sec. A, Jan. 1944, Vol. 47, No. 553, p. 3.)

2129. THE LONG-PERIOD VARIATIONS IN THE LENGTH OF THE 11-YEAR SOLAR PERIOD, AND CONCURRENT VARIATIONS IN TERRESTRIAL PHENOMENA.—H. W. Clough. (*Sci. Abstracts*, Sec. A, Dec. 1943, Vol. 46, No. 552, p. 226.)

2130. TEMPERATURE OF THE SOLAR REVERSING LAYER [Spectrograms covering CN Band Region yield Excitation Temperature as 5100° K], *and* A COMPARISON OF THE LIMB AND DISC SPECTRA OF THE SUN [with Special Reference to M. G. Adam's C_2 Band Results indicating Higher Temperature for Layers at Limb than for Those at Centre].—K. N. Rao. (*Sci. & Culture* [Calcutta], Feb. 1944, Vol. 9, No. 8, pp. 354–355: p. 355.)

2131. THE ULTRA-VIOLET SOLAR RADIATION IN THE SPECTRAL RANGE UVA [3120–4000 A.U., of Particular Importance as regards Chemical & Biological Effects].—T. E. Aurén. (*Physik. Berichte*, 1st April 1943, Vol. 24, No. 7, pp. 553–555: a long summary, from *Ark. Mat., Astron. och Fys.*, 1942.)

2132. THE ABSORPTION, BY THE VAPOUR OF SODIUM, OF THE YELLOW RAY OF THE NIGHT SKY.—J. Bricard & A. Kastler. (*Comptes Rendus* [Paris], 7th/28th June 1943, Vol. 216, No. 23/26, pp. 878–880.)

The note ends: "Knowing the thickness of the absorbing chamber, its temperature, and the pressure of the sodium vapour, calculation allows one to determine the magnitude of the Doppler effect of the ray emitted by the upper atmosphere, and thus to obtain information as to the temperature of the emitting atoms. Measurements of absorption for the yellow twilight ray are in progress."

2133. THE THEORY OF CORONAE AND OF IRIDESCENT CLOUDS [New Theory using only Principles of Wave Optics, and taking into consideration the Portions of the Wave Front transmitted through the Droplets].—G. N. Ramachandran. (*Sci. Abstracts*, Sec. A, Dec. 1943, Vol. 46, No. 552, p. 248.)

2134. ON THE TRANSMISSION OF LIGHT THROUGH A CLOUD OF RANDOMLY DISTRIBUTED PARTICLES [Transparent & Opaque: Calculation on Basis of Wave Optics: Diminution of Intensity (for Opaque Particles) in Forward Direction is Double what would be expected from Simple Geometric Considerations: etc.].—G. N. Ramachandran. (*Sci. Abstracts*, Sec. A, Dec. 1943, Vol. 46, No. 552, p. 235.) For previous work *see* 2647 of 1943.

2135. EXPERIMENTS TO ELUCIDATE SCATTERING IN THE SKY AND IN OPTICAL INSTRUMENTS [Measurements on Scattering of Light by Small Rock-Salt Crystals in Saturated NaCl Solution: the $I \propto r^{-2 \cdot 28}$ Law].—H. Zanstra. (*Sci. Abstracts*, Sec. A, Jan. 1944, Vol. 47, No. 553, p. 16.)

2136. THE FLUCTUATIONS OF THE ATMOSPHERIC TRANSPARENCY [and Their Causes: General Survey].—Chr. Jensen. (*Physik. Berichte*, 1st April 1943, Vol. 24, No. 7, pp. 555–556: a long summary, from *Scientia*, Special Number, 1942.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2137. THE ELECTRICAL STRUCTURE OF THUNDERSTORMS [Investigation of Time Histories of Thunderstorm Charge Distribution during Three Storms, using 8 Synchronised Recording Electrometers].—E. J. Workman & others. (*Sci. Abstracts*, Sec. A, Dec. 1943, Vol. 46, No. 552, p. 248.)

2138. THE BEHAVIOUR OF MEDIUM-VOLTAGE LINE SYSTEMS TO LIGHTNING SURGES.—C. Palestrino. (*E.T.Z.*, 16th Dec. 1943, Vol. 64, No. 49/50, pp. 659–660: long summary, from *Elettrotecnica*, 1943, Vol. 30, p. 229 onwards.)

2139. LIGHTNING STROKES ON AIRCRAFT [and the Three Main Causes: including Experiences reported in *Junkers-Nachrichten*].—(*Génie Civil*, 1st Dec. 1943, Vol. 120, No. 23, p. 273.)

2140. THE "SELF-INDUCTION" OF GASEOUS DISCHARGES [Derivation, from the Condition for the Maintenance of a Stationary Discharge, of the Differential Equation $u + \tau . du/dt = Ri - L . di/dt$].—Chr. van Geel. (*E.T.Z.*, 16th Dec. 1943, Vol. 64, No. 49/50, p. 662: summary, from *Electrotechniek*, Vol. 20, 1942, p. 111 onwards.)

2141. APPLICABILITY OF NEW COMPASSES [of Inductor Type] TO THE DETERMINATION OF THE ANGULAR ELEMENTS OF THE GEOMAGNETIC FIELD.—G. Giulietti & M. Bossolasco. (*Physik. Berichte*, 1st April 1943, Vol. 24, No. 7, p. 548.)

2142. A NEW RECORDING ELECTROMETER [based on Experiences with the Polar Year Expedition].—Dauvillier. (*See* 2283.)

2143. THE IONISATION AND POLLUTION OF THE PARISIAN ATMOSPHERE AT THE PRESENT TIME.—Odette Thellier. (*Génie Civil*, 15th Nov. 1943, Vol. 120, No. 22, p. 262: summary, from *Comptes Rendus* [Paris], 28th April 1943.) "The air of Paris appears, therefore, to be purified as a result of present circumstances."

2144. "Fogs, Clouds, and Aviation" [Book Review].—W. J. Humphreys. (*Scient. Monthly*, Feb. 1944, Vol. 58, No. 2, p. 160.) Favourably reviewed by H. T. Stetson. *Cf.* 1502 of May (book by Douglas).

PROPERTIES OF CIRCUITS

2145. An Equivalent Circuit for the Universe? *and* Equivalent Circuits of the Electromagnetic Field; *also* Equivalent Circuits for Discontinuities in Transmission Lines.—Ramo: McAllister: Whinnery & Jamieson. (*See* 2123/5.)

2146. Current-Produced Forces between Parallel Conductors of Rectangular Cross-Section [including the Derivation of Approximate Formulae (especially for the Simple Case of Bus-Bars): preceded by an Investigation of the Applicability of Eqn. 4 (for Straight Infinitely Long Thin Wires) as Approximation for Coaxial Circles].—A. Duschek. (*Arch. f. Elektrot.*, 30th June 1943, Vol. 37, No. 6, pp. 293–301.)

2147. Some Considerations on the Relation between the Current Distribution and the Course of the Magnetic Lines of Force.—H. Schwarzer. (*Arch. f. Elektrot.*, 30th June 1943, Vol. 37, No. 6, pp. 287–292.)

Spielrein (in 1915) showed that the conductor-surface of a cylindrical wire carrying a direct current in the presence of a uniform magnetic field (earth's field) can be a field-surface only if the direction of the uniform magnetic field is parallel to the axis of the wire. "In the present paper we first investigate how the current density may be distributed in a cylindrical conductor of circular section so that the conductor-surface may be a surface of the magnetic field: it is assumed that no external fields or ferromagnetic bodies are present."

"It is seen that in a straight cylindrical conductor the magnetic lines of force can be concentric circles only if the current distribution is symmetrical to the wire axis, and the conductor cross-section is circular. It is shown that if the magnetic-field lines in a Laplacian field are not concentric circles, so that the orthogonal surfaces are not plane, the field-vector magnitude along a field line is no longer constant. The relation, in such a field, between the curvature of the field lines and the average curvature of the orthogonal surfaces is derived. Further, these results are extended to a source-free eddy-current field,"

2148. Application of the Pulse Generator to the Production of Subharmonic Oscillations in a Series-Type Oscillatory Circuit [containing an Iron-Cored Choke].—R. Dehors. (*Génie Civil*, 1st Nov. 1943, Vol. 120, No. 21, p. 250: summary, from *Comptes Rendus* [Paris], 22nd March 1943.)

2149. Propagation of Sinusoidal Currents in Any Arbitrary Line [in which the Parameters l, r, c, & g are Arbitrary Functions of x, the Distance along the Line].—M. Parodi. (*Comptes Rendus* [Paris], 7th/28th June 1943, Vol. 216, No. 23/26, pp. 876–878.) "The propagation in an arbitrary line is thus controlled by equations analogous to those of a four-terminal network."

2150. Screening Properties of a Squirrel Cage of Wires.—E. B. Moullin. (*Journ. I.E.E.*, Part III, No. 13, March 1944, Vol. 91, pp. 14–22.)

"It is commonly said that an imperfect joint in a metal box which is screening r.f. apparatus is capable of permitting an appreciable field to escape even though the joint is parallel to the general direction of the flow of current induced in the screen. Since this experimental result seems perhaps a little surprising, it appeared worth while to make an analysis of a simple problem comparable with a screen. Accordingly the original source of field is taken as an infinitely long current filament $I \sin pt$: this is surrounded by a squirrel cage of N equally spaced thin wires, and the screening ratio is calculated for this system . . . It appears that the screening ratio depends on two distinct factors; one is the peripheral spacing between the wires of the cage and the other is the radius of the wires themselves. If the peripheral spacing is not greater than about $\lambda/10$ then the radius of the wires is likely to be much more important than the space between them. If the wires are not too thin the screening effect is out of all proportion to the space blocked up by them: this is reminiscent of the properties of the grid of a triode valve, a problem which is a particular case of the present one.

"To obtain good screening effect the radius of the wires should not be less than about $\lambda/100$. Provided this condition is fulfilled, then the energy radiated from the screened filament will be only of the order of 2% of that from the unscreened filament, even when the peripheral distance between wires is as much as $\lambda/10$, whatever the radius of the cage . . . The analysis should form a useful qualitative guide to the screening effect of the screens of finite dimensions used in practice.

"The equations required to solve this problem lead readily to a resonance condition for a coaxial chamber: it is shown that this condition tends very rapidly to the radial distance between the inner and outer conductor of a coaxial box being one half of a wavelength [Fig. 4]. As a final example the Q is calculated of a cylindrical chamber having no inner conductor" [Appendix 8.3]. Following on this, Appendix 8.4 deals with "an interesting paradox" in connection with a tubular current surrounded by a coaxial tube of such an inside radius that $J_0(k) = 0$: *see* also 2151, below. [For Kaden's work on electromagnetic screens with joints and gaps *see* 427 of February].

2151. The Possible Application of a "Screen Tube" as a Filter of Very Narrow Pass-Band.—Moullin. (*See* end of 2150, above.)

"Moreover, power could be transmitted through such a tube, used as a wave-guide, just because there would be no radiation from it even though current were distributed sensibly uniformly across the thickness of the thin wall. Indeed this is one reason why the condition $J_0(k) = 0$ gives the smallest radius for which a tube will act as a wave-guide with an axial electric field."

2152. Ideal Filters [and Transient Response: Letter on Bell's Article (3308 of 1943): Fallacy of Statement that "a Filter with a Large Number of Sections behaves like an Ideal Filter": the Chosen Filter is No Example against the Practicability of the Fourier Integral Concept: the True Representative of the Ideal Filter (Levy's "Reflecting Artificial Line," 2153, below): etc.].—G. L. Hamburger: D. A. Bell. (*Wireless Engineer*, Feb. 1944, Vol. 21, No. 245, pp. 57–58.)

Bell replies on p. 58: "perhaps the realisation of filters which are ideal in the mathematical sense [instead of in the sense in which "ideal" was used in his article] will bring into use filters having a better practical performance than those used hitherto."

2153. The Impulse Response of Electrical Networks, with Special Reference to the Use of Artificial Lines in Network Design.—M. Levy.

(*Journ. I.E.E.*, Part III, No. 12, Dec. 1943, Vol. 90, pp. 153–164.)

From Standard Telephones & Cables, Ltd. " The study which follows originated in a theory published by the author in a series of articles appearing between 1934 and 1937 [1797 of 1935 and back references, and refs. " 4", " 6 "] . . . Although the author has just learnt of an article by H. E. Kallmann based on the same ideas (55 of 1941), it appears to him that the following study preserves its originality as much through its point of view as through the results obtained, for the author seems to be the first to have designed circuits producing satisfactory characteristics and to have indicated the possibility of making networks and filters producing a phase-shift of 90° at all frequencies " : *cf.* Bell's letter, 2152, above.

From the author's summary :—" Part 2 presents a study of the relations between the attenuation and phase characteristics of 4-terminal networks and their response to an impulse of infinitely short duration . . . It is shown that a rigid relationship exists between the characteristics of 4-terminal networks and their impulse response. In particular :—(a) if the phase-shift produced by the network is proportional to frequency, the impulse response is even ; (b) if the phase-shift produced by the network is 90° at all frequencies, the impulse response is odd. From this theoretical analysis is developed, in Part 3, a method of obtaining any desired impulse response by means of a circuit containing a multiple-section artificial line. The response is obtained by effecting appropriate amplitude reflections at the end of each section, these reflections being produced by means of small variable condensers . . . The paper concludes with the practical consideration of filters having a phase-shift of 90° at all frequencies . . ."

2154. Introduction to Four-Terminal-Network and Filter Theory : Part II—Elementary Filter Theory [with Tabulated Results for Low- & High-Pass Types (Basic & *m*-Transformed) and Band-Pass (Basic, *m*-, & Double-*m* Transformed)]. —E. Hameister. (*Zeitschr. f. Fernmeldetech.*, 24th Nov. 1943, Vol. 24, No. 8, pp. 109–118.) For Part I *see* 38 of January.

2155. Single-Section *m*-Derived Filters : an Analysis of Low-Pass and High-Pass Types [Extension of Meixell's Method (3015 of 1941) to *m*-Derived Filters].—C. W. Miller. (*Wireless Engineer*, Jan. 1944, Vol. 21, No. 244, pp. 4–10.)

From the Metropolitan Vickers Company. Author's summary :—" Analytic expressions are developed which determine the total insertion loss and phase shift of *m*-derived filter sections when terminated in a resistance equal to $\sqrt{L_k/C_k}$ and fed from a generator of the same impedance. These expressions are shown to be functions of m and K only, where K is the frequency ratio f/f_c (for the low-pass filter) and f_c/f (for the high-pass filter). It is shown that there are two possible types of circuit which become identical for $m = 1$, and a number of typical curves are given. Analytic expressions are also given for half-section arrangements." An appendix gives definitions of some of the terms used in filter theory.

2156. " Wave Filters " [Book Review].—L. C. Jackson. (*Electrician*, 7th April 1944, Vol. 132, No. 3436, p. 299.)

2157. Coupled Circuits [Origin of the Two Resonant Frequencies, etc., made clear to Junior Students by Howe's 1916 Method].—G. W. O. H. (*Wireless Engineer*, Feb. 1944, Vol. 21, No. 245, pp. 53–57 : Editorial.)

2158. Variable Slope with Constant Current [and Its Employment in Television, Oscillography, & for Abruptly Quashing the Gain of a R.F. Amplifier without introducing Circuit Ringing].—W. H. Stevens. (*Wireless Engineer*, Jan. 1944, Vol. 21, No. 244, pp. 10–12.)

From the Cossor Research Department. " Radio research workers, and, in particular, those circuit engineers who are engaged in the task of forcing the modern valve to perform the electronic acrobatics demanded by television and similar work, feel the need, sooner or later, of a valve having a modulating electrode which would operate only on the slope of the valve and not on its anode current. Probably the most frequent requirement is the special case where it is desired to reduce the slope to zero, using the valve as an electrical 'gate'. Normally, by using standard biasing-off methods, this would mean that the anode current would also drop to zero, thus passing on to subsequent circuits a large, unwanted voltage surge. It is usually the case that the applied cut-off voltage is of transient nature and that the circuit time-constants have to be such that they pass this surge without substantially changing it, and objectionable effects arise because of it " : the case of a television signal containing both picture and synchronising information is taken as an example, and a simple two-valve circuit is described which simulates the desired " valve with variable slope and constant current". The functioning of the circuit depends on the property of pentodes or hexodes that when the anode current is varied by negative voltage applied to the suppressor or outer grid the actual cathode current is not modulated ; all that happens is that space current which was flowing to the anode is now turned back into the screen.

Other applications mentioned for the circuit are in cathode-ray oscillography (two similar pairs of pentodes thus connected are used to produce a circular time-base and also to act as radial deflection amplifiers) and in abruptly quashing the gain of a r.f. amplifier without introducing circuit ringing : this has hitherto involved the use of a push-pull amplifier.

2159. Optimum Load, R_a or $2R_a$? The Answer depends on the Valve Operating Conditions.—K. R. Sturley. (*Wireless World*, May 1944, Vol. 50, No. 5, pp. 150–151.)

"The difference between the two load conditions is therefore seen to be a function of the grid input voltage. If the latter is the limiting factor, and not the anode circuit conditions, then maximum power is obtained for $R_o = R_a$. When the input voltage is unlimited but anode voltage is fixed, $R_o = 2R_a$ gives maximum power output. . . . The result is modified if the I_a/E_a characteristics are not linear . . . but as a general rule $R_o = 2R_a$ gives more satisfactory results in practice, and corresponds to about 5% total harmonic distortion."

2160. Variable-Frequency Resistance–Capacity Oscillators [Survey, leading in Second Instalment to Description & Details of the " Decade " Oscillator (Frequency Direct-Reading on Decade Dials : Wigan's Patent, 1940), of High Accuracy for Audio & Low Carrier Frequencies].—J. A. B. Davidson. (*Electronic Eng:g*, Jan. & Feb. 1944, Vol. 16, Nos. 191 & 192, pp. 316–319 & 361–364.)

2161. Alternating-Voltage Compensators with Adjustable Frequency [Dual-Voltage Generators of Adjustable Phase].—Nüsslein & Rupp. (*See* 2272.)

2162. Coupling Circuits for High-Frequency Amplifiers.—A. Jaumann. (*Hochf:tech. u. Elek:akus.*, Oct. 1943, Vol. 62, No. 4, pp. 111–122.)

