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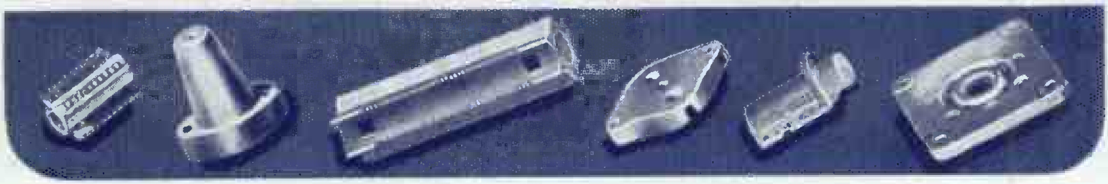

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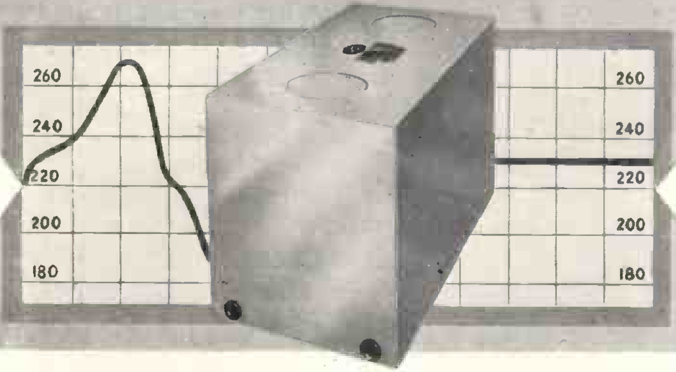

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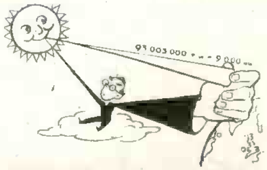

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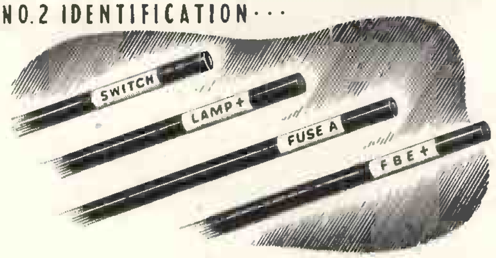