From the Siemens & Halske laboratories. The degree of amplification of an amplifier is in general a complex function of the frequency. Apart from the influence of electron transit-times, which does not begin to show itself until the decimetric-wave frequencies are reached, the amplification becomes frequency-dependent at much lower frequencies because of the internal capacitances which unavoidably bridge the input and output of the valves. Coupling circuits are networks which are introduced between the valves of a multi-stage amplifier and neutralise the bad effect of the valve capacitances over the limited range of frequencies for which the amplifier is designed. As a rule it is neither necessary nor desirable that *all* the effects of the capacitances should be neutralised as completely as possible, in other words that the amplification factor should be made real and constant over the working range; it is enough to eliminate just those effects which influence the application of the amplifier to the prescribed purpose.

There are, therefore, three practically important cases to be distinguished:—(1) The amount of amplification requires to be kept as constant as possible over the working range of frequencies, the phase characteristic being arbitrary: example, a calibrated measuring amplifier: (2) the transmission time is to be constant, so that the phase angle is a linear function of the frequency, while the amount of amplification, as a function of frequency, is left arbitrary: example, a band amplifier for frequency-modulated high frequency, where the working range corresponds to the maximum permissible frequency deviation: and (3) both the amount and the transmission time are to be kept as constant as possible: example, an oscillograph amplifier, where an undistorted reproduction of a frequency-mixture is required. For equally good approximations to complete constancy, and for equal absolute values of amplification, either condition (1) or (2) can be fulfilled over a wider frequency-range than condition (3), so that the division into three separate cases is justified.

The general form of a coupling quadripole (four-terminal network) is shown in Fig. 1, in which the complex shunt admittances $\mathfrak{G}_1$ and $\mathfrak{G}_2$ contain also the output and input capacitances of the valves. Since the internal resistance of the valve working at the input of the quadripole can always be assumed to be large compared with the shunt resistance $1/\mathfrak{G}_1$, the current J of the first valve is given, independently of frequency, by the control voltage: $J = SU_g$. Then the amplification s of a stage is given by $s = U_2/U_1 = S/(\mathfrak{G}_1 + \mathfrak{G}_2 + \mathfrak{G}_1\mathfrak{G}_2\mathfrak{R})$. The formula shows that even an asymmetrical section will give the same amplification characteristic in both directions. In the case where $\mathfrak{R} = 0$ the coupling quadripole becomes a coupling dipole (two-terminal network).

In aperiodic amplifiers the lower limiting frequency ω_1 is zero: hence ω_o, the band centre, is also zero, for ω_o by definition is $\sqrt{\omega_1\omega_2}$. The working range therefore extends from the upper cut-off frequency (represented by Ω_o) down to zero. It is sufficient to derive the coupling circuits for this simple case, since an aperiodic coupling section with the desired properties can be made to yield, by a frequency transformation, a corresponding network for any desired frequency-band. This is done as follows:—the coils L are replaced by series circuits L, K, with the resonance frequency ω_o ($K = 1/\omega_o^2L$), the condensers C by parallel circuits l, C, with the same resonance frequency ($l = 1/\omega_o^2C$). To any frequency Ω in the aperiodic output quadripole there will now correspond a frequency ω in the transformed quadripole, if (as in eqn. 3) Ω is made equal to $\pm[\omega - \omega_o^2/\omega]$, or ω equal to $\pm \Omega/2 + \sqrt{\Omega^2/4 + \omega_o^2}$; for then the impedance of a coil, $\Omega L = L(\omega - \omega_o^2/\omega) = \omega L - 1/\omega K$, correctly transforms into the impedance of a series circuit, and the same applies to the condenser and its derived parallel circuit.

If the working range of the transformed quadripole lies in the band ω_1 to ω_2, eqn. 3 and the relation $\omega_o = \sqrt{\omega_1\omega_2}$ combine to give $\Omega_o = \omega_2 - \omega_1$, so that a start must be made from an aperiodic coupling circuit with the same absolute band width. This makes it clear that the amplification attainable with a given valve (*i.e.* with given values of C and S) depends only on the absolute width of the frequency band which is to be amplified uniformly, and not on the position of this band in the whole frequency range.

On these lines the approximately equally effective coupling dipoles and coupling quadripoles (the comparative merits of the two types of circuit are discussed in each case) are calculated for the three main conditions specified at the beginning of the abstract; the results are expressed in sets of curves designed for direct practical use. The simplicity of their application is shown by some examples which are worked out. It is to be noted that the quantity v encountered throughout the paper is the *relative* amplification, the quotient of the amplification s by its value s_o at zero frequency.

2163. WIDE-BAND CIRCUIT FOR I.F. AMPLIFIERS [*e.g.* in Television Receivers, to separate Vision & Sound Signals: Insensitive to Stray Circuit Capacitances tending to Shift the Range].—(*Electronic Eng:g*, Jan. 1944, Vol. 16, No. 191, p. 350.) No source for this circuit is mentioned, but the inductances and condensers are arranged as in the Telefunken circuit described in 2343 of 1943 (Weber).

2164. MEASUREMENT OF THE MEAN BACKGROUND NOISE OF AN AMPLIFIER BY A THERMOCOUPLE AND A RECTIFIER-TYPE METER.—Baurand & Vallantin. (*See* 2270.)

2165. A PRACTICAL VALVE AMPLIFIER FOR MEASURING GLASS-ELECTRODE POTENTIALS [using only Two RCA 32 and One RCA 30 Valves].—Chun-yu Lin. (*Journ. of Scient. Instr.*, March 1944, Vol. 21, No. 3, pp. 48–49.) "Can be usefully adapted to other purposes where a high gain of voltage amplification and economy of power supply are needed."

2166. CONTRIBUTIONS TO THE THEORY OF AUTOMATIC CONTROLLERS AND FOLLOWERS [Servo-Operated Instruments: Representation by Negative-Feedback Amplifiers: Operational Treatment of Time Lags, etc.].—D. G. Prinz. (*Journ. of Scient. Instr.*, April 1944, Vol. 21, No. 4, pp. 53–64.)

"While much of the contents of this paper is to be found in current literature on automatic control, servo-operated instruments, feedback amplifiers, and operational calculus, there are a number of points which seem novel and interesting. These include:—(1) The treatment of all the system variables on the same footing, regardless of whether they belong to the controlling part or the controlled part; (2) the resolution of the system in non-interacting elements, characterised by simple differential operators which on multiplying lead to the differential equation of the system; (3) the concept of the equilibrium system, giving a simple standard form for operators and equivalent networks; (4) the method of solving the characteristic equation, and some of the quantitative results of this solution; (5) the resolution of over-damped oscillatory systems in two non-interacting delay elements, and the expression for their time constants in terms of the undamped period; (6) the derivation of operators and equivalent networks for stabilising and time-reducing ('potentiometric') systems; and (7) some of the quantitative results on follower response.

"It is hoped that these simplifications, by contributing to a better understanding of control theory, will be of some help in the analysis of problems in the fields of process control and instrument design, as well as in the synthesis of their practical solutions."

2167. Appendix on the Use of a High-Resistance Grid Leak with the Cathode Follower.—Sowerby. (In paper dealt with in 2434, below.)

2168. Cathode-Follower Output Stage: Loud-speaker Damping Improved by Low Output Impedance.—Mitchell. (*See* 2227.)

2169. Cathode-Follower Output Stage [Report on Tests on Same Lines as Mitchell's (2168, above)].—Baker. (*See* 2228.)

2170. New Contrast-Expansion Unit [Cathode-Follower Circuit suggested in 1881 of June: Report on First Trials of Similar Circuit].—W. C. Newman: Felix. (*Wireless World*, May 1944, Vol. 50, No. 5, p. 152.) "In the meantime the writer would thank M. O. Felix for a contrast circuit which causes less distortion of transients than any other circuit the writer has tried, and which is very free from hum pick-up and noise due to contrast operation."

2171. Volume-Expansion Problem [Difficulty encountered with All Types of Expander using Variable-Gain Valves or Valves used as Variable Impedances: Large Voltage Swings (at, *e.g.*, 10 c/s) at Anode of Expander Valve: perhaps the Origin of Previously Reported "Objectionable Flutter": Satisfactory Remedy requested].—A. A. Tomkins. (*Wireless World*, May 1944, Vol. 50, No. 5, pp. 152–153.)

2172. A New Slide-Rule-Type Rapid Calculator [for R.F. Circuits, Coils, etc.].—Allied Radio. (*Journ. Applied Phys.*, Feb. 1944, Vol. 15, No. 2, p. 149.)

2173. Potential-Divider Design: a Simple Formula and a Useful Calculating Chart.—P. F. Cundy. (*Wireless World*, May 1944, Vol. 50, No. 5, pp. 154–155.)

2174. Graphical Method for the Determination of the Harmonics of Rectifiers.—J. Erlach. (*Elektrot. u. Masch:bau*, 10th Dec. 1943, Vol. 61, No. 49/50, pp. 613–614: summary, from *Jahrb. A.E.G.-Forsch.*, 1941.)

TRANSMISSION

2175. On the Theory of Velocity-Modulated Transit-Time Valves [Extension of Kockel's Calculations of the "Heil Chamber" (407 of 1942: the Oscillatory Circuit is so connected that the Two Fields are in Opposed Phase) to a Similar Generator where They are In Phase: also a General Method for calculating the Efficiency].—H. Döring. (*Hochf:tech. u. Elek:akus.*, Oct. 1943, Vol. 62, No. 4, pp. 98–101.)

Author's summary:—" A transit-time generator, similar to a Heil chamber, is discussed in which the electron beam passes through two infinitely short, co-phasal fields of equal amplitude, separated by a field-free drift space. For this discussion, the calculation of the efficiency can be carried out with the help of the results found by Kockel for the Heil chamber, after a simple transformation. It is shown that the oscillation regions of this generator occur at those points where the damping regions occur in the case of the Heil chamber, and *vice versa*. The maximum efficiency of 25% lies in the first damping-reduction region, for a drift-tube length $\Theta = 1.4\pi$ and a modulation $\beta = 0.5$; in the second damping-reduction region the maximum efficiency is 21%, for $\Theta = 3.3\pi$ and $\beta = 0.4$, and it decreases further in subsequent oscillation regions [for a Heil chamber, on the other hand, the strongest damping reduction is in the second region, $\Theta = 2\frac{1}{2}\pi$ and $\beta = 0.5$, which in the co-phasal generator now considered is a region of damping. In both cases the efficiency is about half that of the klystron generator, primarily because the modulation at an infinitely short "catching" field can amount at most to 0.5, whereas in the klystron β_2 approaches unity]. It is pointed out [footnote "4"] that the calculation of the efficiency from the active component of the convection-current fundamental wave yields the same formulae and results.

"Finally, a method is described by which the efficiency can be calculated for a generalised velocity-modulated transit-time generator with infinitely short fields of different modulations and phases. The application of the general formulae here obtained to the special cases of the Heil chamber, the co-phasal generator here considered, and the klystron with low velocity-modulation and a long drift space, is carried through and leads to the partly known values of 26, 25, and 58% respectively". This last method, for calculating the efficiency of a transit-time generator from the mean energy of emergence of the electrons, may also be applied to arrangements with fields of finite length; but it is pointed out that in this case the electron motions in the fields are represented by transcendental equations which must be solved for the most widely different phases of entry, so that the electron velocity averaged over a period may be determined. Also the generator without any drift space (discussed in footnote "3"), with at least one field of finite length, could be dealt with by the method.

2176. Limits for the Generation of the Shortest Undamped Electric Waves: Preliminary Report.—W. Dällenbach. (*Hochf:tech. u. Elek:akus.*, Oct. 1943, Vol. 62, No. 4, pp. 102–103.)

The balance of power of a generator of undamped electric waves can be written $N = \bar{\bar{U}}\,\bar{\bar{i}}\eta_E - \frac{1}{2}(G_1/\sqrt{\lambda})\hat{U}^2$ ..(1), where N is the useful power, $\bar{\bar{U}}$ the d.c. feed voltage, $\bar{\bar{i}}$ the mean value of the supplied d.c., η_E the efficiency of the electron flow, $\hat{U}$ the peak value of the alternating voltage at the place where oscillation is set up, and G_1 the loss admittance, at a wavelength $\lambda = 1$ cm, of the oscillatory system made up of the resonator, retroaction channel, and control space. Thus for a given wavelength λ the useful power N depends on a number of parameters, namely $\bar{\bar{U}}$, $\bar{\bar{i}}$, and $\hat{U}$, the geometrical dimensions of the arrangement, and material constants such as the volume resistivity of the conducting parts carrying h.f. currents. It must be fundamentally possible so to choose these parameters that, for a given wavelength, N shall take on the highest possible value N_{max}. It is of particular interest to find how this N_{max} decreases with decreasing wavelength: obviously there exists a shortest wavelength, still possible to generate, for which N_{max} will be just on zero.

"It is not to be expected that a full and general solution of this problem will be found in the present note. What I believe I can provide is merely a theoretical treatment, carried through, it is true, to the point of numerical results [not in this preliminary note] but only in an example with radical simplifications. If, nevertheless, certain viewpoints emerge which seem to me to be useful for the planning of a systematic advance in the field of very short undamped electric waves, this is due to the fact that all the reasoning is based on the two pillars 'mechanics of the electron' and 'Maxwell's theory,' so that calculations are possible in which adequate judgments can be formed as to the practical importance of the simplifying assumptions made, and as to the degree of approximation to actual conditions which is attained".

The results of the work contained in this preliminary report may be indicated by quoting the final paragraph, describing the last stages of the application of the general equations to the simplified case of a generator in which the controlled and oscillation-producing electron flow is a parallel beam of circular cross-section q arriving at an oscillation-producing space of length d in the form of electron bunches which constitute a series of pulses of mean d.c. value $\bar{\bar{i}}$ and uniform velocity $\bar{U}$. These pulses follow each other at intervals of one h.f. period and are very short compared with the length of a period. Among several other assumptions made, the resonator is taken to be a cylindrical concentric cavity resonator of the intermediate, lowest-loss form, half-way between the narrow tube and the flat box, described in a previous paper (29 of January) whose results are utilised here.

This final paragraph runs as follows :—" If, in eqn. 1 [*see* above], we insert in succession the values of $\bar{\bar{i}}$ from eqns. 3, 4, and 5, taking into account also eqns. 7, 8, and 9, and also that (according to paragraph " a ") G_1 is determined from the parameter g of eqn. 6, we obtain for the three effects of thermal dissipation, current density, and space charge three separate equations corresponding to eqn. 1, in which the quantities $\bar{\bar{U}}$, q/λ^2, and d/λ remain as important parameters still to be determined [$\hat{U}$ has already been eliminated by expressing it in terms of $\bar{\bar{U}}$. This occurs as follows :—if the ratio $\hat{U}/\bar{\bar{U}}$ is suitably chosen, the electron bunches arrive at the anode with zero velocity, and the efficiency of the electron flow becomes $\eta_E = 1$. The ratio $\hat{U}/\bar{\bar{U}}$ satisfying this condition is, according to unpublished calculations by Kleinsteuber, a function of a single variable, namely of the parameter $\beta = \{m(2\pi c)^2/e\bar{\bar{U}}\} \cdot (d/\lambda)^2$, and this relation is used to express $\hat{U}$ in eqn. 1 in terms of $\bar{\bar{U}}$]. The discussion of these three equations yields numerically [not here] three viewpoints for the optimum choice of the remaining parameters, and therewith three values for N_{max} as a function of λ. The important point is the smallest N_{max} of these three values, at the corresponding wavelength ; always, of course, on condition that the wavelength remains above the limit set by the entry of disturbing autoelectronic discharges". Similar treatments can be applied to other generating mechanisms and other types of resonator.

2177. Impulse Formation and Oscillatory Output for an Electron Flow in the Longitudinal-Field Chamber [and the High Efficiency of the Energy Conversion when the Entering Flow of Electrons occurs in Periodic Pulses : Methods based on (i) " Field Focusing " and (ii) the " Screening-Out of Phases "].—M. Geiger. (*Physik. Berichte*, 1st Aug. 1941, Vol. 22, No. 15, p. 1571 : 1st April 1943, Vol. 24, No. 7, p. 515.) Abstracts of the two papers referred to in 3336 of 1943. For an introductory paper *see* 109 of 1942.

2178. Modulation Theory [Unified Concept of Modulation (Properly Adapted Complex Notation allows Amplitude- and Phase- or Frequency-Modulation to be considered as Special Cases of a General Type of Modulation, here called Hybrid, which is encountered in Practice more often than a Pure Type, as a result of Passage through a Transmission Network) : Number & Strength of Sidebands : Fate of Modulation on Passage through a Filter: etc.].—A. Bloch. (*Journ. I.E.E.*, Part III, No. 13, March 1944, pp. 31–42.)

One of the chief reasons why complex notation has so far been used to such a small extent in this special field is probably the inherent clumsiness of its usual form, $e^{j\omega t}$. The writer therefore uses a combination of Campbell's cisoidal notation ($e^{j\omega t} = \text{cis}\ \omega t$), the (script) R operator giving the order to take the real part of the expression following, and the cos $\omega t = \frac{1}{2}e^{j\omega t} - \frac{1}{2}e^{-j\omega t}$ form used by Wheeler (3297 of 1941). In this way he is able in a large number of instances to make the analytical expression the direct counterpart of the usual vector treatment, one term for each sideband vector. Thus the simple a.m. carrier becomes $R[\text{cis}\ \omega_c t + \frac{1}{2}m\ \text{cis}\ (\omega_c + \omega_a)t + \frac{1}{2}m\ \text{cis}\ (\omega_c - \omega_a)t]$. "In collecting the material for the paper, new mathematical viewpoints presented themselves automatically so that the contents are not altogether a mere array of known results in novel dress." For example, if the filter function is given as a power series, the new complex " modulating function " can be derived without actually performing the spectral analysis of the original modulating function, and a formula is obtained which contains Carson & Fry's " variable-frequency circuit theory " as a special case. If on the other hand the filter function is given as a trigonometrical series, the method of " paired echoes " is arrived at by simpler and more general means than in Wheeler's paper (3642 of 1939) and is further simplified to a method of unpaired echoes. The first of two appendixes gives an introduction to Bessel functions, leading to the spectrum of a f.m. wave ; the second arrives at a concise calculation of modulation products by expressing the modulator characteristic as a straight line with a superposed disturbance function.

2179. Method of Altering the Width of the Frequency Band of Electrically Transmitted Intelligence.—Krawinkel. (*See* 2346.)

2180. A Valve Oscillator Theorem [Letter prompted by Williams's Paper (3348 of 1943) : Criticism of Treatment of Tuned-Anode & Colpitts Oscillators as " Essentially of Different Types " : the Maintenance Condition for the Colpitts Oscillator].—W. P. N. Court : Williams. (*Wireless Engineer*, Jan. 1944, Vol. 21, No. 244, pp. 23–24.)

2181. Energy Conversion in Electronic Devices [Short Summary of I.E.E. Paper].—D. Gabor. (*Electrician*, 14th April 1944, Vol. 132, No. 3437, p. 322.)

2182. Control Circuits [for Transmitters].—H. D. Hall. (*QST*, Feb. 1944, Vol. 28, No. 2, pp. 60–61.) " Although my circuits do not prevent the operator from coming into contact with high voltage, they provide really flexible control of the station and also incorporate some desirable safeguards for the tubes."

RECEPTION

2183. The Phase Discriminator : Its Use as Frequency/Amplitude Converter for F.M. Reception.—K. R. Sturley. (*Wireless Engineer*, Feb. 1944, Vol. 21, No. 245, pp. 72–78.)

The characteristics required of a phase discriminator when it is to function thus are not exactly the same as those needed for a.f.c. purposes, its original field of employment. Linearity of output voltage with change of frequency is now all-important, and maximum rate of change of amplitude with change of frequency (the requirement for a.f.c.) must be sacrificed for this. " Couplings greater than critical ($Qk = 1$) are necessary in order to obtain a linear characteristic over a sufficiently wide range of off-tune frequencies. The greatest range is from $QF = 0$ to ± 1 ($\Delta f = 0$ to $\pm 0.5\ f_m/Q$) with $Qk = 2$, $E_2/E_1 = 2$, and $L_2/L_1 = 1$, but greater conversion efficiency at a slight sacrifice of linearity (the QF range is from 0 to $\pm$ 0.8) is obtained with $Qk = 1.5$, $E_2/E_1 = 2$, and $L_2/L_1 = 1.77$, and these values appear to give the optimum practical design " ; here F represents twice the off-tune frequency from the mid-frequency f_m, divided by f_m.

2184. IGNITION NOISE ON THE V.H.F. AND U.H.F: AN INVESTIGATION OF THE PROBLEM OF ELECTRICAL DISTURBANCES IN MOBILE RECEPTION.—C. M. Dean. (*QST*, Jan. 1944, Vol. 28, No. 1, pp. 44–49 and 90, 92.)

2185. REDUCING MAINS-BORNE INTERFERENCE: TRANSFORMER SCREENING [Letter prompted by Ledward's Article, 1156 of April: the Effect of Interference re-radiated by House Wiring: Author's Reply].—J. Weaver: T. A. Ledward. (*Wireless World*, April 1944, Vol. 50, No. 4, p. 118.)

2186. A TENTATIVE STATISTICAL STUDY OF DOMESTIC RADIO INTERFERENCE [Hitherto Unpublished Account of Investigation leading to Key Specification B.S. 800 " Permissible Limits of Radio Interference ", providing Criterion for Award of " Radio-Interference-Free Mark "].—S. Whitehead. (*Journ. I.E.E.*, Part III, No. 12, Dec. 1943, Vol. 90, pp. 181–192.)

" Applications for licences to use the Mark had been received and legislation recognising it was under review in 1939, so that more comprehensive information was quickly anticipated. Action was, however, deferred by the advent of war, and when resumed the subject may require reconsideration in the light of the probably different conditions and of the technical progress in the high-frequency field made in war-time. Publication therefore seems advantageous both in order to describe a technical basis of coordination which has been taken further in Great Britain than in other countries, and also to indicate those directions in which this coordination can be improved and extended. . . ."

Among various tentative conclusions arrived at are the following: " it is estimated that the application of B.S. 800 would, on the long-wave band, eliminate 50% of instances of interference for broadcast fields of 1 mv/m, 70% for 3.16 mv/m, and 80% for 10 mv/m, while the remanent interference in the medium-wave band for these field strengths should be negligible ": and " it is estimated that the chance of interference to existing outdoor aerials is of the order of one-half that applying to all existing aerials. The employment of standardised aerials comprising one or more of those recommended in B.S. 905 would effect a considerable reduction of interference ".

2187. NON-INTERFERING DOMESTIC DEVICES [Letter prompted by " Diallist's " Remarks, 1915 of June: the Induction-Type Motor as the Solution].—T. L. Franklin: " Diallist." (*Wireless World*, April 1944, Vol. 50, No. 4, p. 119.) *See* also " Diallist's " welcome to Franklin's recommendation, issue for May, No. 5, p. 158.

2188. THE EFFECTS OF DIRT ON THE DESIGN AND WORKING OF OPEN-AIR HIGH-VOLTAGE SYSTEMS [near Factories & Railways].—A. Roggendorf. (*E.T.Z.*, 4th Nov. 1943, Vol. 64, No. 43/44, pp. 572–578.)

2189. AMERICAN BROADCAST SETS [Some R.M.A. Statements on the First 10 000 Imported Receivers].—R.M.A. (*Wireless World*, April 1944, Vol. 50, No. 4, p. 120.)

2190. ECONOMIES IN METAL, ETC., IN THE 1942 BROADCAST RECEIVER COMPARED WITH THE CORRESPONDING 1939 TYPE [French Data].—(*Génie Civil*, 1st Nov. 1943, Vol. 120, No. 21, p. 242.)

2191. " RADIO RECEIVER DESIGN," *and* " THE TECHNIQUE OF RADIO DESIGN " [Book Reviews].—K. R. Sturley: E. E. Zepler. (*Wireless Engineer*, Jan. 1944, Vol. 21, No. 244, pp. 22–23: p. 23.) For previous reviews *see* 2132 of 1943 and 258 of January.

2192. " RADIO UPKEEP AND REPAIRS: SIXTH EDITION " [Book Review].—A. T. Witts. (*Electrician*, 10th March 1944, Vol. 132, No. 3432, p. 209.)

2193. THE TESTOSCOPE, FOR RADIO FAULT FINDING [" Vest-Pocket " Tester for Electricians, Wiremen, & Wireless Service-Men].—Runbaken Elec. Products. (*Electrician*, 24th Dec. 1943, Vol. 131, No. 3421, p. 640.)

2194. SERVICE-MEN'S ORGANISATION [Active Steps now being Taken: Letter prompted by 1922 of June].—J. H. Corbett: Goldstein. (*Wireless World*, April 1944, Vol. 50, No. 4, p. 119.)

AERIALS AND AERIAL SYSTEMS

2195. SCREENING PROPERTIES OF A SQUIRREL CAGE OF WIRES.—Moullin. (*See* 2150.)

2196. ON ESTIMATING THE TOTAL OUTPUT OF A CURTAIN ARRAY OF AERIALS AND THE CURRENT DISTRIBUTION AMONG ITS MEMBERS.—E. B. Moullin. (*Journ. I.E.E.*, Part III, No. 13, March 1944, pp. 23–30.)

" The purpose of this paper is to investigate the practicability of estimating the total power output of a wide and high curtain array by measuring the field strength at one point near the ground and distant about a wavelength from the plane of the curtain [*cf.* McPetrie, for a half-wave aerial]; and, moreover, to see whether the distribution of currents across the curtain can be disclosed by the response of a monitor aerial which is moved in a plane parallel to the curtain. The method of approach is to investigate analytically the field close to a grid of N current filaments of infinite length. Such an investigation shows that the radiated field approximates to a plane wave at points near the grid, and to a cylindrical wave at distant points. It is the plane-wave region which offers desirable properties for the practical application envisaged in this paper.

" It is shown that a Franklin array approaches very rapidly to an infinite current filament, and thereby an expression is derived for the limiting value of the power gain of a curtain array of any width and height: such expression, however, is a by-product of the investigation."

Conditions for the best use of a monitor aerial for measuring the total output of a broadside array are found. As regards exploration of the current distribution (equality of loading), it is shown that a monitor aerial is in essence the wrong means to employ, and that such exploration ought to be carried out with a monitor loop: such a loop, however, is liable to yield a spurious reading in consequence of its tendency to act simultaneously as an ill-constructed monitor aerial. " Reliable monitor loops may well merit development by systematic experimental methods ": at wavelengths below, say, 5 m " the difficulty may well be almost insuperable.". As regards equality of phase, on the other hand, it is shown how maladjustments of phase can be located by systematic analysis of the inequalities in response of a monitor aerial which is moved parallel to the plane of a curtain array.

2197. HALLEN'S THEORY FOR A STRAIGHT, PERFECTLY CONDUCTING WIRE, USED AS A TRANSMITTING OR RECEIVING AERIAL.—C. J. Bouwkamp. (*Physica*, July 1942, Vol. 9, No. 7, p. 609 onwards: in English.)

It is assumed that the wire is of uniform diameter $2a$, much smaller than $2l$. From Hallén's general theory the writer first derives the current distribution $I(z)$ (where $-l \leq z \leq +l$) as a function of the constant $\Omega = 2 \log_e (2l/a)$. Iteration of the integral equation leads to a representation of $I(z)$ as the quotient of two power series in increasing powers of $1/\Omega$, whose convergence is not at present investigated generally. Treatment of the terms up to Ω^{-2} is made possible by tables of the corresponding coefficient functions, dependent chiefly on the ratio l/λ. The value for I (0) yields the aerial impedance as a function of $2\pi l/\lambda$, the real component representing, as usual, the radiation resistance and the imaginary component the aerial reactance.

The writer then shows, by taking into account a form factor $\mu(2\pi l/\lambda)$, also developed to the second order, that a receiving aerial of effective length $2l\mu$ is to be regarded as a generator with an internal resistance corresponding to the input resistance of a similar aerial used as a transmitter. The numerical values of the functions determining the impedance are given in tables for the range $0 \leq 2\pi l/\lambda \leq 5$. Finally, the departures from the results of the "classical" formulae, based on $\Omega = 0$ for sinusoidal current distribution, are calculated for three finite values of Ω for a full-wave and a half-wave aerial.

2198. THE IMPEDANCE OF SHORT, LONG, AND CAPACITIVELY LOADED ANTENNAS, WITH A CRITICAL DISCUSSION OF THE ANTENNA PROBLEM.—R. King & C. W. Harrison, Jr. (*Journ. Applied Phys.*, Feb. 1944, Vol. 15, No. 2, pp. 170–185.)

Part I "extends and supplements the data computed from Hallén's formula (817 of March) for the self-impedance of a symmetrical, centre-driven antenna and represented graphically in an earlier paper (423 of 1943)". Part II is "a critical discussion of formulas for the self-impedance of antennas obtained in different ways by a number of investigators, including Hallén": it is concluded that "Hallén's formula probably is a better approximation for an antenna consisting of two sufficiently thin ellipsoids each of semi-minor axis a placed end to end than for cylinders, but that cylindrical antennas driven in various ways can be approximated by using an effective value of h/a and a suitably chosen capacitance across the input terminals". For other recent papers *see* 1933 & 1934 of June.

2199. TERMINAL FUNCTIONS FOR ANTENNAS [Recently Calculated Values of Input Impedance of Cylindrical Aerials (423 of 1943) now expressed in Form adapted to Transmission-Line Equations: Curves showing Effect of Various Aerial & Line Parameters on Circuit consisting of Line with Aerial as Load, and Application to the Transfer of Power from Line to Aerial].—D. D. King & R. King. (*Journ. Applied Phys.*, Feb. 1944, Vol. 15, No. 2, pp. 186–192.)

"The mathematical form of a new theoretical or experimental result is often determined by the methods used to obtain it, or perhaps by some long-standing convention. A suitable transformation may facilitate the physical interpretation and engineering application of the original expression . . ."

2200. ON THE MAXIMUM EFFICIENCY OF A WAVE PROJECTOR [Theoretical Treatment based on the Huygens Principle].—H. Gutton & A. Ortusi. (*Comptes Rendus* [Paris], 20th April 1942, Vol. 214, No. 16, p. 736 onwards.) The value of ϕ for which the maximum output occurs is calculated for the energy $W = A\iint_s \phi^2 dS$ linked with a surface element dS, and some indications are given as to the application of the result.

2201. COMPARATIVE MERITS OF DIFFERENT TYPES OF DIRECTIVE AERIALS FOR COMMUNICATIONS [Summary of Opening Paper & Discussion, Wireless Section, I.E.E.].—J. A. Smale & others. (*Journ. I.E.E.*, Part III, No. 13, March 1944, Vol. 91, pp. 12–13) Summaries have already been referred to in 1203 of April and 1582 of May.

2202. A DIRECTIVE-ANTENNA FOR THE LOW FREQUENCIES [Principles of Pattern Control by Phase Shifting, applied to Simple Three-Element System for Amateur Low-Frequency Bands].—B. Penners. (*QST*, Feb. 1944, Vol. 28, No. 2, pp. 40–42.)

2203. DATA SHEET NO. 57: AERIAL CHARACTERISTICS, V—RADIATION RESISTANCE AND EFFECTIVE HEIGHT: *and* NO. 58: CONICAL AERIALS.—(*Electronic Eng:g.*, Jan. 1944, Vol. 16, pp. 329–330: pp. 331–332.) Corrections to Data Sheet No. 56 (1202 of April) are given at the foot of p. 330.

2204. DATA SHEETS NOS. 59 TO 62: AERIAL CHARACTERISTICS, VI—THIN CYLINDRICAL AERIALS.—(*Electronic Eng:g.*, Feb. 1944, Vol. 16, No. 192, pp. 373–376.)

2205. A NETTING AERIAL FOR LIFEBOATS [increasing the Efficiency of Radiation].—Rees Mace Mfg. (*Wireless World*, May 1944, Vol. 50, No. 5, p. 155: photograph & caption only.)

2206. ON THE MELTING OF ICE COATINGS ON LINES [Deficiencies of the Usual Halbach Formula for the Required Current: a New Formula taking into account the Thickness of the Deposit and the Melting Time: Some Results].—L. von Verebély. (*E.T.Z.*, 4th Nov. 1943, Vol. 64, No. 43/44, pp. 585–586: summary only.)

VALVES AND THERMIONICS

2207. ON THE THEORY OF VELOCITY-MODULATED TRANSIT-TIME VALVES.—Döring. (*See* 2175.)

2208. NEW PUSH-PULL BEAM TETRODE V.H.F. TRANSMITTING TUBE [Type 829-B: Max. Plate Dissipation 40 Watts: Advantages over the Type 829].—R.C.A. (*QST*, Feb. 1944, Vol. 28, No. 2, p. 48.)

2209. "MICROTUBE" VALVES FOR AMERICAN "PERSONAL PORTABLES" AND HEARING AIDS.—(*Wireless World*, May 1944, Vol. 50, No. 5, p. 139 and Cover.)

2210. VALVE AMPLIFICATION FACTOR.—H. Herne. (*Wireless Engineer*, Feb. 1944, Vol. 21, No. 245, pp. 59–64.)

Author's summary:—"A new treatment of the electrostatic field of a triode is outlined [based on consideration of "the shaded cell of the infinite uniform grid shown in

Fig. 1. From this it is possible by an appeal to symmetry to build up the whole electrostatic field of the grid . . ."], and it is shown to be valid for values of the grid wire diameter from zero to two-thirds of the grid pitch. A formula for the amplification factor of a planar triode is deduced, and it is shown to be the product of two factors, the first dependent on the grid geometry alone and the second on the anode-to-grid plane spacing; a graph is given for the rapid evaluation of the amplification factor of specific geometries. The extension of the method to other geometries and to multi-grid valves is indicated."

2211. Variable Slope with Constant Current.—Stevens. (*See* 2158.)

2212. Optimum Load, R_a or $2R_a$? The Answer depends on the Valve Operating Conditions.—Sturley. (*See* 2159.)

2213. The Measurement of the Internal Resistance of Amplifier Valves [Survey of Methods, from Barkhausen to Eccles and Feussner (around 1921)].—J. Bärisch. (*Zeitschr. f. Fernmeldetech.*, 24th Nov. 1943, Vol. 24, No. 8, pp. 122–124.)

2214. The Plotting of Electrostatic Fields with the Help of Exploring Electrodes (Probes).—R. Strigel. (*Arch. f. Tech. Messen*, Part 147, 1943, V312–3: summary in *Elektrot. u. Masch:bau*, 26th Nov. 1943, Vol. 61, No. 47/48, p. 592.) The hot-wire probe for steady fields: the capacitance probe (three-plate condenser) for alternating fields: transient-process fields by a special bridge-arrangement of probes. *Cf.* same writer, 1946 & 1947 of June.

2215. A New Electrode Material for Field Measurements in the Electrolytic Trough [to avoid the Formation of Surface Layers between Metal & Electrolyte].—H. Schmude & H. Schwenkhagen. (*Telefunken-Röhre*, Oct. 1942, No. 24/25, p. 47 onwards.)

Failures of the current-flow field to correspond precisely with the electrostatic field have recently been traced to the formation of such films, and the obvious way of avoiding this trouble—the use of a noble metal—is not suitable for war-time conditions. The writers therefore employed a brass exploring electrode on which the very thinnest layer of finely divided graphite had been sprayed and (after drying) polished to a high shine. With this electrode, and an electrolyte consisting of a 0.5 to 1% soda solution, the departures from the theoretical values did not exceed 0.05%. Polarisation phenomena made no appearance, and consequently it was generally unnecessary to carry out a supplementary balance to the absolute minimum of the indicating note.

2216. Dehydrated Graphite Sols [Application to Guard Rings, Connectors, Electrodes, Contacts, Special-Purpose Forms, & Small Parts normally made of Metal].—B. H. Porter. (*Review Scient. Instr.*, Jan. 1944, Vol. 15, No. 1, p. 13.) For applications of dilute solutions of aqueous colloidal graphite *see* 1978 & 3597 of 1942 and 550 of 1943.

2217. Adsorption of Thorium on Tantalum [Results similar to Those given by Adsorption on Tungsten & Molybdenum: Work Function decreases from 4.07 to 2.52 Volts, Emission Constant *A* decreases by Factor of 30: Similar Phenomenon of Surface Migration: Desirability of Extending the Activation Curves to determine Work Function for Optimum Thoriation more Precisely].—C. J. Gallagher. (*Phys. Review*, 1st/15th Jan. 1944, Vol. 65, No. 1/2, pp. 46–50.)