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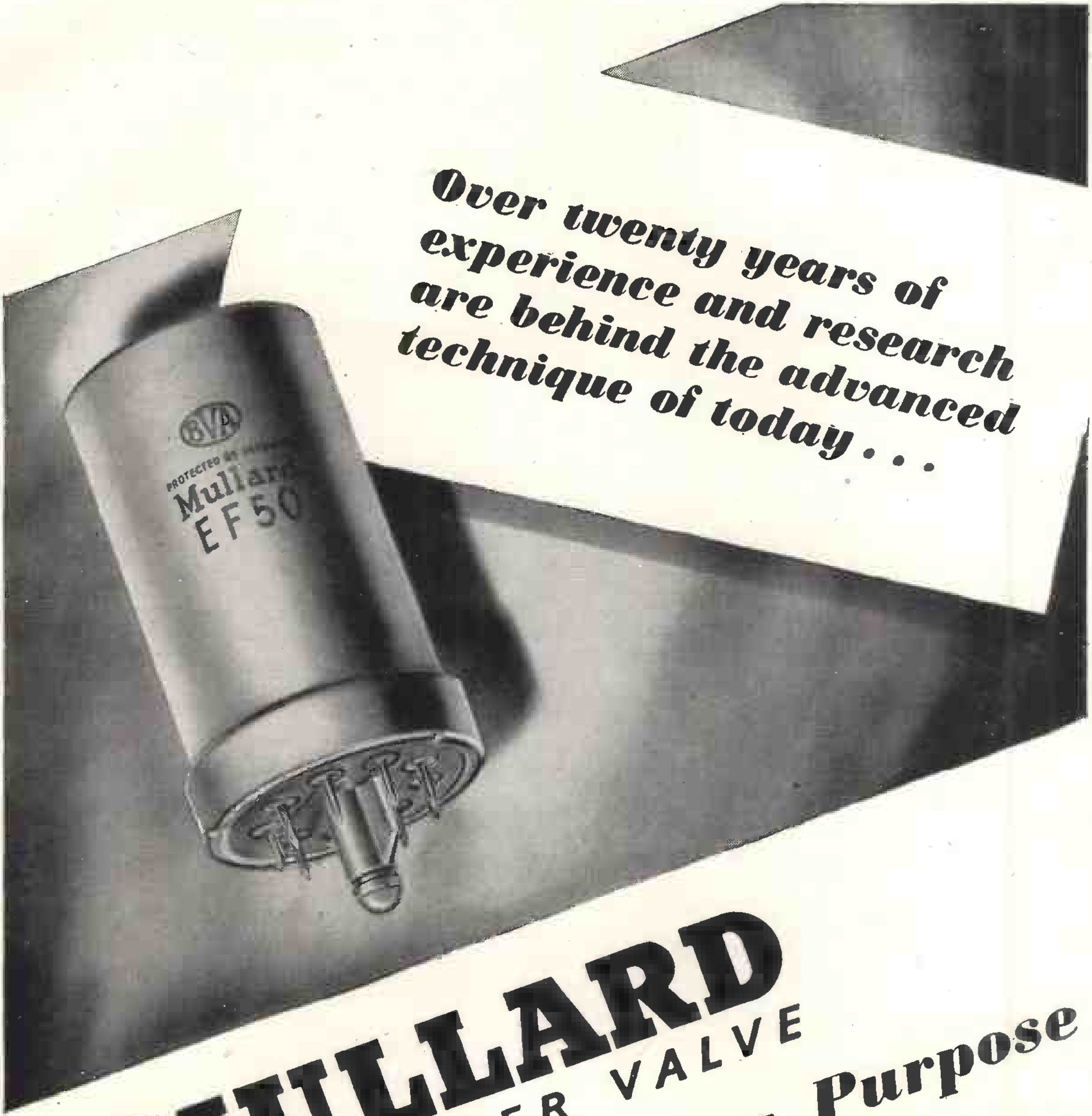
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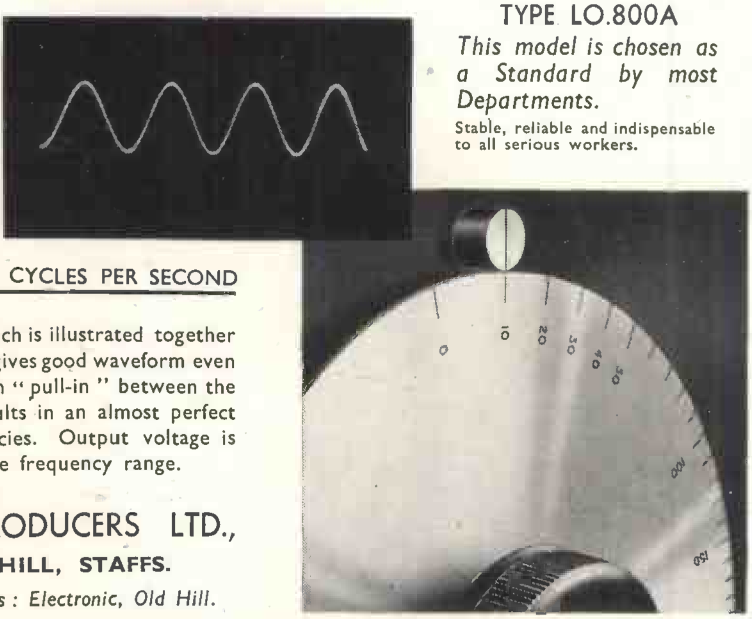

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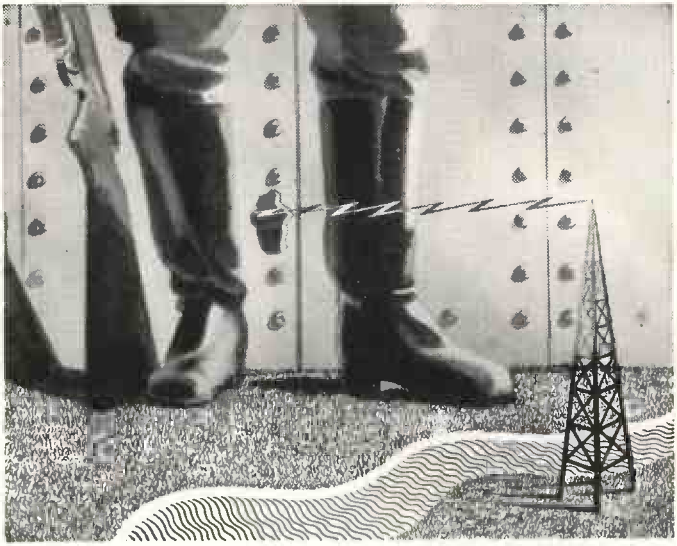

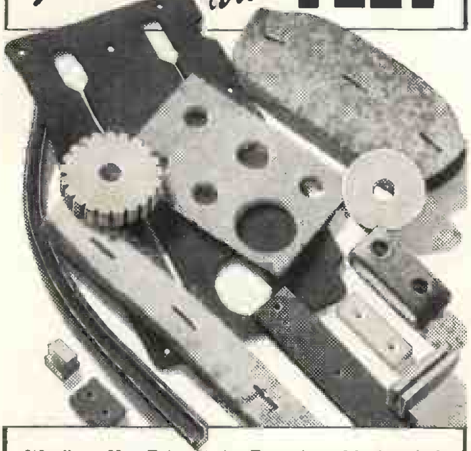

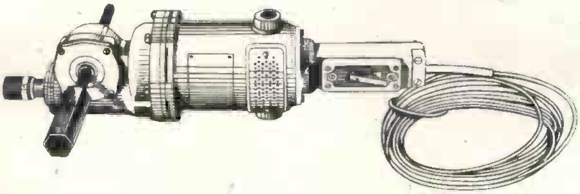


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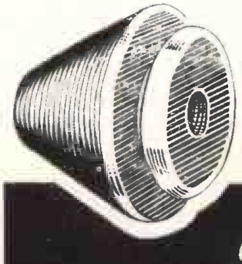

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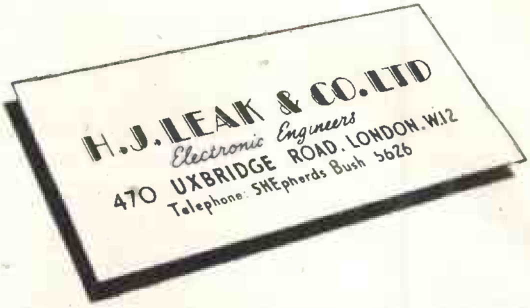

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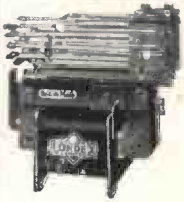

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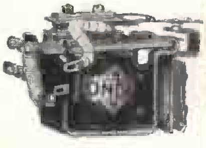

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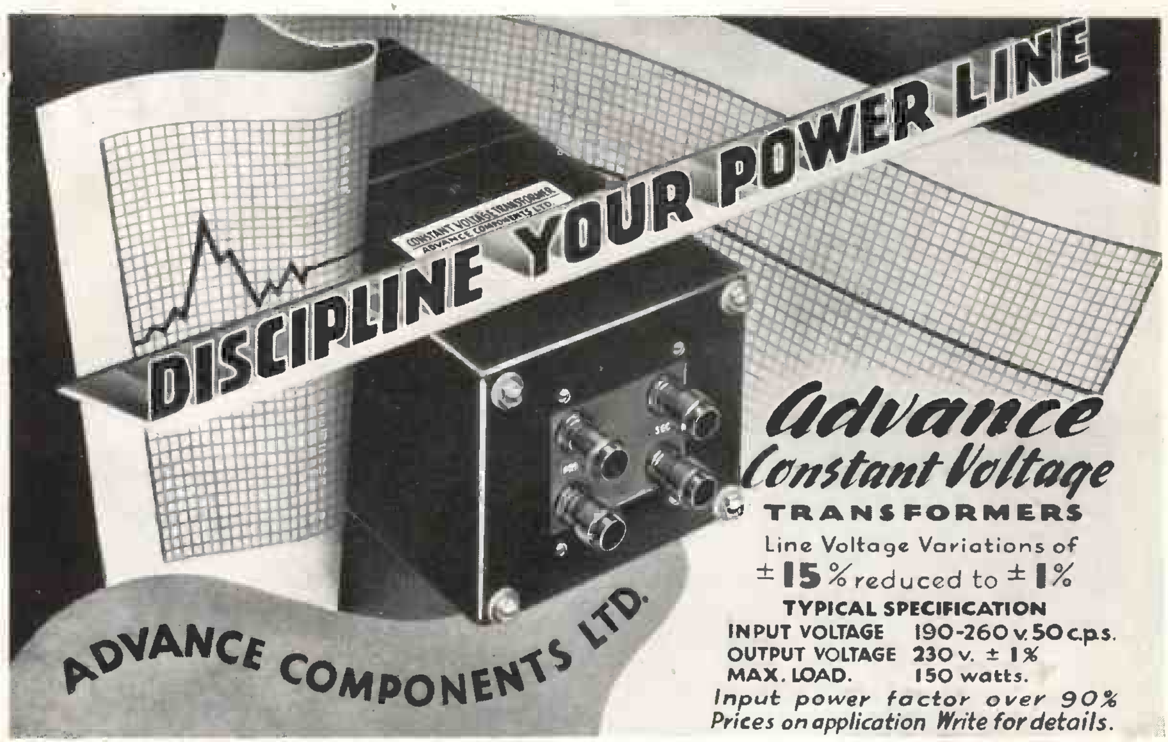
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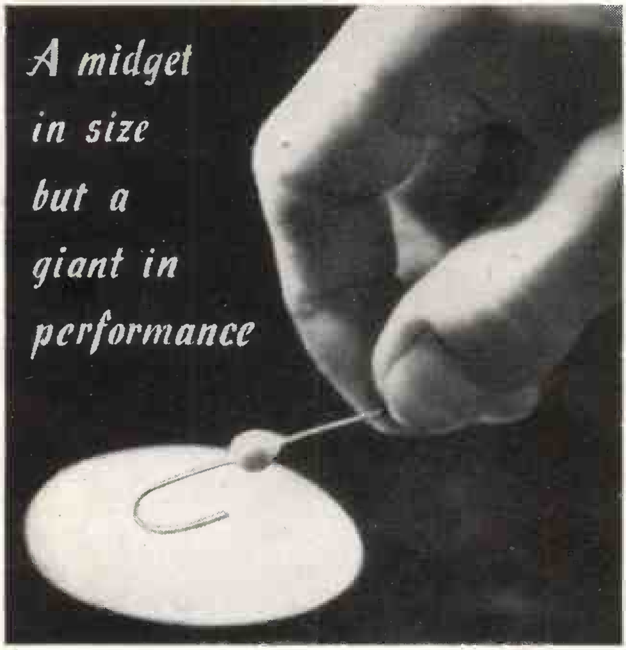
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WIRELESS ENGINEER