2218. Valuable Alloy Metals separated by New Process [Chemical Method of extracting Molybdenum & Tungsten separately].—G. S. Smith. (*Sci. News Letter*, 19th Feb. 1944, Vol. 45, No. 8, p. 121.) Patent assigned to U.S. Vanadium Corporation.

2219. Grid Support Wires of High Strength and Conductivity [Comparison of Mallory 3M Wire with Deoxidised Copper & Pure Nickel].—L. B. Hunt. (*Electronic Eng:g*, Feb. 1944, Vol. 16, No. 192, p. 372.)

DIRECTIONAL WIRELESS

2220. Air Traffic Signals [Anti-Collision Equipment comprising Transmitter sending out Carrier Wave of Frequency varying with Height of Flight, and Receiver tuned automatically by Change in Height & responding only to Signals from Aircraft within 5–10 Miles at a Height different by less than 1000 Feet].—(*Electrician*, 14th April 1944, Vol. 132, No. 3437, p. 310.) Paragraphs on the development of "an American firm".

2221. Radio Aids to Avigation: a Description of Modern Airlines Equipment.—P. K. Onnigian. (*QST*, Feb. 1944, Vol. 28, No. 2, pp. 24–28 and 92..96.)

2222. The Army Airways Communications System: Part I—What the A.A.C.S. Is and What It Does.—C. B. DeSoto. (*QST*, Feb. 1944, Vol. 28, No. 2, pp. 9–14 and 100..104.) *See* also Fawcett, 1608 of May.

ACOUSTICS AND AUDIO-FREQUENCIES

2223. "Wave Filters" [Book Review].—L. C. Jackson. (*Electrician*, 7th April 1944, Vol. 132, No. 3436, p. 299.)

2224. Noises give Vividness to Talking Books [for the Blind, especially Children].—(*Sci. News Letter*, 15th Jan. 1944, Vol. 45, No. 3, p. 39.)

2225. Direct Recording on Film [Embossing on Plain Cellophane Strip: at 40 ft/min, a 320 ft Loop gives 8 Hours' Playing Time].—Fonda Corporation. (*Wireless World*, April 1944, Vol. 50, No. 4, p. 115.) Already in use by American Airlines for recording ground/air conversations. *Cf.* 2688 of 1942.

2226. Oscillator for Gramophone Records ["a Compact Oscillator for Reproduction of Records by Modulation of a 1500 kc/s Note"].—W. Embree. (*Electronic Eng:g*, Feb. 1944, Vol. 16, No. 192, p. 368: summary, from *Radio Craft*, Aug. 1943.)

2227. Cathode Follower Output Stage: Loud-speaker Damping Improved by Low Output Impedance ["while Large Negative Feedback renders Stage practically Distortionless"].—C. J. Mitchell. (*Wireless World*, April 1944, Vol. 50, No. 4, pp. 108–110.)

2228. Cathode-Follower Output Stage [Report on Tests on Same Lines as Mitchell's (2227, above): Use of Another Cathode Follower for Feed to Transformer coupling Preceding Stage ("Most Satisfying Improvement in Extreme Bass":

etc.): Use of *RC* Coupling: Excellent Results].—D. Baker. (*Wireless World*, May 1944, Vol. 50, No. 5, p. 153.)

2229. New Contrast-Expansion Unit [Cathode-Follower Circuit: Report on First Trials].—Newman: Felix. (*See* 2170.)

2230. Volume-Expansion Problem [Large Voltage Swings at Anode of Expander Valve: Origin of Previously Reported "Objectionable Flutter"?].—Tomkins. (*See* 2171.)

2231. The New Signal Corps Sound-Powered Telephone [operating without Batteries: Power generated by Whistling into Transmitter].—Signal Corps. (*QST*, Feb. 1944, Vol. 28, No. 2, p. 56: paragraph only.) Range from 5 to 10 miles.

2232. The Mirrophone [for Language Instruction & Speech Training: 2747 of 1943] on All Aircraft Carriers.—(*Bell Lab. Record*, March 1944, Vol. 22, No. 7, p. 343.)

2233. Electronic Music [Preliminaries to the Formation of a Discussion Group: Encouragement from the Institute of Musical Instrument Technology].—(*Electronic Eng:g*, Feb. 1944, Vol. 16, No. 192, p. 359.)

2234. Applications of a Visual and Photographic Reception of Time Signals [Speaking-Clock Transmissions recorded on Seismograms: Example of Use of Neon-Bulb Device converting Audible Signals into Visual: also used to enable Deaf People to recognise Service Signals on Telephone, and even to Communicate, by Code].—P. Bernard. (*Génie Civil*, 1st Dec. 1943, Vol. 120, No. 23, p. 274: summary, from *Comptes Rendus* [Paris], 10th May 1943, pp. 631–632.)

2235. Incidence of Deafness [Letter & Editorial Note on 1240 of April].—J. A. Hamilton: Lilburn. (*Wireless World*, March 1944, Vol. 50, No. 3, p. 75.)

2236. Physiological Loudness, *and* Loudness and Loudness Difference.—J. Holtsmark. (*Physik. Berichte*, 1st April 1943, Vol. 24, No. 7, pp. 522–523: p. 523.) In the first paper it is shown that the results of statistical subjective investigations can be brought into agreement with the Fletcher–Munson scale if the loudness ratio is changed from 1 : 2 to 1 : 2.45.

2237. Evidences for a Neural Quantum in Auditory Discrimination.—S. S. Stevens & others. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, p. 84: summary only.) *See* also 1114 of 1941.

2238. Altered Acoustical Resonance of the External Auditory Canal as a Factor in the Transient Improvement of Hearing obtained by Fenestration Operations in Chronic Progressive Deafness [and the Consequent Preference to be given to Medical Treatment & Hearing Aids].—E. M. Josephson. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, p. 83: summary only.)

2239. Electrical Response of the Auditory Nerve to Different Sound Intensities under Pathological Conditions [and Its Influence on Hearing-Loss Measurements].—K. Lowy. (*Journ. Acous. Soc. Am.*, July 1941, Vol. 13, No. 1, pp. 83–84: summary only.)

2240. Abstracts of Numerous Norwegian Papers by Holtsmark & Berg on Sound Transmission through Homogeneous and Subdivided Walls, Ceilings, Porous Materials, etc., on the Improvement of Audibility by Reflectors, on the Excitation of the Basilar Membrane, on Masking, & Other Subjects.—J. Holtsmark & R. Berg. (*Physik. Berichte*, 1st April 1943, Vol. 24, No. 7, pp. 523–527 and 541–543.)

2241. Standard Musical Pitch [Addition of Pure 440 c/s Note (on 2.5 Mc/s) to Standard-Frequency Broadcasts].—Nat. Bureau of Standards. (*Science*, 4th Feb. 1944, Vol. 99, No. 2562, Supp. p. 10: *Sci. News Letter*, 12th Feb. 1944, Vol. 45, No. 7, p. 101.) *See* also *QST*, Feb. 1944, Vol. 28, No. 2, p. 57, where WWV schedules are given, with general ranges.

2242. A Rotary Audio-Frequency Generator: Tone Wheels for Code Practice and Testing Purposes.—P. J. Palmer. (*QST*, Jan. 1944, Vol. 28, No. 1, pp. 37–39.)

2243. Cenco Model 70029 Electronic-Type Audio-Frequency Generator, giving 1000 ± 5 c/s.—Central Scientific. (*Review Scient. Instr.*, Jan. 1944, Vol. 15, No. 1, p. 14.) Nominal output 50 mw to a matched load impedance.

2244. Linked Test Unit [for "Simplifying & Speeding-Up the Testing of A.F. Response Characteristics"].—Sound Apparatus. (*Review Scient. Instr.*, Jan. 1944, Vol. 15, No. 1, pp. 15–16.) *See* also 1621 of May.

2245. Variable-Frequency Resistance-Capacity Oscillators [Survey, and the "Decade" Oscillator].—Davidson. (*See* 2160.)

2246. Alternating-Voltage Compensators with Adjustable Frequency [Dual-Voltage Generators of Adjustable Phase].—Nüsslein & Rupp. (*See* 2272.)

2247. Communication at Supersonic Frequencies [including the Effects on Birds, etc.].—Weitzer. (*See* 2457.)

PHOTOTELEGRAPHY AND TELEVISION

2248. The Rôle of Ultra-High Frequencies in Post-War Broadcasting.—Jones, Bell, & others. (*See* 2344.)

2249. Frequencies for Television: Factors Affecting the Choice of Carrier.—(*Wireless World*, April 1944, Vol. 50, No. 4, pp. 98–101.)

The Riverhead, N.J., reception of London television signals, winters of 1936/9: ionosphere measurements: sporadic E: tropospheric refraction: atmospheric discontinuities: 50 Mc/s upwards as the most suitable choice for middle latitudes of Northern Hemisphere: the upper limit.

2250. More Television Proposals: Definition Standards for Our Post-War Service [Bedford's Views (including his Tests on Acuity of Vision in relation to Television): Edwards's Suggestions (with "Backbone" of Distribution System from Maidstone to Glasgow) & Discussion].—L. H. Bedford: B. J. Edwards. (*Wireless World*, April

1944, Vol. 50, No. 4, pp. 116–118.) Summaries of British Inst. Rad. Eng. and I.E.E. papers, respectively.

2251. Post-War Television Sets will require Trained Men [and Engineers & Manufacturers will have to Design & Produce the Proper Testing Equipment for the Trained Service-Man].—A. Stringer. (*Sci. News Letter*, 19th Feb. 1944, Vol. 45, No. 8, p. 121.)

2252. Television over Telephone Cable [between Madison Square Garden & Radio City].—(*Bell Lab. Record*, Jan. 1944, Vol. 22, No. 5, p. 230.)

2253. Colour Television produced by Subtractive Method [and requires only a Fraction of the Illuminating Light necessary in the Additive Method].—A. H. Rosenthal. (*Sci. News Letter*, 15th Jan. 1944, Vol. 45, No. 3, p. 45.)

2254. Contribution to the Study of the Photo-Dichroism of Coloured Plates of NaCl [containing *F* & *F′* Centres: Effects of Polarised White Light].—S. Nikitine. (*Comptes Rendus* [Paris], 7th/28th June 1943, Vol. 216, No. 23/26, pp. 758–760.)

2255. Variable Slope with Constant Current [Description of a Circuit and Its Application to Television, etc.].—Stevens. (*See* 2158.)

2256. The Impulse Response of Electrical Networks, with Special Reference to the Use of Artificial Lines in Network Design [Low-Pass Filter with Linear Phase-Shift, for Television: Filters with 90° Phase-Shift at All Frequencies: etc.].—Levy. (*See* 2153.)

2257. Wide-Band Circuit for I.F. Amplifiers [*e.g.* in Television Receivers].—(*See* 2163.)

MEASUREMENTS AND STANDARDS

2258. Determination [Theoretical & Practical] of the Dielectric Constants of Mixed Bodies [Powder Aggregates, etc.].—R. Vieweg & Th. Gast. (*E.T.Z.*, 4th Nov. 1943, Vol. 64, No. 43/44, p. 585.) Long summary of the paper dealt with in 3467 of 1943.

2259. Ceramic Insulating Materials: Dielectric Properties at Centimetric Wavelengths [Theory & Practice of Concentric-Line Resonance Method for Measurement of Loss Angle & Dielectric Constant: a Specially Accurate (Tunable Concentric-Line) Wavemeter: Results for Calit, Tempa, & Condensa].—W. Küsters. (*Wireless Engineer*, Jan. 1944, Vol. 21, No. 244, pp. 13–22.) Translation of the paper dealt with in 3643 of 1942.

2260. Taming the High-Frequency Signal Generator: Analysis of Design Factors involved in Generators of High Stability and Accuracy [and the Step-by-Step Development of the Model 75 Standard Signal Generator, Measurements, Inc., Boonton: 50–400 Mc/s, Modulation to 50% from Internal 400 or 1000 c/s Oscillator, or from External Source covering the Audio Range].—J. M. Van Beuren & J. B. Minter. (*Proc. Radio Club of America*, Dec. 1943, Vol. 20, No. 1, pp. 3–9.)

An instrument "capable of making measurements with an accuracy heretofore unattainable at these frequencies". Calibration accuracy, thanks to high oscillator-stability, can be maintained to better than ½% over long periods: output voltage is continuously variable from 0.2 V to 0.2 μV. Leakage below 300 Mc/s is not measurable on a sensitive receiver: "recent experimentation has enabled us to maintain leakage even at 400 Mc/s at less than 1 μV".

Among the many points in design discussed are the following:—(i) "Even 5 watts, under these conditions [of screening], can cause a considerable rise in temperature of the oscillator unit. . . . The use of negative-t.c. compensating condensers naturally suggests itself, but in practice we usually find that owing to different rates of heating of different parts, and variations in tuning capacity, the ultimate result of trying to compensate usually turns out to be worse than the uncompensated generator." (ii) "It was found that the parallel-rod oscillator seemed to have many advantages for use in a signal generator": the difficulty lay in the fact that the position of the shorting slider had to be varied in combination with the variable loading condenser, while the unused portions of the parallel rods had to be shorted to prevent resonance as a half-wave line. "We finally found that if we used circular-shaped rods, and moved the rods instead of the slider, all three operations . . . could be done very simply with only one moving part." (iii) For coupling the oscillator with the attenuator, variably over a 10 to 1 range, "various systems of slide wires, capacity and resistance devices were tried and found sadly wanting", but a simple variable-coupling loop (Fig. 7) near the main shorting contact (point of max. current) worked very well, and caused less frequency reaction when varied than any of the other systems. (iv) The problems of connecting the various attenuator steps to the output cable system was solved by the drum switch of Fig. 12, consisting of six sections of balanced transmission line of different lengths.

2261. The Frequency Synthesizer [for Precision Frequency Measurements by Semi-Skilled Observers: enabling Any Frequency that is Harmonically Related to a Sub-Multiple of a Standard Frequency to be generated by means of a Decade System involving a Synthesis Process: Adjacent Harmonic Interference substantially Independent of Order of Harmonic, & can be Extremely Small: Mechanical Masking System for Direct Reading without Ambiguity].—H. J. Finden. (*Journ. I.E.E.*, Part III, No. 12, Dec. 1943, Vol. 90, pp. 165–177: Discussion pp. 177–180.)

From the Plessey Company, Ltd. "Very high orders of accuracy can now be realised, but the skill required to make the measurement is far greater than is necessary for the measurement of many other electrical properties in general use. Frequency measurements have, in fact, become the prerogative of the skilled observer, who has acquired an intimate knowledge of his apparatus by daily contact. This condition is due to the type of apparatus hitherto in use, and consequently the engineer tends to distrust the results. War-time conditions in particular have made it necessary that the tools for making measurements of fundamental properties should be designed for operation by semi-skilled observers . . ." "Standards of frequency accurate to 1 part in 10^8 are now available and are checked in terms of the rotating earth. In view of the fact that these local standards are now available internationally by daily radio transmissions, every endeavour should be made to utilise this service . . ."

2262. Direct-Reading Frequency-Measuring Methods based on the Condenser-Charging Principle [and the Extension of the Frequency Limit by the Use of a New Pentode Circuit].—W. Oehrl. (*E.T.Z.*, 16th Dec. 1943, Vol. 64, No. 49/50, pp. 653–656.)

From the Rohde & Schwarz laboratories. Methods of using the condenser-charging principle at higher frequencies, based on reducing the charging time for a given capacitance and given charging currents, have been developed by Fecker (3900 of 1936) and Wahl (4062 [& 2924] of 1938). Fig. 1 shows a pentode circuit taken from the first paper: the charging is carried out by a triode 1, and this and the discharging pentode are controlled in push-pull by two other triodes 3 and 4, so that the whole circuit is fairly complicated, and moreover the extension to higher frequencies is made difficult by the no longer perfect action of the controlling valves.

A great simplification is reached if the charging process is made to take place through a resistance instead of through a controlled valve, thus eliminating also the push-pull control. Such a circuit is shown in Fig. 2: the pentode is retained as the discharge valve, and a rectifier (half- or full-wave: dry-plate, for frequencies up to 50 kc/s, or diode type) yields the d.c. for the moving-coil meter. This simple circuit is improved (p. 654, r-h column) by the addition of a diode for amplitude-limitation of the charging process through the anode-circuit resistance (Fig. 5).

Fig. 6 shows a small frequency-indicator on these lines, for the range 10 c/s to 30 kc/s. Fig. 7 shows a larger instrument, using valves of higher emission, two mixing stages, filters, etc., and capable of driving an ink-writing recorder. Its frequency range is up to 500 kc/s. A few of the many possible applications are discussed on p. 655, r-h column, and a final section deals with the effect of mains hum on the accuracy of the readings.

2263. Temperature Coefficient of Capacitance: Its Measurement in Small Radio Condensers.—W. Schick. (*Wireless Engineer*, Feb. 1944, Vol. 21, No. 245, pp. 65–71.)

Author's summary:—" The paper discusses the requirements for the measurement of the t.c. of capacitance of small radio condensers, and analyses possible errors with a view to defining conditions for the achievement of a certain accuracy. Various electrical and thermal methods are then reviewed as a preliminary to the description of an apparatus which was specially designed for the purpose." From the United Insulator Company.

2264. Inspecting and Determining the Axis Orientation of Quartz Crystals [Use of the Inspectoscope, the Conoscope, the Pin-Hole Orioscope, & the X-Ray Goniometer].—G. W. Willard. (*Bell Lab. Record*, March 1944, Vol. 22, No. 7, pp. 320–326.) *See* also 1283 of April.

2265. A New Type of Low-Frequency Piezoelectric Crystal [vibrating on Low & High Modes, so that Dual-Frequency Crystals can be produced readily: " Better than One Part per Million per Degree Centigrade Drift ": etc.].—James Knights Company. (*QST*, Feb. 1944, Vol. 28, No. 2, p. 56: paragraph only.) *See* 1653 of May for a paper from this Company's laboratories.

2266. The Dielectric Properties of Ammonium Phosphate and Sulphate at Low Temperatures [Measurements at Frequencies 7×10^4 to 1.4×10^7 c/s].—R. Guillien. (*Physik. Berichte*, 1st April 1943, Vol. 24, No. 7, p. 507: from *Ann. de Physique*, June/Aug. 1942.) The dielectric behaviour of both substances is different from that of Rochelle salt.