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

VOL. XXI MAY, 1944 No. 248

Editorial

Variable-mu or Variable-μ?

A TYPE of valve which is largely used in connection with automatic gain control is commonly referred to as a variable-mu valve. One occasionally sees it referred to as a variable-μ valve, and this has recently been given a certain amount of official sanction by its appearance in the Journal of the Institution of Electrical Engineers where it is used by T. E. Goldup in his address as Chairman of the Wireless Section. The question arises whether these two terms are justifiable alternatives or whether they occur as the result of some misunderstanding. A valve has three characteristic constants, viz., the amplification factor $\partial V_a/\partial V_g$, usually represented by the symbols m or μ, the a.c. or differential resistance $\partial V_a/\partial I_a$, usually represented by the symbols r_a, R_a or ρ, and the mutual conductance $\partial I_a/\partial V_g$, usually represented by the symbol g_m. Now the outstanding characteristic of the special type of valve under consideration is that, if I_a is plotted against V_g, instead of decreasing linearly as V_g is made progressively more and more negative, I_a tails off, giving a curved characteristic, so that the slope $\partial I_a/\partial V_g$ decreases gradually. All descriptions of the valve emphasise this variation in the value of the mutual conductance g_m, and it was generally understood that the term " variable-mu " was an abbreviation of " variable mutual conductance." If this be so, any further abbreviation, or symbolisation, should be " variable-g " and not " variable-μ." It is doubtless true that the amplification factor is also variable to some extent, but that this is merely incidental is shown by such textbooks as the Admiralty Handbook of Wireless Telegraphy, which uses " m " for amplification factor, and not μ. Dealing with variable-mu valves the Handbook says, " in this country the name is taken to refer to the smooth change which takes place in the mutual conductance as the bias point is gradually altered," and in another place, " the slowly decreasing value of the mutual conductance (g_m) makes them admirable for use in A.G.C. circuits."

In the new British Standard Glossary of terms used in Telecommunication, term No. 1782 is Variable-mu valve or variable mutual conductance valve or remote cut-off tube (U.S.A.) and the definition is " a valve the mutual conductance of which can be altered smoothly over a wide range by variation of grid bias."

In " Thermionic Valve Circuits," by E. Williams, μ is employed as the symbol for amplification factor, but in discussing variable-mu valves, there is no suggestion that μ is involved ; he says " thus, the mutual conductance (i.e. the slope of the i_a–v_g curves) will increase continuously with grid-voltage, over a wide range of grid-voltage."

A clue to the origin of the muddle is obtained in F. E. Henderson's book " Introduction to Valves," in which the variable-mu valve is quite clearly described ; the author discusses " the conditions for variation of mutual conductance with grid-voltage." He uses m as the symbol for amplification factor, but says on page 20 that μ is sometimes employed. In the Appendix, however, he gives a list of symbols, and it is here that the muddle occurs, for we read " m = amplification factor of valve (sometimes mu) " and g = mutual conductance of valve." The uninitiated, looking down this list, might very well conclude that " mu " was a symbol for amplification factor, and that a " variable-mu " valve was one with a variable m or μ. To be correct the two items should read as follows:

m = amplification factor of valve (sometimes μ).
g = mutual conductance of valve (sometimes abbreviated to mu).