2267. New Contributions to Interferometry: Part II—New Interference Phenomena with Newton's Rings [and a Number of Possible Applications].—S. Tolansky. (*Phil. Mag.*, Feb. 1944, Vol. 35, No. 241, pp. 120–136 and Plates.)

For Part I *see* 3271 of 1943: and *see* also 2449, below. " It is not too much to claim that very small displacements of the order of one-thousandth of a wavelength should be detectable with components of good optical quality."

2268. Standard Musical Pitch [Addition of Pure 440 c/s Note (on 2.5 Mc/s) to Standard-Frequency Broadcasts].—Nat. Bureau of Standards. (*Science*, 4th Feb. 1944, Vol. 99, No. 2562, Supp. p. 10: *Sci. News Letter*, 12th Feb. 1944, Vol. 45, No. 7, p. 101.) And *see* 2241, above.

2269. Applications of a Visual and Photographic Reception of Time Signals [Use of Neon-Bulb Device converting Audible Signals into Visual].—Bernard. (*See* 2234.)

2270. Measurement of the Mean Background Noise of an Amplifier by a Thermocouple and a Rectifier-Type Meter.—J. Baurand & B. Vallantin. (*Génie Civil*, 15th Nov. 1943, Vol. 120, No. 22, p. 262: summary, from *Comptes Rendus* [Paris], 19th April 1943.) No details are given in the summary.

2271. The Measurement of the Internal Resistance of Amplifier Valves [Survey of Methods].—Bärisch. (*See* 2213.)

2272. Alternating-Voltage Compensators with Adjustable Frequency [for Simple & Accurate Measurements of Impedances, Transmission Equivalents, " Klirr " Factors, etc: Generators giving Two Equal-Frequency Voltages of Adjustable Phase & Amplitude].—G. Nüsslein & H. Rupp. (*E.T.Z.*, 16th Dec. 1943, Vol. 64, No. 49/50, pp. 660–661: summary, from *Funktech. Monatshefte*, No. 12, 1943, p. 17 onwards.)

Cf. Madella, 1243 of April. The original variable-frequency compensator, the Franke machine, is too expensive and clumsy for widespread use, and its upper frequency limit, 2400 c/s, is too low for modern requirements. The chief difficulty in designing valve-circuit dual-oscillators to replace it is in making the phases of the two variable-frequency voltages adjustable independently of the frequency. In the arrangement now described use is made of the fact that a phase displacement of one oscillation which is mixed with a second oscillation reappears after the mixing process, at the same value in the sum and difference frequencies. The dual beat-note generator consists of an oscillator with one fixed and one variable frequency, combined with two mixing-stages and one or more phase-shifting circuits. These various components can be combined in five different ways, to give either (a) adjustment in amplitude and phase; or (b) adjustment of real and imaginary components, according to Table 1. The last arrangement in the table is shown in Fig. 3, " a circuit for control of real and imaginary components ". In the amplitude-&-phase arrangements the rotating-field transducer mentioned in the table (" Drehübertrager ") takes the place of several phase shifters, mounted on a common spindle, which would otherwise be necessary if phase displacements greater than 90° were required. It is dispensed with in the (b) arrangements, where a fixed displacement of 90° is used.

2273. NEW KELVIN BRIDGE [for Operation at High Speeds by Unskilled Personnel: 60 c/s Supply: Electron-Ray Null Indicator: Single Dial directly Calibrated in Resistance].—Industrial Instruments. (*Review Scient. Instr.*, Jan. 1944, Vol. 15, No. 1, p. 14.)

2274. THE MEASUREMENT OF LOW IMPEDANCE [especially by the Thomson Double Bridge modified for A.C: with Equations].—P. F. Soper. (*BEAMA Journal*, March 1944, Vol. 51, No. 81, pp. 101–103.) For impedances from about 0.001 ohm to 2 ohms.

2275. " ALTERNATING CURRENT BRIDGE METHODS: FIFTH EDITION " [Book Review].—B. Hague. (*Electrician*, 31st March 1944, Vol. 132, No. 3435, p. 276.) With an Appendix containing " supplementary notes " covering recent developments.

2276. DEMOUNTABLE COIL FOR MAGNETIC MEASUREMENTS ON THE A.C. BRIDGE [*e.g.* the Hay Impedance Bridge, for Study of Ferro-Nickels: Defects of Usual Demountable Cores: a Demountable Coil suitable for Tests on Ring Cores (Solid, Ribbon, Wire, or Compressed Powder)].—M. Fallot. (*Génie Civil*, 1st Dec. 1943, Vol. 120, No. 23, p. 274: summary, from *Comptes Rendus* [Paris], 3rd May 1943, pp. 604–605.)

2277. TESTING TRANSFORMER COILS [Simple Method for Production Testing of Correct Winding, using Telephones as Indicator].—H. P. Zade. (*BEAMA Journal*, March 1944, Vol. 51, No. 81, pp. 87–90.)

2278. COIL TESTING SPEEDED [by Mercury-Pool Contacting Device, eliminating Removal of Insulation from Ends of Wires: Improved Results in Half the Time].—(*Gen. Elec. Review*, March 1944, Vol. 47, No. 3, p. 54.)

2279. THE TESTING OF RADIO EQUIPMENT AND COMPONENTS, AND THEIR TREATMENT TO MEET EXTREME CLIMATIC CONDITIONS [Wireless Section, I.E.E., Informal Discussion].—P. R. Coursey & others. (*Electrician*, 7th April 1944, Vol. 132, No. 3436, pp. 298–299: summary only.)

2280. UNIVERSAL MEASURING INSTRUMENT: I—GENERAL DESIGN CONSIDERATIONS [of an Instrument for measuring D.C. & A.C. Voltage and Insulation Resistance: the " Magic Eye " & Its Circuits, alone & combined with a Suitable Diode Circuit].—G. A. Hay. (*Wireless World*, May 1944, Vol. 50, No. 5, pp. 130–132.)

2281. A NEW TYPE OF ELECTRON-OPTICAL VOLTMETER [for measuring Peak Voltages in Range 2–20 kV, D.C. or A.C., to an Accuracy within 3%: Usable in Some Circuits up to 1 Mc/s or over: Summary of I.E.E. Paper & Discussion].—L. Jacob. (*Electrician*, 28th April 1944, Vol. 132, No. 3439, pp. 365–366.)

" Its action is based on the proportionality theorem for a triode electron-optical system, in that the angle of the beam is defined by the ratio of two voltages, the anode voltage and the voltage of the modulator grid. The beam angle remains constant when both terms of this ratio are multiplied by the same factor, the modulator bias voltage being directly proportional to the voltage to be measured when the latter is applied to the anode. A high voltage is thus measured in terms of a low voltage, the instrument constituting an electron-optical potentiometer."

2282. AN INDEPENDENT DETERMINATION OF FIXED POINTS ON THE HIGH VOLTAGE SCALE.—A. O. Hanson & D. L. Benedict. (*Phys. Review*, 1st/15th Jan. 1944, Vol. 65, No. 1/2, pp. 33–38.) The absolute values of the proton energies obtained for the various calibration points are thought to be accurate to within 0.3%, the relative values to about 0.1%.

2283. A NEW RECORDING ELECTROMETER [Improved Form of the Benndorf Instrument, based on Experiences with the Polar Year Expedition].—A. Dauvillier. (*Génie Civil*, 1st Dec. 1943, Vol. 120, No. 23, p. 274: summary, from *Comptes Rendus* [Paris], 17th May 1943, pp. 661–663.)

2284. STANDARDS FOR RADIO COMPONENTS [List of War Emergency British Standards (BS/RC Series) already published].—British Standards Institution. (*Electrician*, 14th April 1944, Vol. 132, No. 3437, p. 326.)

2285. NEW WAR STANDARDS FOR RADIO DRY ELECTROLYTIC CAPACITORS AND R.F. THERMOCOUPLE CONVERTERS]—American Standards Association. (*Science*, 4th Feb. 1944, Vol. 99, No. 2562, Supp. p. 12.)

2286. THE STANDARDISATION OF VARIABLE RESISTANCES OF THE LAYER [" Metallised "] TYPE FOR COMMUNICATION TECHNIQUE.—H. C. Riepka. (*E.T.Z.*, 4th Nov. 1943, Vol. 64, No. 43/44, p. 592.)

2287. THE STANDARDISATION OF FLAT AND WIRE-TYPE SOLDERING TABS USED IN COMMUNICATION TECHNIQUE.—E. König. (*E.T.Z.*, 4th Nov. 1943, Vol. 64, No. 43/44, p. 592.)

SUBSIDIARY APPARATUS AND MATERIALS

2288. SOME UNUSUAL APPLICATIONS OF THE CATHODE-RAY OSCILLOGRAPH.—Patchett. (*See* 2425.)

2289. VARIABLE SLOPE WITH CONSTANT CURRENT [Description of a Circuit and Its Application to a Circular Time-Base & Its Radial Deflection].—Stevens. (*See* 2158.)

2290. PHOTOGRAPHY OF CATHODE-RAY-TUBE TRACES, *and* THE RECORDING OF HIGH-SPEED TRANSIENT PHENOMENA BY THE HOT-CATHODE, GLASS-BULB CATHODE-RAY OSCILLOGRAPH.—Hendry: Nethercot. (*Electronic Eng:g*, Jan. 1944, Vol. 16, No. 191, pp. 324–326: Feb. 1944, No. 192, pp. 369–371.) Summaries were referred to in 881 of March.

2291. APPLICATIONS OF THE ELECTRON MICROSCOPE IN METALLURGY.—Zworykin. (*Sci. Abstracts*, Sec. B, Dec. 1943, Vol. 46, No. 552, p. 219.)

2292. TWINNING IN ZINC OXIDE [and the Technique of Stereoscopic Electron-Microscopy employed in the Crystallographic Analysis].—Fuller. (*Journ. Applied Phys.*, Feb. 1944, Vol. 15, No. 2, pp. 164–170.) For a note on the technique successfully used for the mounting of pigments for electron-microscopy *see* p. 201.

2293. A NEW ELECTRODE MATERIAL FOR FIELD MEASUREMENTS IN THE ELECTROLYTIC TROUGH.—Schmude & Schwenkhagen. (*See* 2215.)

2294. The Plotting of Electrostatic Fields with the Help of Exploring Electrodes.—Strigel. (*See* 2214.)

2295. The Refractive Index in Electron Optics [in the Cases of Constant and Relativistic Mass].—Opatowski. (*Phys. Review*, 1st/15th Jan. 1944, Vol. 65, No. 1/2, pp. 54–55.)

From the Armour Research Foundation. When ***A***, the magnetic vector potential, is not equal to nought, the general formula for μ in terms of the electrostatic potential V and of ***A*** contains a unit vector **s**, parallel to the electron velocity, which is not known in general and which can be eliminated only if a suitable integral of the equations of motion of the electron is known. "If V and ***A*** are symmetric about an axis, **s** may be eliminated from μ by means of a momentum integral (Glaser). This elimination is generalised in the present paper to include cylindrical fields (not necessarily symmetrical) as well as some more general fields with a transversal field component." The result is reached by using the well-known analogy between magnetism and hydrodynamics and interpreting the magnetic scalar potential U as a velocity potential of an ideal fluid, making use of the corresponding stream function w to obtain expressions for μ for the cases of constant mass and relativistic mass.

2296. A Vector Treatment of Ionic Motion through a Gas in Combined Electric and Magnetic Fields.—Rogers. (*American Journ. of Phys.*, Oct. 1943, Vol. 11, p. 247 onwards.) A 2-page paper.

2297. On the Different Actions of Electron Impact and Light in the Excitation of Organic Molecules [as shown by the Difference in the Emission & Absorption Spectra for the Two Types of Irradiation].—Schüler & Woeldike. (*Physik. Berichte*, 1st April 1943, Vol. 24, No. 7, p. 517: from *Physik. Zeitschr.*, Nov. 1942, p. 415 onwards.)

2298. Improvised Memorising Machine [892 of March: Letter suggesting Use of Magnetic Tape instead of D.C. Motors].—Goodell. (*Electronics*, Dec. 1943, Vol. 16, No. 12, p. 338.)

2299. On the Theory of the Arc Discharge and Its Extinction.—Mayr. (*E.T.Z.*, 16th Dec. 1943, Vol. 64, No. 49/50, pp. 645–652.)

2300. The "Self-Induction" of Gaseous Discharges.—van Geel. (*See* 2140.)

2301. Internal Discharges in Dielectrics: Their Observation and Analysis.—Austen & Hackett. (*Electrician*, 10th March 1944, Vol. 132, No. 3432, pp. 212–214: short summary, and Discussion, of an I.E.E. paper.)

2302. On the Influence of Adsorbed Films of Molecules of Dielectric Substances on the Contact Potential Difference between Two Metals [Experimental Investigation in connection with One Suggested Explanation of the Conductivity of even the Purest Dielectric Liquids (1820 [and 2985] of 1937: 3508 of 1941)].—von Duhn. (*Ann. der Physik*, 26th June 1943, Vol. 43, No. 1/2, pp. 37–52.)

2303. Determination of the Dielectric Constants of Mixed Bodies [Powder Aggregates, etc.].—Vieweg & Gast. (*See* 2258.)

2304. Temperature Coefficient of Capacitance: Its Measurement in Small Radio Condensers.—Schick. (*See* 2263.)

2305. Small Vacuum Capacitors for Peak Voltages 7500–16 000 Volts [" Comparatively Loss-Free": Total Capacitance lumped into Volume of about One Cubic Inch].—General Electric. (*QST*, Feb. 1944, Vol. 28, No. 2, p. 56: paragraph & photograph only.

2306. The Replacement of Mica in High-Frequency Condensers by Ceramic Materials.—Dirks. (*E.T.Z.*, 4th Nov. 1943, Vol. 64, No. 43/44, pp. 587–588: long summary, from *Lorenz-Berichte*, No. 1/2, 1942, p. 2 onwards.)

This is the paper referred to in 2033 of June. The endeavour to replace mica in condensers by indigenous substitutes has led to various dielectrically satisfactory materials, of which the ceramic type stand foremost for h.f. condensers because of their power of standing up to high temperatures. But because of their other properties, compared with the extremely accommodating mica, the matter of replacement is not straightforward and cannot be carried out in all cases, particularly when conditions as to dimensions are rigid. The tubular ceramic condensers so useful for low powers and voltages in small transmitters, and in receivers, form satisfactory substitutes in many ways, since comparatively thin layers of the ceramic material, of the same order of thickness as the usual mica, can be obtained with the necessary mechanical strength, and by applying a beading or "roll" to the ends, near the edges of the coating, a satisfactory ratio between breakdown and edge-discharge voltages can be obtained, so that full use can be made of the dielectric as regards voltage. Pot condensers require the beading at one end only, and provide large capacitance for small dimensions. But both tubular and pot condensers lack one desirable property of the corresponding mica condenser, in which the piling of the mica gives a practically inductance-free series connection of component capacitances: for a series or parallel connection of tubular or pot condensers requires connecting wires, which alter the electrical behaviour. Pot condensers are particularly suitable for low powers and capacitances and fairly high voltages—such as in the aerial part of small short-wave transmitters. Large disc condensers with thickened edges are suitable for big transmitters, if enough gap is left between the discs for proper cooling.

In small piled-disc condensers the maximum capacitance of a disc is governed by the smallest thickness of the middle part of the disc which can be obtained reliably in mass production: by using a material with high dielectric constant (around 80) about half the capacitance of the mica disc, of the thickness most commonly employed (0.05 mm), can be arrived at. But for reasons discussed later (*see* below) such high dielectric constants can seldom be used in h.f. condensers, and only a quarter of the mica-capacitance value can be reckoned on as an average. The *smallest* obtainable capacitance per disc is given when the thickness at the middle is equal to that at the edges: for normal values of the latter this gives a reduction to about one-third. By using other dielectric materials this reduction can be multiplied about seven times, so that the ratio between maximum and minimum capacitances per disc is about 20 : 1. The dimensions of the ceramic disc condenser are of the same order as those of the mica condenser; but for large capacitances the ratio of dimensions becomes the more unfavourable to the ceramic type, the lower the specified maximum voltage, so that (as with the pot and tubular types also) it is just those condensers which consume the greatest quantity of mica that cannot be replaced.

The special ceramics with very high dielectric constant unfortunately, as a rule, have also a high temperature coefficient; thus materials with $\epsilon = 80$ have a t.c. on the average of about -700×10^{-6} per °C, which would swamp any compensating positive t.c. in the rest of the oscillating circuit (probably of the order of $+50 \times 10^{-6}$). Recently, however, materials have been prepared with ϵ between 30 and 40 and with t.cs within the limits permissible in transmitter circuits (0 and -100×10^{-6}), so that by their use it is no longer necessary to think of temperature compensation by the employment of two or more condensers with different dielectrics.

With the usual ceramic material the loss-angle curve rises steeply at as low a temperature range as 100–150° C. However tolerable a fairly high loss may be, in a transmitter circuit for example, only a certain steepness of rise can be tolerated, otherwise thermal regeneration will occur, the losses and temperature rising in a "vicious spiral" until the condenser is destroyed. To avoid this serious defect, attempts are being made to evolve materials which, while retaining the other good electrical properties, will stand high temperatures without developing too steep a loss-angle characteristic.

The variation of loss angle with frequency, on the other hand, already makes itself visible at quite low frequencies, well below the usual h.f. range, so that in this respect no special difficulties are encountered in ordinary transmitter and receiver design. Nor is the effect of moisture a serious problem in ordinary conditions, "given a suitable design of condenser and appropriate treatment (lacquering, vitrification)". For mass production it is necessary to keep down the mechanical and electrical tolerances to a minimum; the latter present by far the greater difficulty, leading to increased expenditure in work-hours and sometimes in material, and tending to limit the extent to which, in a given time, the replacement of mica condensers by ceramic substitutes can be carried out.

2307. Ceramic Insulating Materials: Dielectric Properties at Centimetric Wavelengths [including Results for Calit, Tempa, & Condensa].—Küsters. (*See* 2259.)

2308. Some Further Notes on Crack Detection by the Naphthalene Process [Application to Uncoloured Ceramics & Refractories].—Hoban. (*Distribution of Electricity*, April 1944, Vol. 16, No. 154, pp. 261–262.)