In publication No. 560 "British Standard Engineering Symbols and Abbreviations" issued in 1934 by the British Standards Institution the symbol μ is given for the amplification factor of a valve and the symbol m for that of an amplifier but the Admiralty Handbook of Wireless Telegraphy published in 1938 ignores this and defines m as the valve amplification factor.

Another cause of confusion is seen in Terman's "Fundamentals of Radio," an American book in which, after explaining the variation of mutual conductance and giving curves showing the variation of I_a with V_g, it is stated that the principle is normally used only in small pentode and screen-grid valves designed for voltage amplifier service. "In such cases it is the amplification factor μ_{sg} that has the variable-mu characteristic." μ_{sg} is used to designate the ratio of the variation of screen grid voltage to that of control grid voltage for constant current. Hence in this case it is a "μ" that has the variable-mu characteristics!

It is obviously very unfortunate that two entirely different characteristics of the valve, one a numerical ratio and the other a conductance, should be represented by μ (pronounced mu) and mutual conductance (abbreviated to mu) respectively. Confusion is almost bound to occur, and the only way to avoid it would appear to be to give up the use of μ and use m as the symbol for amplification or magnification factor as is done consistently throughout the Admiralty Handbook. The fact that it is the first letter of the word "mutual" is not likely to lead to any misunderstanding unless "variable mutual" is still further abbreviated and referred to as "variable-m" which would make confusion worse confounded.

It is interesting to note that in another field an iron alloy has been christened "mumetal" because of the high value of its permeability μ at low values of H. G. W. O. H.

Specific Resistance, Volume Resistivity, and Mass Resistivity

EVERYONE engaged in teaching electrical technology to elementary students will have come across cases in which the student, when given a problem involving the calculation of the resistance, simply multiplied the cross-section by the length to obtain the volume of the wire and then multiplied the volume by the specific resistance.

In the current number of the *Proceedings of the Physical Society* there is a paper by J. T. Kendall of the Research Department of Metropolitan Vickers Electrical Co. on the rectifying property of carborundum. On page 124 we read "The specific resistance while at bright yellow heat was measured as 0.07 ohm/cm³ . . . In this experiment it was impossible to tell how much of the resistance was localised at the contacts and how much represented *volume* resistivity."

Now if one turns to publication No. 560 of 1934 entitled "British Standard Engineering Symbols and Abbreviations" issued by the British Standards Institution, one finds two alternative abbreviations for cubic centimetre viz. cm.³ or c.c. Hence 0.07 ohm/cm³ means per cubic centimetre and not per centimetre cube, and should certainly not be employed; the correct expression is either 0.07 ohm/cm. cube or 0.07 ohm-cm, the dimensions being those of a resistance multiplied by a length—not divided by the cube of a length. The term volume resistivity is an unfortunate one and the decision of the British Standards Institution to give it precedence over the term "specific resistance" (Definition 1278 in the Glossary) is to be regretted. It suggests that the resistance is a function of the volume whereas it is really independent of the volume unless the shape is specified. A 10-ohm manganin resistor can have any volume you like. The definition given in the Glossary is correct; it is "the resistance between opposite faces of a unit cube of a given material at a given temperature." It is the resistance of a specified piece of the material, specified as to size and shape, and correctly designated "specific resistance." It may be argued that it is necessary to distinguish between volume resistivity and mass resistivity, which little used term is used to designate the product of the specific resistance and the density of the substance. It is open to the same objection as volume resistivity, for the resistance of a gramme of copper, like that of a cubic centimetre, can be anything you like. Mass resistivity is, however, a more objectionable term than volume resistivity; the latter is at least the resistance of a given volume, say a cubic centimetre, in the form of a cube, but the former is not the resistance of a given mass. One might expect it to be the resistance of a given mass, say one gramme, in the form of a cube, but, assuming for the sake of simplicity a density of 8, a mass of 1 gramme would be represented by a cube of 0.5 cm. side, which would have twice the resistance of the cm. cube, i.e. twice the specific resistance, whereas the definition given for mass resistivity requires it to be eight times the specific resistance. To obtain this result the mass of the cube would have to be inversely proportional to the square of the density. Surely it is preferable to employ either "resistivity" or the old-established term "specific resistance" to the exclusion of the misleading terms "volume resistivity" and "mass resistivity." If one ever requires the product of specific resistance and density one can refer to it as such or as the "density-ρ" of the material. G. W. O. H.