2309. "Plastics in the Radio Industry" [Book Review].—Couzens & Wearmouth. (*Nature*, 8th April 1944, Vol. 153, No. 3884, p. 418.) The second of the *Electronic Engineering* technical monographs.

2310. Cold-Moulded Plastics [including Their Applications to Electrical Equipment].—Delmonte. (*Sci. Abstracts*, Sec. B, Dec. 1943, Vol. 46, No. 552, p. 228.)

2311. The Production of Moulded Parts in Synthetic Resins.—Gorol. (*Zeitschr. V.D.I.*, 25th Dec. 1943, Vol. 87, No. 51/52, pp. 797–802.) With a section on the inclusion of metal and ceramic parts in the moulded body, and another on tolerances.

2312. Catalin Cast Resin [and Its Advantages over Laminated Plastic Materials].—Catalin, Ltd. (*Electrician*, 24th Dec. 1943, Vol. 131, No. 3421, p. 640.)

2313. Polystyrene for War-Time Electronics [Former Defects removed by Better Techniques of Production & Moulding: the Necessity for Correct Machining Methods: etc.].—Wiley. (*Sci. Abstracts*, Sec. B, Dec. 1943, Vol. 46, No. 552, p. 211.) For another summary see *Electronic Eng:g*, Jan. 1944, Vol. 16, No. 191, p. 348 (from *Mod. Plastics*, Aug. 1943).

2314. The Machining of Laminated Plastics, *and* Basic Physical Properties of Laminates.—Anon: Field. (*Sci. Abstracts*, Sec. B., Dec. 1943, Vol. 46, No. 552, p. 228: p. 228.)

2315. Laminated Wood as an Insulator [Survey, with Original Investigations on Various Applications (including the Raising of the Radio-Interference Point of Porcelain Pin-Type Insulators): Impulse Data: H.F. Heating during Pressing: Bibliography: etc.].—Jervis. (*Electronic Eng:g*, Feb. 1944, Vol. 16, No. 192, pp. 365–368.) *See* also 1260 [and 1261] of 1943, and 2316, below.

2316. Synthetic-Resin Laminated-Wood Insulation.—Jervis. (*Sci. Abstracts*, Sec. B, Dec. 1943, Vol. 46, No. 552, p. 212.) *See* also 1260 of 1943, and for h.f. heating of laminated materials *see* 2099 of June.

2317. "Ardux" Adhesive [for bonding Plastic Materials such as Laminated Sheet] now available in Powder Form.—Aero Research. (*Wireless World*, May 1944, Vol. 50, No. 5, p. 132.)

2318. Physical Properties of Fiberglas Laminated Plastics [using New Thermo-Hardening Resins which require No External Pressure in Process of Moulding a Plastic Part].—Armstrong. (*Sci. Abstracts*, Sec. B, Dec. 1943, Vol. 46, No. 552, p. 228.)

2319. Types of Fiberglas [with Data].—Owens–Corning Fiberglas. (*Review Scient. Instr.*, Jan. 1944, Vol. 15, No. 1, p. 16.) *See* also 1320 of April.

2320. Dielectric Losses in Enamelled Wires [Measuring Procedure].—Potthoff & Müller. (*E.T.Z.*, 23rd Sept. 1943, Vol. 64, No. 37/38, p. 503 onwards.)

2321. Effect of Temperature upon the Mechanical Properties of Rubber-like Materials [with Practical Conclusions of Importance in connection with Anti-Vibration Devices].—Fletcher. (*Nature*, 18th March 1944, Vol. 153, No. 3881, pp. 341–342.)

2322. Potentiometer Recorder – Controller [the "Pyromaster", primarily for Temperature Measurement & Control: with Pressure-Reinforcing Circuit to enable Contact between Galvanometer Arm & Fixed Contact to pass Adequate Relay-Current].—Bristol's Instrument Company. (*Journ. of Scient. Instr.*, April 1944, Vol. 21, No. 4, pp. 70–71.)

2323. Snap-Action Sensitive Relays [Type 79XAX, operating on 10 Milliwatts, and Similar Types].—Struthers–Dunn, Inc. (*Review Scient. Instr.*, Jan. 1944, Vol. 15, No. 1, p. 15.)

2324. Snap-Action Switch [with Patent "Rolling Spring" enabling Smaller Coils to be used in Relays, and giving Very Fast Action which reduces Contact Burning].—Acro Electric. (*Electronics*, Nov. 1943, Vol. 16, No. 11, p. 286.)

2325. Voltage-Regulating Transformers [Letter on the Sola Constant-Voltage Transformer].—Sola Electric Company: Lambert. (*Electronic Eng:g*, Jan. 1944, Vol. 16, No. 191, p. 326.) A letter prompted by Lambert's article, 1226 of 1943.

2326. Researches on the Preparation of Wire from Sintered Copper Powder.—Goetzel. (*Physik. Berichte*, 1st April 1943, Vol. 24, No. 7, p. 532: from an American paper.)

2327. "Pulvermetallurgie und Sinterwerkstoffe" [Book Review].—Kieffer & Hotop. (*Zeitschr. V.D.I.*, 25th Dec. 1943, Vol. 87, No. 51/52, p. 820.) Vol. 9 of Köster's series on pure and applied metallurgy. *Cf.* Skaupy, 1347 of April.

2328. "Symposium on Powder Metallurgy" [Book Review].—American Soc. for Testing Materials. (*Journ. Applied Phys.*, Feb. 1944, Vol. 15, No. 2, p. 148.)

2329. Powder Metallurgy [a General Picture], *and* Powder Metallurgy [Short Survey].—Williams: Jones. (*G.E.C. Journal*, Feb. 1944, Vol. 13, No. 1, pp. 3–9: *Distribution of Electricity*, April 1944, Vol. 16, No. 154, pp. 237–239.)

2330. Correspondence on "Dust-Cored Coils" [1348 of April & back references: the Need for treating L.F. and R.F. Cores Separately: Some Data & Remarks on R.F. Cores: Table of "Best Choices" at Various Frequencies: etc: Author's Reply].—Friedlander: Welsby. (*Electronic Eng:g*, Feb. 1944, Vol. 16, No. 192, pp. 388–390.)

2331. The Insulation of Magnet Stampings by Phosphate Films [Advantages over Paper & Enamel].—Macchia & Borla. (*Zeitschr. V.D.I.*, 25th Dec. 1943, Vol. 87, No. 51/52, p. 819: short summary only.)

2332. An Iron–Silicon Alloy of High Initial Permeability due to Special Metallurgical Treatment.—Pawlek. (*Sci. Abstracts*, Sec. B, Dec. 1943, Vol. 46, No. 552, p. 216.)

2333. The Use of Ticonal and Permendur in Conjunction, for Magnetic Circuits.—Hughes. (*Electrician*, 17th Dec. 1943, Vol. 131, No. 3420, p. 616.) Reply to a question. "It is not generally realised that the reluctance of permanent-magnet materials is comparatively high. . ."

2334. Some Considerations on the Relation between the Current Distribution and the Course of the Magnetic Lines of Force.—Schwarzer. (*See* 2147.)

2335. The Geometry of Demagnetising Curves, and Its Consequences for Permanent-Magnet Materials.—Hoselitz. (*Phil. Mag.*, Feb. 1944, Vol. 35, No. 241, pp. 91–102.)

As an example of the conclusions reached by purely geometrical methods, "for commercial alloys of the FeNiAl type an increase in H_c with constant B_r is about 15–20 times as effective as *vice versa*. . . ."

2336. The Anisotropy of Hysteresis in Ferromagnetic Single Crystals: III—The Effect of Thermal Treatment in a Magnetic Field upon the Character of the Anisotropy of the Coercive Force.—Shur. (*Journ. of Phys.* [of USSR], No. 5, Vol. 4, 1941, pp. 439–447: in English.) The Russian original was referred to in 589 of 1941.

2337. Dehydrated Graphite Sols [Application to Electrodes, Contacts, etc., & Small Parts normally made of Metal].—Porter. (*See* 2216.)

2338. Low-Resistance Materials with Low Temperature Coefficients ["Mancoloys 8 & 10": for Instruments & Wireless Apparatus].—Mallory Metallurgical Products. (*Journ. of Scient. Instr.*, April 1944, Vol. 21, No. 4, p. 71.) *See* also 3562 of 1943.

2339. Relay Contact Welder [Special Thin-Nosed Welding Pliers], *and* Economise in Tin! [Illustrated Advertisements of the "AEG-Kleinzange" (Small Tongs) for Welding, Tin-less Soldering, etc: for Fine Work on Radio Apparatus & the Like].—Pritchard: A.E.G. (*Bell Lab. Record*, April 1944, Vol. 22, No. 8, pp. 374–375; *Zeitschr. V.D.I.*, 11th & 25th Dec. 1943, Vol. 87, Nos. 49/50 & 51/52, Advt. pp. 35 & 23.)

2340. Tinsel for Navy Telephones [to stand Repeated Bending better than Stranded-Wire Cords].—Staebner. (*Bell Lab. Record*, March 1944, Vol. 22, No. 7, pp. 333–334.)

2341. Substitutes for Diamonds [in the Workshop].—Dawihl. (*Physik. Berichte*, 1st April 1943, Vol. 24, No. 7, p. 539.) From *Zeitschr. V.D.I.*, 26th Dec. 1942, Vol. 86, No. 51/52, p. 780 onwards.

2342. A Proposed Substitute for Instrument Oil [Reason for the Exceptionally Lasting Qualities of Porpoise-Jaw Oil: the Finding of a Satisfactory Substitute].—Bloomenthal. (*Phys. Review*, 1st/15th Jan. 1944, Vol. 65, No. 1/2, pp. 64–65: summary only.) For instruments which must operate for long periods without attention.

2343. The Precipitation of Antimony on the Negative Plates of Accumulators [and Its Injurious Action: Suggested Use of Ca–Pb Alloys: etc.].—Byfield. (*Physik. Berichte*, 1st April 1943, Vol. 24, No. 7, p. 509.)

STATIONS, DESIGN AND OPERATION

2344. The Rôle of Ultra-High Frequencies in Post-War Broadcasting [Summary of Opening Paper & Discussion, Wireless Section, I.E.E.].—Jones, Bell, & others. (*Journ. I.E.E.*, Part III, No. 13, March 1944, Vol. 91, pp. 11–12.)

The openers believe "that all the more populous areas of Great Britain and Northern Ireland could be supplied with a television service through 12 stations, and that three separate carrier frequencies would be sufficient . . .", using vestigial-sideband transmission. The combined u.h.f. services—television and f.m. sound broadcasting—would be organised on a regional basis. In the Discussion "it was suggested that amplitude modulation, in place of frequency modulation as proposed, would allow more channels and require less complicated receivers. It was generally agreed, however, that the 'capture effect', whereby a weaker signal is suppressed by a stronger one, was an extremely valuable characteristic of frequency modulation for a service organised on the lines suggested". The text of the opening remarks is given in *Electronic Eng:g*, Jan. 1944, Vol. 16, No. 191, pp. 320–323.

2345. EQUATORIAL RADIO GIRDLE: AVOIDING ZONES OF IONOSPHERE DISTURBANCE [Discussion of American Plan, reported in *Daily Telegraph*, for "Trunk Line" girdling the Earth about 20° North of Equator].—(*Wireless World*, May 1944, Vol. 50, No. 5, pp. 140–141.) For a short leading article *see* p. 129.

2346. METHOD OF ALTERING THE WIDTH OF THE FREQUENCY BAND OF ELECTRICALLY TRANSMITTED INTELLIGENCE.—Krawinkel. (*Zeitschr. f. Fernmeldetech.*, 24th Nov. 1943, Vol. 24, No. 8, p. 125.)

D.R.P.728 838. "A frequency mixture is reduced or raised in all its frequencies by time-expanding or compressing arrangements, with simultaneous preceding or subsequent phase of frequency modulation of the oscillations to be so transformed or already so transformed, whereby a continuous narrowed or broadened frequency band is obtained." Application is to all fields of communication, the improvement lying in the fuller utilisation of the channels and apparatus, as regards frequencies.

2347. MORSE BY PULSES: A "DOUBLE-CURRENT" SYSTEM OF RADIO TELEGRAPHY [with Economy in Radiated Energy: Key releases "Marking" & "Spacing" Pulses (at First Contact & at Break, respectively) operating Receiver Relay which controls A.F. Oscillator].—Whitehead. (*Wireless World*, April 1944, Vol. 50, No. 4, pp. 102–105.)

2348. ARMY'S HIGHEST-POWERED MOBILE STATION, DESIGNED FOR DIRECT WORKING BETWEEN ALL THEATRES OF WAR ["Golden Arrow"].—(*Wireless World*, April 1944, Vol. 50, No. 4, pp. 106–107.) *See* also *Engineer*, 17th March 1944, Vol. 177, No. 4601, pp. 215–216.

2349. SIGNAL CORPS TROOPS IN ITALY: A REPORT ON COMMUNICATIONS DURING THE INVASION OF THE SALERNO SECTOR.—(*QST*, Jan. 1944, Vol. 28, No. 1, pp. 57 and 86.)

2350. THE NEW FREQUENCY-MODULATED SCR-300 WALKIE-TALKIE [with Various Improvements over the Original A.M. Equipment].—(*QST*, Jan. 1944, Vol. 28, No. 1, p. 56 and Cover.)

2351. A WERS HANDIE-TALKIE FOR $1538.77 [or, without Frivolous Expenses, about $25.00: Communication at R9 over 10–12 Miles].—Long. (*QST*, Feb. 1944, Vol. 28, No. 2, pp. 32–38.)

2352. A SIMPLE WERS TRANSCEIVER WITH TRANSFORMER-LESS POWER SUPPLY.—Roth. (*QST*, Jan. 1944, Vol. 28, No. 1, pp. 11–13.)

2353. WHAT SHOULD BE THE POWER LIMITATION ON AMATEUR STATIONS AFTER THE WAR?—Editorial. (*QST*, Jan. 1944, Vol. 28, No. 1, pp. 9–10.)

2354. POST-WAR PROSPECTS [for Amateur Radio: Readers' Views & Proposals].—A.R.R.L. (*QST*, Feb. 1944, Vol. 28, No. 2, pp. 62–66.)

2355. POST-WAR AMATEUR TRANSMISSION ["Ominous Outlook looming Ahead": the Week-End Chaos even before the War: are we making a Rope to Hang Ourselves with?].—"P.B.P." (*Wireless World*, May 1944, Vol. 50, No. 5, p. 153.) Prompted by signs of a tendency "to commercialise the amateur movement", and the proposal to grant a licence to every qualified radio operator coming out of the Services.

GENERAL PHYSICAL ARTICLES

2356. INTRODUCTORY NOTES ON A REFORMULATION OF THE SPECIAL THEORY OF RELATIVITY [Unnecessary & Impeding Rigidity removed from Meaning of Special Theory, by modifying Einstein's Postulate of Constancy of Velocity of Light to cover Velocities measured over Closed Paths only].—Scott-Iversen. (*Phil. Mag.*, Feb. 1944, Vol. 35, No. 241, pp. 105–120.)

2357. SPACE, TIME, AND NATURAL LAWS [and the Question of the Limits of Validity of Geometry on the Transition to Smaller & Smaller Dimensions (Electrons, etc.)].—March. (*Naturwiss.*, Vol. 31, 1943, p. 49 onwards.) For a long summary see *Zeitschr. f. Instr:kunde*, Nov. 1943, Vol. 63, No. 11, pp. 398–400.

2358. ON THE BOUNDARY-VALUE PROBLEMS OF LAPLACE'S EQUATION RELATING TO TWO SPHERES: A NEW METHOD OF SOLUTION.—Mitra. (*Sci. & Culture* [Calcutta], March 1944, Vol. 9, No. 9, pp. 397–398.)

2359. PHYSICS IN 1943 [Neutrons, Mesotrons, Disintegration by Protons, Čerenkov Radiation, Ions, Thermal Diffusion, Electron Microscopy, X-Rays: Looking Ahead: Bibliography].—Osgood. (*Journ. Applied Phys.*, Feb. 1944, Vol. 15, No. 2, pp. 89–107.)

MISCELLANEOUS

2360. "A SHORT COURSE IN TENSOR ANALYSIS" [Book Review].—Kron. (*BEAMA Journal*, March 1944, Vol. 51, No. 81, p. 96.) "Like its two predecessors, it makes electrical engineering history." For recent work *see* 2 of January and 2123/4, above.

2361. "DIE METHODEN DER MATHEMATISCHEN PHYSIK" [Vols. I & II: Book Review].—Courant & Hilbert. (*Journ. Applied Phys.*, Feb. 1944, Vol. 15, No. 2, p. 148.) Available in a photolithoprint reproduction. "If, as some persons think, the scientific work during the war may bring about a revival of interest in the problems of classical physics, this volume may be of considerable value in future developments."

2362. GEOMETRIC FIGURES IN AFFINE SPACE [from "A Tensor Interpretation of Study's *Geometrie der Dynamen*"].—Spencer. (*Journ. of Math. & Phys.* [of M.I.T.], Feb. 1944, Vol. 23, No. 1, pp. 1–23.) "If the tensor coordinatization of these geometric figures can be found, it will make a contribution to geometry and applied mathematics comparable with that made by vector analysis."

2363. TABLE OF $f_n(x) = n!/(x/2)^n \cdot J_n(x)$.—Mathematical Tables Project. (*Journ. of Math. & Phys.* [of M.I.T.], Feb. 1944, Vol. 23, No. 1, pp. 45–60.)

2364. MEASURABLE FUNCTIONS [Elementary Proofs of Series of Theorems on Approximation of Measurable, Summable, & Riemann Integrable Functions: Carathéodory's Classes of Bounded Measurable Functions on a Finite Interval (Modification, & Application to Functions on Infinite Intervals): etc.].—Franklin. (*Journ. of Math. & Phys.* [of M.I.T.], Feb. 1944, Vol. 23, No. 1, pp. 24–44.)

2365. A TAUBERIAN THEOREM AND ITS APPLICATION TO CONVERGENCE OF FOURIER SERIES, *and* NEW CONVERGENCE AND SUMMABILITY TESTS FOR FOURIER SERIES.—Iyengar. (*Sci. Abstracts*, Sec. A, Jan. 1944, Vol. 47, No. 553, p. 1: p. 1.)

2366. ON THE REPRESENTATION OF THE FUNCTIONS OF A REAL VARIABLE IN TRIGONOMETRICAL SERIES MORE GENERAL THAN THE FOURIER SERIES.—Bayard. (*Comptes Rendus* [Paris], 7th/28th June 1943, Vol. 216, No. 23/26, pp. 792–793.)

2367. ALTERATION OF THE HARMONIC COMPONENTS OF A SERIES OF OBSERVATIONAL DATA BY THE SMOOTHING OF THE SERIES THROUGH OVERLAPPING MEANS.—Zimmer. (*Physik. Berichte*, 1st April 1943, Vol. 24, No. 7, p. 545: from *Meteorolog. Zeitschr.*, No. 5, Vol. 59, 1942, p. 145 onwards.)

2368. THE ELIMINATION OF THE EFFECTS OF ACCIDENTAL ERRORS OF MEASUREMENT IN STATISTICAL INVESTIGATIONS.—Malmquist. (*Sci. Abstracts*, Sec. A, Jan. 1944, Vol. 47, No. 553, p. 2.)

2369. THE STATISTICAL CONTROL OF QUALITY: APPLICATION OF STATISTICAL INSPECTION IN THE TELEPHONE INDUSTRY.—Vroom. (*Sci. Abstracts*, Sec. B, Dec. 1943, Vol. 46, No. 552, p. 205.)

2370. THE SELECTION OF FANS [for Forced Air Circulation: Method using Cursor moving over a Logarithmically Divided Field: capable of Application to Other Problems in which Relationships between Powers of the Variables are combined with a Form of Variation Not Capable of Mathematical Expression].—Daly. (*G.E.C. Journal*, Feb. 1944, Vol. 13, No. 1, pp. 33–40.) "So far as the writer is aware, the principal is an original one."

2371. THE FRUITION OF RESEARCH [Leading Article on Eccles's Article (1750 of May) & Riverdale's Speech at Manchester].—Eccles: Riverdale. (*Engineer*, 10th March 1944, Vol. 177, No. 4600, p. 190.) "The bond between the two is that in the opinion of both authors the application of discoveries in Great Britain lags behind the scientific research from which they spring. . . ."

2372. FUNDAMENTAL SCIENTIFIC RESEARCH AND ITS PRACTICAL IMPORTANCE [Summary of Manchester Address].—Appleton. (*Electrician*, 28th April 1944, Vol. 132, No. 3439, p. 369.) For an Editorial note on this and on the Chancellor of the Exchequer's proposals, *see* pp. 353–354. *See* also *Nature*, 29th April 1944, Vol. 153, No. 3887, p. 520.

2373. THE ADVANCEMENT OF LEARNING IN THE UNITED STATES IN THE POST-WAR WORLD [Franklin Medal Lecture].—Conant. (*Science*, 4th Feb. 1944, Vol. 99, No. 2562, pp. 87–94.)

2374. THE PROMISE OF TECHNOLOGY.—Jewett. (*Science*, 7th Jan. 1944, Vol. 99, No. 2558, pp. 1–6.) In a series of conferences on "Post-War Goals and Economic Reconstruction", New York University. "Covers a number of points of high significance in the discussions at present proceeding in Great Britain" (*Nature*, 22nd April 1944, Vol. 153, No. 3886, pp. 502–503).

2375. THE KILGORE BILL [Letter to Senator Kilgore: the Appropriate Organization of Science & Technology for the Prosecution of the War, and the Corresponding Problem in Times of Peace].—Bush. (*Science*, 31st Dec. 1943, Vol. 98, No. 2557, pp. 571–577.)

2376. THE NATIONAL ROSTER OF SCIENTIFIC AND SPECIALISED PERSONNEL [including a Paragraph on its Usefulness during the Immediate Post-War Period].—Carmichael. (*Scient. Monthly*, Feb. 1944, Vol. 58, No. 2, pp. 141–147.) By the Director.

2377. POST-WAR PLANNING IN RUSSIA [for Astrophysical Research].—Struve. (*Science*, 4th Feb. 1944, Vol. 99, No. 2562, pp. 100–101.) "The breathtaking scope of this plan will probably startle those who have had little inclination during the past two years to indulge in post-war planning. . . ."

2378. SCIENTIFIC RESEARCH AND THE WAR EFFORT OF U.S.S.R.—Tolpin. (*Science*, 7th Jan. 1944, Vol. 99, No. 2558, pp. 7–9.) With an abbreviated list of the researches winning "Stalin prizes" (*cf.* 992 of March), particularly in the field of chemistry: N. P. Bogoroditski's invention of an improved "ultra-porcelain" insulating material is mentioned as already being produced on a large scale by the radio industry.

2379. ORGANISATION OF SCIENTIFIC RESEARCH IN THE U.S.S.R.—Naik. (*Sci. & Culture* [Calcutta], March 1944, Vol. 9, No. 9, pp. 365–367.)

2380. THE SCIENTIFIC ORGANIZATION, OFFICIAL AND UNOFFICIAL, IN THE UNITED KINGDOM [Lecture to Indian Science Congress, 5th Jan. 1944].—Hill. (*Sci. & Culture* [Calcutta], Feb. 1944, Vol. 9, No. 8, pp. 312–318: Editorial Notes & Appendix, pp. 319–321.) Preceded by an Editorial (pp. 308–311) and followed (p. 322) by a note on Hill's work.

2381. A NATIONAL RESEARCH COUNCIL FOR INDIA.—Ghosh. (*Sci. & Culture* [Calcutta], Jan. 1944, Vol. 9, No. 7, pp. 255–258.) From the presidential address to the National Institute of Sciences of India, Dec. 1943. *Cf.* 1397 of April.

2382. INDUSTRIAL RESEARCH AND UNIVERSITIES [Leading Article].—(*Sci. & Culture* [Calcutta], March 1944, Vol. 9, No. 9, pp. 359–364.)

"Let us therefore scrutinise the methods which have been evolved in the capitalistic countries . . . to prevent the small industrialist from being swallowed up by his Big Brothers, by allowing him to share the benefits of scientific research. The question is of supreme importance to the Indian industrial producer . . ."

2383. A COMMUNITY OF RESEARCH ASSOCIATIONS [to be established at Leatherhead].—E.R.A. & others. (*Journ. of Scient. Instr.*, April 1944, Vol. 21, No. 4, p. 72.) For Dunsheath's suggestion see *Engineer*, 17th March 1944, Vol. 177, No. 4601, p. 214.

2384. TELECOMMUNICATION ENGINEERING AND MANUFACTURING ASSOCIATION [Formation of].—(*Journ. of Scient. Instr.*, April 1944, Vol. 21, No. 4, p. 72.)

2385. BRITISH INDUSTRIAL MEASURING AND CONTROL APPARATUS MANUFACTURERS' ASSOCIATION [Formation of].—B.I.M.C.A.M. Association. (*Journ. of Scient. Instr.*, April 1944, Vol. 21, No. 4, p. 72.)

2386. AIDING BRITISH EXPORTS [Note on the Issue, as soon as possible after the War, of the *British Engineering Exporter*, for Overseas Circulation].—(*Wireless World*, May 1944, Vol. 50, No. 5, p. 151.)

2387. WIRELESS SECTION, I.E.E.: CHAIRMAN'S ADDRESS [Thermionic Valve Manufacturing Progress: Broadcasting: Television: Commercial Radio Communication: Industrial Applications of Thermionic Devices: the Radio Industry: the Work of the Radio Amateurs: the Wireless Section].—Goldup. (*Journ. I.E.E.*, Part III, No. 13, March 1944, Vol. 91, pp. 2–11.) The complete address, parts of which were referred to in 1387 of April.

2388. DISCUSSIONS [and the Desirability of Cooperation between the Various Bodies interested in Radio Science].—Clifford. (*Electronic Eng:g*, Jan. 1944, Vol. 16, No. 191, p. 347.) Letter from Secretary, British I.R.E. The position in America and Australia is compared with that in Great Britain; the cooperative attitude of some British institutions is recognised.

2389. OUTWORKING: UTILISING NON-FACTORY LABOUR FOR ASSEMBLY WORK [Report based on Recent Tour].—(*Wireless World*, May 1944, Vol. 50, No. 5, pp. 156–157.) "It will be seen from the foregoing that there is ample scope in the radio industry for outwork. There is no dearth of outworkers; the problem is to convince manufacturers that outworking is practicable."

2390. TRIMETRIC PROJECTION [presenting Engineering Drawings in a Simplified & "Picturesque" Manner: especially suited to Unskilled Operatives].—Fawcett. (*BEAMA Journal*, March 1944, Vol. 51, No. 81, p. 98: summary, from *Met.-Vick. Gazette*.)

2391. CORRESPONDENCE ON "SIMPLIFYING SYMBOLS" [1772 of May].—Lane-Smith: Stevens: Shannon. (*Electronic Eng:g*, Jan. 1944, Vol. 16, No. 191, pp. 346–347.)

2392. BRITISH STANDARDS SPECIFICATION: RECOMMENDATIONS FOR THE STORAGE OF MICRO-FILMS.—British Standards Institution. (*Engineering*, 17th March 1944, Vol. 157, No. 4079, p. 208.)

2393. THE UNIVERSAL DECIMAL CLASSIFICATION [Progress of the English Edition: Class 621.3 Electrical Engineering hoped for Soon: Preliminary Draft available Now].—British Standards Institution. (*Engineering*, 17th March 1944, Vol. 157, No. 4079, p. 207.)

2394. PITY THE AUTHOR! [of a Textbook: Readers' Requests for Information, and the Omission of the Stamped Addressed Envelope].—(*Wireless World*, March 1944, Vol. 50, No. 3, p. 75.)

2395. "A GERMAN PHYSICS READER" [Book Review].—Calthrop. (*Nature*, 4th March 1944, Vol. 153, No. 3879, p. 271.) "The book can be strongly recommended", but (by a beginner) should be used in conjunction with a volume such as Wiener's "German for the Scientist" (1032 of March).

2396. "SUB-ATOMIC PHYSICS" [Book Review].—Dingle. (*Journ. Applied Phys.*, Feb. 1944, Vol. 15, No. 2, p. 148.) "Forms half of a course in physics for aeronautical students".

2397. "PRACTICAL RADIO COMMUNICATION: REVISED SECOND EDITION" [Book Review]—Nilson & Hornung. (*QST*, Feb. 1944, Vol. 28, No. 2, p. 44.)

2398. "THE TECHNIQUE OF RADIO DESIGN" [Book Review].—Zepler. (*Wireless Engineer*, Jan. 1944, Vol. 21, No. 244, p. 23.)

2399. "FOUNDATIONS OF WIRELESS: FOURTH EDITION" [Book Review].—Scroggie. (*Electrician*, 10th March 1944, Vol. 132, No. 3432, p. 209.) Completely revised.

2400. "RADIO QUESTIONS AND ANSWERS: VOL. I—BASIC RADIO" [Book Review].—Squire. (*Wireless World*, May 1944, Vol. 50, No. 5, p. 136.)

2401. "RADIO AMATEURS' HANDBOOK FOR 1944" [Book Review].—A.R.R.L. (*Wireless World*, May 1944, Vol. 50, No. 5, p. 151.)

2402. "FUNDAMENTAL RADIO EXPERIMENTS" [Book Review).—Higgy. (*QST*, Feb. 1944, Vol. 28, No. 2, p. 44.)

2403. THE MIRROPHONE [for Language Instruction & Speech Training: 2747 of 1943] ON ALL AIRCRAFT CARRIERS.—(*Bell Lab. Record*, March 1944, Vol. 22, No. 7, p. 343.)

2404. A SIMPLIFIED TAPE CODE-PRACTICE OSCILLATOR: A COMBINATION CIRCUIT REQUIRING NO RELAYS.—Bartlett & Burns. (*QST*, Feb. 1944, Vol. 28, No. 2, pp. 45–48.)

2405. HISTORIC FIRSTS: AIRPLANE RADIO TELEPHONY [in 1917].—(*Bell Lab. Record*, Jan. 1944, Vol. 22, No. 5, p. 221.)

2406. THE ARMY AIRWAYS COMMUNICATIONS SYSTEM: PART I—WHAT THE A.A.C.S. IS AND WHAT IT DOES.—DeSoto. (*QST*, Feb. 1944, Vol. 28, No. 2, pp. 9–14 and 100..104.) *See* also Fawcett, 1608 of May.

2407. CAPTURED ENEMY EQUIPMENT EXHIBITED AT THE LABORATORIES [and Some Comparisons with American Counterparts: Photographs of German Photophone (3613 of 1943 [& 1097 of March]), Italian "Deck Chair" Pedal Generator, etc.].—(*Bell Lab. Record*, March 1944, Vol. 22, No. 7, pp. 338–339.)

2408. GERMAN SPIRAL-4 CABLE [and the Difference between It & the American Cable (1843 of May & Back Reference)].—(*Bell Lab. Record*, March 1944, Vol. 22, No. 7, p. 337.) For unorthodox use under water of the American cable *see* pp. 340–341.

2409. SUBSTITUTE MATERIALS IN TELEPHONE BOOTHS [Redesign saving 300 Tons of Steel, 95 of Rubber Compound, 35 of Brass & Bronze, on 8000 Booths].—Niles. (*Bell Lab. Record*, Jan. 1944, Vol. 22, No. 5, pp. 214–217.)

2410. DEVELOPMENT OF THE ELECTRICAL DIRECTOR.—(*Bell Lab. Record*, Jan. 1944, Vol. 22, No. 5, pp. 225–230.) *See* also 1413 of April, and for pictures *see* issue for April 1944, No. 8, p. 370 and Cover.

2411. REMOTE CONTROL OF THE ANTI-AIRCRAFT ARTILLERY [Guns & Searchlights: including the Use of Electrical Amplification].—Hopf. (*Zeitschr. V.D.I.*, 11th Dec. 1943, Vol. 87, No. 49/50, pp. 785–790.)

2412. BASIC CONSIDERATIONS IN SELECTION OF ELECTRICAL SYSTEMS FOR LARGE AIRCRAFT.—Boice & Levoy. (*Gen. Elec. Review*, March 1944, Vol. 47, No. 3, pp. 37–44.)

2413. "ELECTRONIC EAR" TESTS SMALL-CALIBRE SHELLS [the "Sonotest" Device (Microphone & Amplifier controlling Coloured Lamps) for "Ringing" to detect Shell-Cases unsuitable for Loading].—(*Sci. News Letter*, 29th Jan. 1944, Vol. 45, No. 5, p. 73.)

2414. "ELECTRONICS IN INDUSTRY" [Notice of Pamphlet in Non-Technical Language]. — R.C.A. Victor. (*Journ. Applied Phys.*, Feb. 1944, Vol. 15, No. 2, p. 149.) For business executives, manufacturers, and industrialists.

2415. ELECTROMAGNETIC VELOMETRY : I—A METHOD FOR THE DETERMINATION OF FLUID VELOCITY DISTRIBUTION IN SPACE AND TIME [particularly Suitable for Study of Rapidly Varying Velocities, owing to Absence of Lag in the Electromagnetic Induction Process : Design of Self-Contained Unit : etc.].—Kolin. (*Journ. Applied Phys.*, Feb. 1944, Vol. 15, No. 2, pp. 150–164.) *See* also 665 of 1942.

2416. A PRACTICAL VALVE AMPLIFIER FOR MEASURING GLASS-ELECTRODE POTENTIALS [using only Three Valves].—Chun-yu Lin. (*See* 2165.)

2417. THE TESTING OF RADIO EQUIPMENT AND COMPONENTS, AND THEIR TREATMENT TO MEET EXTREME CLIMATIC CONDITIONS.—Coursey & others. (*See* 2279.)

2418. THYRATRON MOTOR CONTROL ["All-Electronic" D.C. Motor Drive for A.C. Mains, and Its Various Control Functions].—Moyer & Palmer. (*Elec. Engineering*, Nov. 1943, Vol. 62, No. 11, Transactions pp. 706–712.)

2419. CONTRIBUTIONS TO THE THEORY OF AUTOMATIC CONTROLLERS AND FOLLOWERS.—Prinz. (*See* 2166.)

2420. ELECTRONIC CONTROL FOR STEEL-MILL AUXILIARIES.—Hopper. (*Sci. Abstracts*, Sec. B, Dec. 1943, Vol. 46, No. 552, p. 212.)

2421. ELECTRONIC WELDING CONTROL : I, *and* SEAM AND PULSATION WELDING CONTROLS : II—Palmer : Bivens. (*Sci. Abstracts*, Sec. B, Dec. 1943, Vol. 46, No. 522, pp. 212–213 : p. 212 : from *Electronics*, Aug. & Sept. 1942.) For Biven's earlier paper *see* 279 of 1943.

2422. SERVICING RESISTANCE-WELDING CONTROLS : VI [Oscilloscope Circuits : Calibration : etc.].—Weller. (*Sci. Abstracts*, Sec. B, Dec. 1943, Vol. 46, No. 552, p. 213 : from *Electronics*, Jan. 1943.)

2423. AUTOMATIC VOLTAGE COMPENSATOR FOR RESISTANCE-WELDING CONTROL [giving Consistent Welds on Poorly Regulated Lines, even in Wartime].—Callender & Phair. (*Elec. Engineering*, Nov. 1943, Vol. 62, No. 11, Transactions pp. 701–705.)

2424. EFFECT OF STRAIN RATE UPON PLASTIC FLOW OF STEEL [Investigation using Electrical Strain Gauges, Rectifier & Sweep Circuits, and C.R. Oscillograph].—Zener & Hollomon. (*Journ. Applied Phys.*, Jan. 1944, Vol. 15, No. 1, pp. 22–32.)

The rectified impulse was required to be linear over as wide a range as possible : "reference to electronic texts gave no indication of a philosophy of the linearity of rectifier units", so the circuit of Fig. 4 was evolved, giving the calibration curve of Fig. 5.

2425. SOME UNUSUAL APPLICATIONS OF THE CATHODE-RAY OSCILLOGRAPH [Measurement of Shaft Speeds : Integration & Differentiation : Colour-Response Measurements on Photoelectric Cells : Measurement of Acoustic Wavelengths].—Patchett. (*Electronic Eng:g*, Feb. 1944, Vol. 16, No. 192, pp. 378–380.) Continued from 172 of January.