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.

"Power Loss in Deflecting Condensers"

To the Editor, "Wireless Engineer"

SIR,—It is gratifying that Dr. Gabor, in his article of the above title appearing in the March 1944, *Wireless Engineer*, should establish on the basis of his new analysis the correctness of Recknagel's result. It cannot be too strongly emphasised that a result such as Benner's, which gives a finite conductance at zero frequency, is completely inadmissible.

I cannot concur with the implications of Dr. Gabor's footnote, as the error in my formula published in the February 1941 issue was due to a mistake in calculation, not in principle; the same principle correctly worked out leads to Recknagel's formula as stated in the April issue. This result is obtained by equating the instantaneous flow of displacement current (neglecting the purely capacitive current) into an electrode to be

$$-\frac{d}{dt}\int g\rho d\tau \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where the integration is taken over all space.

$\rho d\tau$ is the space charge in a volume element $d\tau$ situated at a point P. g is that fraction of this charge which is induced, with opposite sign, on the electrode and it will depend only on the co-ordinates of P.

For the upper plate of an idealised parallel plate condenser system, of length l and gap D, g has the value, $\left(\frac{1}{2}+\frac{y}{D}\right)$ for a charge within the condenser plates and has the value $\frac{1}{2}$ for a charge anywhere outside the condenser plates. The x axis is taken to be midway between the plates.

It follows that no matter how charges move outside the system they will not give rise to current fluctuations in the condenser plates, provided that $\int\rho d\tau$ remains constant outside the condenser. Equation (1) can therefore be written

$$i = -\frac{1}{D}\frac{d}{dt}\int_0^l y\rho d\tau \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where the limits indicate that the integration need only be taken within the volume of the condenser.

It should be noted that equation (2) is not mathematically equivalent to

$$-\frac{1}{D}\int_0^l\left(\frac{\partial y}{\partial t}\right)\rho d\tau \quad \ldots \quad \ldots \quad (3)$$

which is sometimes employed.

In fact (3) leads to the absurd result that if an electron beam were projected through a pair of plates maintained at fixed potentials then a steady current should flow in the deflector plates, even without direct electron capture!

It may not be without interest to enunciate the principles by which g may be ascertained in the general case.

Suppose that we have N electrodes and wish to find g for the Mth electrode. First imagine a charge $+\frac{1}{4\pi}$ to be placed at the given point P with all the electrodes at zero potential, and denote by the symbol G the resulting potential distribution in the system. G is thus the Green's function for the point P. Secondly, suppose that the charge at P is removed and that the space is free from charges, it is known that

$$V_p = \int\int V\left(\frac{\partial G}{\partial n}\right)dS \quad \ldots \quad (4)$$

where $\left(\frac{\partial G}{\partial n}\right)$ is the gradient of G at the surface element of an electrode, and V is the electrode potential. The integration is taken over all the electrode surfaces. Thirdly, let $V =$ unity at the Mth electrode and zero at all other electrodes; then the integration vanishes over all electrodes except the Mth, and equation (4) reduces to

$$V_p = \int\int\left(\frac{\partial G}{\partial n}\right).\,dS \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

From the way in which G has been defined the R.H.S. of equation (5) is the flux of intensity entering the Mth electrode, when a charge $\frac{1}{4\pi}$ is placed at P. It is therefore -4π times the charge induced on the Mth electrode. If the latter is denoted by q'

$$-4\pi q' = V_p \qquad \text{or} \qquad q' = -\frac{V_p}{4\pi}$$

The ratio of q' to the charge placed at P is therefore $-V_p$, so that $g = V_p$. Thus the fraction of the charge placed at P which is induced, with opposite sign on the Mth electrode, is numerically equal to the potential at P, with zero charge at P, when unit potential is applied to the Mth electrode with all other electrodes at zero potential, and the space free of charges.

It is not difficult to show that equation (1) leads to the same expression for transit power T in the deflecting condenser as Dr. Gabor's equation (3), *loc cit*, p. 115. The energy dissipated in time t is obtained by multiplying the instantaneous electrode voltage by the instantaneous current, and integrating with respect to time.

Thus

$$W = -\int_0^t V\left[\frac{d}{dt}\int g\rho d\tau\right]d\tau \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

Integrate by parts,

$$W = -\left[V\int g\rho d\tau\right]_0^t + \int_0^t \frac{dV}{dt}\left[\int g\rho d\tau\right]dt \quad \ldots \quad (7)$$

Over a complete number of cycles the first term vanishes.