2426. POLARISED-LIGHT SERVO-SYSTEM [Link between Primary & Secondary Shafts is Light whose Plane of Polarisation rotates with Primary Shaft, making possible an Accurate Following of Shaft Rotation without Imposition of any Load : already successful in Electro-Mechanical Calculating Machines].—Berry. (*Elec. Engineering*, Dec. 1943, Vol. 62, No. 12, p. 547 : summary only.) *Cf.* Kuehni & Peterson (General Electric) "A New Differential Analyser", abstract on same page.

2427. METHOD OF MEASURING THE ANGLE OF TORSION IN AXLES ROTATING AT 30 000 r.p.m. [Combination of C.R. Oscilloscope and Electron-Multiplier Photocell].—Bauder. (*Elektrot. u. Masch:bau*, 9th July 1943, Vol. 61, No. 27/28, p. 311 onwards.) For a short summary see *Génie Civil*, 15th Nov. 1943, Vol. 120, No. 22, p. 264.

2428. A NEW METHOD FOR USING PHOTOCELLS IN AUTOMATICS AND TELEMECHANICS.—Kushnir & Kaverin. (*Automatics & Telemechanics* [in Russian], No. 4/5, 1941, pp. 71–75.)

Photocells are often used for registering the passage of moving objects. In this paper a method is proposed for registering moving objects of a predetermined shape only. To achieve this, a number of small photocells are arranged in the focal plane of a lens so as to reproduce the outline of the object to be registered. By connecting the cells in parallel or in series it is possible to ensure the operation of the registering device only if an object of the predetermined shape passes in front of the lens. One of the suggested applications of this method is the registration of cars of a predetermined type moving on the road in a predetermined direction (Fig. 4). Experiments are described which have proved the practicability of the method.

2429. DIRECT-READING INSTRUMENT FOR SPECTROCHEMICAL ANALYSIS [Photographic *versus* Direct Photoelectric Recording : Satisfactory "Direct Reading" requires Entirely New Spectrum-Dispersing Instrument : Present Limitations & Future Developments of Such an Instrument].—Hasler & Dietert. (*Journ. Opt. Soc. Am.*, Dec. 1943, Vol. 33, No. 12, p. 687 : summary only.)

2430. THE APPLICATION OF MULTIPLIER PHOTOTUBES TO QUANTITATIVE SPECTROCHEMICAL ANALYSIS [Two RCA 931 Tubes with Their Last Stages in Bridge Circuit, measuring Ratio of Output : Governing Factor of Sensitivity & Accuracy is the Supplementary Equipment, principally Spectrograph & Source : Use also of a Developmental Tube (C-7045) having Ultra-Violet-Transparent Envelope].—Boettner & Brewington. (*Journ. Opt. Soc. Am.*, Jan. 1944, Vol. 34, No. 1, pp. 6–11.)

2431. SPECTROPHOTOMETRIC EXPERIMENTS WITH AN ULTRA-VIOLET MULTIPLIER PHOTOTUBE [the RCA C-7045 : *see* 2430, above].—Pfister. (*Journ. Opt. Soc. Am.*, Dec. 1943, Vol. 33, No. 12, p. 689 : summary only.)

2432. THE TECHNIQUE OF MATERIALS TESTING : VI—OPTICAL PROPERTIES [*e.g.* of Transparent Plastics : the Kline–Bowen Haze Meter, etc.].—Owen. (*BEAMA Journal*, Feb. 1944, Vol. 51, No. 80, pp. 48–56.)

2433. PHOTOELECTRIC PHOTOMETERS : THEIR PROPERTIES, USE, AND MAINTENANCE [including a Portable Type capable of measuring down to 10^{-9} Lumen].—Preston. (*Sci. Abstracts*, Sec. A, Dec. 1943, Vol. 46, No. 552, p. 233.)

2434. A PHOTOELECTRIC PHOTOMETER FOR MEASURING THE LIGHT SCATTERED BY THE SURFACE OF A TRANSPARENT MATERIAL [primarily for Measurement of Obscuration of Plastic Surfaces produced by Abrasion : with an Appendix on the Use of a High-Resistance Grid Leak with a Cathode Follower].—Sowerby. (*Journ. of Scient. Instr.*, March 1944, Vol. 21, No. 3, pp. 42–45.)

2435. PAPERS ON STELLAR PHOTOELECTRIC COLORIMETRY USING AN Sb–Cs PHOTOCELL AND COLOUR FILTERS.—Nikonov & Brodskaja : Nikonov. (*Sci. Abstracts*, Sec. A, Dec. 1943, Vol. 46, No. 552, p. 226 : p. 226.) " The cell is of higher sensitivity, higher range and greater stability than the best K cells." *Cf.* Stebbins & Whitford, *ibid.*, p. 227.

2436. STUDY ON MEASUREMENTS OF DAYLIGHT : THE INFLUENCE OF POLARISED LIGHT [on the Response of a Photocell].—Hausner. (*Sci. Abstracts*, Sec. A, Dec. 1943, Vol. 46, No. 552, p. 232.)

2437. A PHOTOELECTRICALLY OPERATED STOP-WATCH.—Wey. (*Electronic Eng:g*, Jan. 1944, Vol. 16, No. 191, pp. 334–336.)

2438. THE DIFFERENCE IN RESISTANCE OF COLD AND HOT LAMP-FILAMENTS [Rough Measurements on Lamps of Various Powers gives a Ratio of about 8 : 100].—" Diallist." (*Wireless World*, May 1944, Vol. 50, No. 5, p. 158.)

" I had expected a big difference . . . but I had no idea it would turn out to be as big as it is." A cheap lamp of unknown make differed from the others by showing definite warming-up by the test current (from a 2-volt cell) : this was the only 25-watt lamp tested, the others, of well-known makes, ranging from 40 to 75 watts.

2439. SPEECH-ON-LIGHT SYSTEM [in the German Army].—(*Wireless World*, May 1944, Vol. 50, No. 5, p. 143.) *Cf.* 3613 of 1943 [and perhaps 1097 of March—Goos & Hänchen].

2440. CAMERAS IN LIGHT-BEAM COMMUNICATION : SUGGESTIONS FOR ADAPTING AVAILABLE TYPES TO TRANSMISSION AND RECEPTION.—Saunders. (*QST*, Jan. 1944, Vol. 28, No. 1, pp. 22–25.) *See* also 3612 of 1943 ; also Stevens, 2872 of 1942.

2441. THE NEW HIGH-SPEED, ELECTRONIC " PHOTOLIGHT ".—Bellinger. (*Gen. Elec. Review*, March 1944, Vol. 47, No. 3, pp. 31–33.) *See* also 1824 of May and back reference.

2442. THE PRODUCTION OF VERY HIGH TEMPERATURES IN THE ELECTRIC ARC [Trebling or Quintupling the Current Density raises Temperature from 4000° to 10 000° (of Interest in Many Ways, including Use as Source of White Light of Great Intensity) : Experimental Results].—Finkelnburg. (*Génie Civil*, 1st Dec. 1943, Vol. 120, No. 23, p. 275 : summary, from *Forschungen u. Forschritte*, 1st/10th July 1943.)

2443. ON THE PERCEPTION OF THE EXTERNAL WORLD IN MONOCULAR OR BINOCULAR VISION, WITH OR WITHOUT INSTRUMENTS, *and* THE SENSATION OF RELIEF AND ITS INTERPRETATION BY THE SUBCONSCIOUS MIND.—Dunoyer : Dévé. (*Zeitschr. f. Instr:kunde*, Nov. 1943, Vol. 63, No. 11, p. 400 : p. 401 : summaries, from *Revue d'Opt.*, 1940.)

2444. CALCULATION OF RADIATION PRESSURE ON ABSORBING PARTICLES.—Schalén & Wernberg. (*Sci. Abstracts*, Sec. A, Jan. 1944, Vol. 47, No. 553, pp. 12–13.)

2445. LIGHT-EFFECT IN CHLORINE UNDER ELECTRICAL DISCHARGE : INFLUENCE OF THE GAS PRESSURE.—Joshi & Deo. (*Nature*, 8th April 1944, Vol. 153, No. 3884, pp. 434–435.) Following on 2291 of 1943.

2446. ON THE ABSOLUTE SENSITIVITY OF PHOTOELECTRIC COUNTERS [with CuI Cathodes, highly sensitive to Ultra-Violet Light between 2000 & 2850 A.U.].—Mattler. (*Comptes Rendus* [Paris], 7th/28th June 1943, Vol. 216, No. 23/26, pp. 760–762.)

2447. COUNTER CORRECTIONS AT HIGH COUNTING RATES.—Kohman. (*Phys. Review*, 1st/15th Jan. 1944, Vol. 65, No. 1/2, p. 63 : summary only.)

2448. RECORDING NEGATIVE IONS AND ELECTRONS IN A GAS WITH A GEIGER–MÜLLER COUNTER.—Murray. (*Phys. Review*, 1st/15th Jan. 1944, Vol. 65, No. 1/2, p. 63 : summary only.) " It is planned to develop the apparatus further for the efficient detection of space-localised low-energy ionising particles."

2449. AN INTERFEROMETRIC PROCEDURE FOR THE EXAMINATION OF CRYSTAL SURFACES [the Two-Beam *versus* the Multiple-Beam Technique].—Siegbahn : Tolansky. (*Nature*, 8th April 1944, Vol. 153, No. 3884, p. 435.) Correspondence prompted by 1450 of April : *see* also 1827 of May, and 2450, below.

2450. NEW CONTRIBUTIONS TO INTERFEROMETRY : PART II—NEW INTERFERENCE PHENOMENA WITH NEWTON'S RINGS [and Possible Applications].—Tolansky. (*See* 2267.)

2451. INTERFERENCE-BAND INSPECTION OF SURFACE FINISH [Simple Microscopic Process].—Kayser. (*Engineering*, 17th March 1944, Vol. 157, No. 4079, pp. 205–207.)

2452. X-RAY DIVERGENT-BEAM PHOTOGRAPHY AS A TEST OF CRYSTAL PERFECTION.—Lonsdale. (*Nature*, 8th April 1944, Vol. 153, No. 3884, pp. 433–434.) Following on 1066 of March.

2453. A CONTRIBUTION TO THE GEOMETRICAL–OPTICAL ENLARGEMENT WITH X-RAYS [Surface Enlargement by Successive Total Reflection of Primary Homogeneous X-Ray Beam at Two Cylinders at Right Angles].—Kellermann. (*Ann. der Physik*, 26th June 1943, Vol. 43, No. 1/2, pp. 32–36.)

2454. METEORITE DETECTORS, *and* SYNTHETIC SYMMETRY IN MUTUAL-INDUCTANCE BALANCES : A PRACTICAL PROBLEM WITH METEORITE DETECTORS.—LaPaz : Wisman. (*Sci. Abstracts*, Sec. A, Dec. 1943, Vol. 46, No. 552, p. 226 : p. 226.)

2455. FUTURE PROSPECTS OF RADIO-PROSPECTING BY REFLECTION [Lately Neglected owing to Development of Other Geophysical Methods : Recent Improvements in the Radio-Reflection (Echo) Apparatus : Successful Tracing of Strata 5000 m Deep].—Fritsch. (*Génie Civil*, 1st Dec. 1943, Vol. 120, No 23. p. 276 : summary, from *Glückauf*, 3rd July 1943.)

2456. "Morning Incidents" on Very High Tension Electric Lines [Sunrise Effects producing Short Interruptions of Service: Suggested Explanations include Birds, Moisture, etc: Statistics point to Dew as Most Probable Cause].—Cabanes. (*Génie Civil*, 1st Dec. 1943, Vol. 120, No. 23, pp. 274–275: summary, from *Rev. Gén. de l'Élec.*, July 1943.)

2457. Communication at Supersonic Frequencies [Long Summary of Weitzer's Article, 513 of February].—Weitzer. (*Electronic Eng:g*, Jan. 1944, Vol. 16, No. 191, pp. 327–328.)

The experiments started from the desire of health officials to rid their water reservoirs of sea-gulls. The effect on these, and on flies, is reported [*cf.* D'Orsay Bell's proposal for eliminating mosquitoes, 1928 Abstracts, p. 694, l-h column].

2458. A Spring-Pressure-Contact Electrode for use in Electroencephalographic Recording [eliminating the Disadvantages of the Solder-Pellet/Collodion Method].—Ulett & Claussen. (*Science*, 28th Jan. 1944, Vol. 99, No. 2561, pp. 85–86.)

2459. Brain Rhythms [R.I. Discourse].—Adrian. (*Nature*, 25th March 1944, Vol. 153, No. 3882, pp. 360–362.)

2460. A Simple Variable "Square-Wave" Stimulator for Biological Work [Independently Variable in Intensity, Duration, & Frequency over Wide Ranges].—Ritchie. (*Journ. of Scient. Instr.*, April 1944, Vol. 21, No. 4, pp. 64–65.)

The basic circuit is a multivibrator, designed with small power valves in an asymmetric manner so that one valve provides the stimuli and the other the interval between stimuli: regulation of the power pack is of no importance since the rectifier load is constant. The stimulus characters are very little affected by minor fluctuations in power-supply voltage.

2461. Papers on the Effect of Wave-Form and Frequency on Let-Go Currents.—Dalziel & others. (*Elec. Engineering*, Dec. 1943, Vol. 62, No. 12, Transactions pp. 739–744 & 745–750.) Summaries, and previous work, were referred to in 1075 of March.

2462. Maybe Moon Does Affect Plants After All [Recordings of Potential Difference between Electrodes in Trees show Sharp Rise about Once a Month].—Burr. (*Sci. News Letter*, 19th Feb. 1944, Vol. 45, No. 8, p. 120.) From the Yale School of Medicine.

2463. A Mass Spectrometer and Gaseous Thermal Diffusion Isotope Separator [Nier-Type Mass Spectrometer with Alnico Permanent Magnet & Other Modifications].—Taylor. (*Review Scient. Instr.*, Jan. 1944, Vol. 15, No. 1, pp. 1–8.)

2464. Mass Spectrometer [Commercial Installation].—Consolidated Engineering. (*Journ. of Scient. Instr.*, April 1944, Vol. 21, No. 4, pp. 69–70.) With automatic (photographic) recording. For a note on this, and also on a Westinghouse equipment, see *Journ. Applied Phys.*, Feb. 1944, pp. 202 and xii.

2465. Gaseous Diffusion as a Tool for locating Critical Points in Metals and Alloys [Its Great Sensitivity illustrated by Reference to Ham & Bennett's Work on Carefully Homogenised Ferromagnetic Alloys].—Coleman & Yeagley. (*Journ. Applied Phys.*, Feb. 1944, Vol. 15, No. 2, pp. 125–127.) For "Comments on the Anisotropy of Metals", by the same authors, see *Phys. Review*, 1st/15th Jan. 1944, Vol. 65, No. 1/2, pp. 56–57.

2466. The Non-Destructive Testing of Metallic Components.—Chalmers. (*Proc. Phys. Soc.*, 1st March 1944, Vol. 56, Part 2, No. 314, pp. 132–142: Discussion pp. 143–147.)

2467. An Electronic Defectoscope [for Magnetic Detection of Flaws, especially in Railway Lines: using Flat-Topped Magnetic-Field Valve with Semi-Cylindrical Anode].—Gorelik & others. (*Journ. Roy. Aeron. Soc.*, Jan. 1944, Vol. 48, No. 397, Abstracts pp. 5–6.) An R.T.P.3 Abstract, from a Russian paper.

2468. The Cyclotron: I [Information on Design, etc., based on the M.I.T. Cyclotron].—Livingston. (*Journ. Applied Phys.*, Jan. 1944, Vol. 15, No. 1, pp. 2–19.)

"The cyclotron is in process of metamorphosis from an academic luxury for nuclear physicists to an indispensable tool for applied science and industry. . . . The time is near when the use of the cyclotron as a production unit may even outweigh its further scientific usefulness." For the second (concluding) part *see* issue for February, No. 2, pp. 128–147.

2469. Radio Heating Equipment: II—Coupling "Work" to the R.F. Generator.—Langton. (*Wireless World*, May 1944, Vol. 50, No. 5, pp. 137–139.) For I *see* 2100 of June.

2470. Correction to Equation in "The Theory and Practice of Industrial Electronic Heating" [1476 of April].—Jordan. (*Gen. Elec. Review*, March 1944, Vol. 47, No. 3, p. 21.)

2471. Radio Tubes for Heat-Treating by High-Frequency Induction, *and* Electric Fusion of Tinplate.—Humphrey: Stoltz & others. (*Sci. Abstracts*, Sec. B, Dec. 1943, Vol. 46, No. 552, p. 217.)

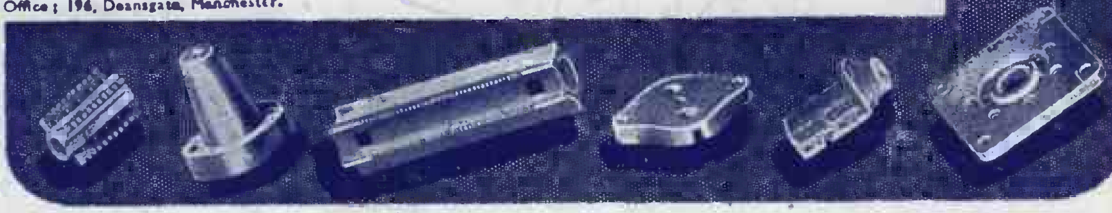
2472. High-Frequency Gluing of Resins [in Glider Construction, etc: including a Discussion of the Perpendicular, Parallel, & Stray Field Heating Methods].—Godfrey & Bilhuber. (*Electronic Eng:g*, Jan. 1944, Vol. 16, No. 191, p. 348: summary, from *Mod. Plastics*, Sept. 1943.)

2473. "Heat-Conduction Problems in Presses used for Gluing of Wood" [Correction to Decimal Classification of Paper dealt with in 1073 of March].—Brown. (*Proc. I.R.E.*, Dec. 1943, Vol. 31, No. 12, p. 656.)

2474. The Application of Radiant and Inductive Heating to Industrial Processes.—Connell. (*G.E.C. Journal*, Feb. 1944, Vol. 13, No. 1, pp. 10–32.) With 22 literature references.

2475. Control Equipments for Induction Heating: Modern Equipments for both Core and Core-less Types of Induction Furnaces [and the Use of the Amplidyne].—Ackley. (*Gen. Elec. Review*, March 1944, Vol. 47, No. 3, pp. 16–21.)

GA



Printed in England for the Publishers, ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1, by The Cornwall Press Ltd., Paris Garden, Stamford Street, London, S.E.1.