Hence $$\frac{d\overline{W}}{dt} = T = \frac{dV}{dt}\int g\rho d\tau \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

where the bar indicates that the average over a complete number of cycles is to be taken. Since $\frac{dV}{dt}$ depends only on t, it can be brought into the integrand,

so that $$T = \int \overline{g\frac{dV}{dt} . \rho\, d\tau} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

But $\left(g\frac{dV}{dt}\right)$ is the time rate of change of potential at the volume element $d\tau$ in the condenser, assuming all space charges to be absent. This is not precisely the same as Dr. Gabor's $\dot{\phi}$, which can be split into two components.

$\dot{\phi}_e$ due to potential variations at the electrodes and $\dot{\phi}_\rho$ due to space charges.

Now the work done, over a complete number of cycles, by the mutual interaction of space charges, is zero.

Hence $$T = \int \overline{\dot{\phi}\rho\, d\tau} = \int \overline{(\dot{\phi}_e + \dot{\phi}_\rho)\rho\, d\tau} = \int \overline{\dot{\phi}_e \rho\, d\tau}$$

which is the same as equation (9).

New Barnet, Herts. S. RODDA.

To the Editor "Wireless Engineer"

SIR,—Dr. Gabor's procedure in his interesting article[1] is open to criticism if only on account of its brevity. He starts off well by separating out a surface integral which can be made to vanish by taking the surface to extend sufficiently far from the deflectors. He then applies the continuity equation

$$\dot{\rho} + \text{div}\,\mathrm{i} = 0 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (a)$$

to reach the following expressions for the transit power, with the difference that the bar should extend over dV,

$$T = \int \overline{\phi\,\text{div.}\,\mathrm{i}\, dV} = -\int \overline{\dot{\rho}\phi dV} = \int \overline{\rho\dot{\phi}dV} \quad \ldots \quad (b)$$

Neater than the sequel, to which it is equivalent, we then have, since ρdV is an invariable charge,

$$T = \int \overline{\rho\dot{\phi}dV} = \int \rho\overline{\dot{\phi}}dV \quad \ldots \quad \ldots \quad \ldots \quad (c)$$

It can be shown that to the degree of approximation required we may *now* take both ρ and dV as separately constant. Gabor's procedure then leads to (10) apart from a minus sign. But, a serious inconsistency is involved. In reaching the last of (b) we have used the property, where f is any function periodic in time,

$$\overline{\dot{f}} = 0 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (d)$$

In this case f was equal to $\rho\phi$, but we are, in (d), equally entitled to take f as ϕ, when (c) is seen to yield zero immediately. Provided we accept (d), therefore, we must reject Gabor's equation (6), namely

$$\dot{\phi} = -\omega Ey\cos\omega t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (e)$$

which leads to a non-zero result when substituted in (c). The problem now presents itself: what is wrong with (e)? It has been obtained from the approximate expression $\phi = \phi_0 - Ey\sin\omega t \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (f)$

by partial differentiation with respect to time, y being held constant. But, in taking this partial differential coefficient, suppose we instead replace y by Gabor's (9), which is correct, namely

$$y = \frac{eE}{m\omega^2}\left[\sin\omega t - \sin\omega\left(t - \frac{x}{v_0}\right) - \frac{\omega x}{v_0}\cos\omega\left(t - \frac{x}{v_0}\right)\right] \quad \ldots \quad \ldots \quad (g)$$

Our partial time differential coefficient must now be taken at x constant. We then readily find $\dot{\phi}$ averages to zero, Gabor's error is very excusable. It has caused me a great deal of trouble.

The fact is that y is a *de*pendent variable, and, at a given value of x, fluctuates in time. Thus $\dot{y}$ (which is here not to be confused with dy/dt) is not zero. We may check our results by replacing (*e*) by

$$\dot{\phi} = -\omega Ey\cos\omega t - E\dot{y}\sin\omega t \quad \ldots \quad \ldots \quad (h)$$

Apart from a constant, $\dot{y}$ is obtained from (g) as

$$\cos\omega t - \cos\omega\left(t - \frac{x}{v_0}\right) + \frac{\omega x}{v_0}\sin\omega\left(t - \frac{x}{v_0}\right),$$

so that $-\dot{y}\sin\omega t$ when averaged with respect to time gives, writing $\omega x/v_0 = \tau$,

$$\tfrac{1}{2}(\sin\tau - \tau\cos\tau) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (i)$$

Integration over the path gives, to a constant

$$\int_0^\tau (\sin\tau' - \tau'\cos\tau')\,d\tau' = \Big[-\cos\tau' - (\tau'\sin\tau' + \cos\tau')\Big]_0^\tau$$
$$= 2(1 - \cos\tau) - \tau\sin\tau \quad \ldots \quad \ldots \quad (j)$$

This formula is identical to a constant, with Gabor's (10), but in the latter an error in sign has occurred. The contributions thus actually cancel.

We thus arrive at the following conclusions. The power loss is not given by Recknagel's formula, which, as confirmed by the writer[2], applies only in the hypothetical case of an abruptly terminating exit field. It is, to the degree of approximation contemplated, given by zero. This result is known for low frequencies, the revised Gabor analysis extends it to any frequency. We infer that attempts to derive oscillatory power by connecting a tuned circuit or Lecher wires to the deflector plates of a cathode-ray device are foredoomed to failure. Even if we allow that some inter-plate loss, positive or negative, might occur at large angle deflection, since there is no loss at small deflections oscillations could never start.

Fordcombe, Kent. W. E. BENHAM.

Transversely Deflected Electron Beams

To the Editor, "Wireless Engineer"

SIR,—In my note on "Power Loss in Deflecting Condensers" (*Wireless Engineer*, March 1944, p. 115), I gave a short derivation of a formula previously obtained by Recknagel and several other authors. As the problem was well known, I did not think it necessary to waste much space on stating it in detail, or on explaining the limitations of the solution, but referred for further details to my paper on "Energy Conversion in Electron Valves." I must now admit that my attempt to save paper has miscarried, as a few more explanations might have avoided the letter from Mr. Harries (*Wireless Engineer*, April 1944, p. 176.) I hope that the following remarks will clear up the situation:—

(1) My analysis applies only in a frequency range in which the transit time of the electrons through the field region is an appreciable fraction of a cycle, but the field can still be adequately represented by a scalar potential ϕ, and the contribution of the vector potential can be neglected, as explicitly stated in a footnote. This "quasi-static" description is no longer possible if the wavelength becomes comparable with the dimensions of the field

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[1] D. Gabor, *Wireless Engineer*, Vol. 21, p. 115, March 1944.

[2] W. E. Benham, *Wireless Engineer*, Vol. 18, p. 277, July, 1941.

region. *Resonators are therefore* ipso facto *excluded.* For further details I must again refer to my paper on "Energy Conversion," which was discussed before the Wireless Section of the Institution of Electrical Engineers on 5th April.

(2) Mr. Harries thinks to have found a contradiction in my calculation. He states that I have assumed $v_x = v_{x0}$, which would mean, of course, that the deflecting power is necessarily positive. It appears that he has failed to understand an essential advantage of the expression which I have called "transit power." This is, that it is sufficient to know the trajectories in zeroth approximation (i.e. neglecting the change of velocity in the X-direction), in order to calculate the deflecting power in first approximation. I have estimated also the correction due to the retardation in the exit fringe of the field, but I considered this as too complicated, and not sufficiently important to justify publication.

Rugby. D. GABOR.

To the Editor, "Wireless Engineer."

SIR,—In his letter replying to mine which appeared in the April 1944 *Wireless Engineer*, Dr. Gabor refers once more to his I.E.E. paper. I had arranged to join in the discussion on this paper; but unfortunately the advance copy did not reach me in time, and my letter to *Wireless Engineer* was written before the text of his paper was available. Nevertheless, having now read it, I do not see that there is anything therein to cause me to modify the remarks in my letter. Dr. Gabor's I.E.E. paper consists of an admirable and interesting attempt to generalise valve energy relations. Without going into the merits of these generalisations, it is nevertheless true to say that their particular application by Dr. Gabor in his article on "Power Loss in Deflecting Condensers" (*Wireless Engineer*, March 1944, p. 115) is in need of correction.

With regard to paragraph 1 of Dr. Gabor's letter, my point is that the mathematical operations set out in his *Wireless Engineer* article applied neither to resonator fields having curl nor to lamellar fields having scalar potential only. In fact they did not apply to any fields at all.

With regard to Dr. Gabor's paragraph 2, my point is not that there is a contradiction in his calculations, but that the derivation of his expression for transit power (as developed in the specific application to deflection valves in his *Wireless Engineer* article) is wrong. He states in deriving his equation (10) that $\frac{\omega L}{v_0} = \tau$. This is another way of stating that $v_x = v_{x0}$. He then arrives at an expression for transit power which can become negative. This is the same kind of incorrect result deduced in the past by Recknagel, Hollmann and Thoma. I do not agree that this result is a first approximation.

Another way of putting my point is that, whilst in my letter I did not question Dr. Gabor's then unpublished expressions for the microscopic power relations in a differentially small volume of a deflection valve, I did question, and still disagree on several grounds with, those integrated results which were published in his *Wireless Engineer* article. These grounds include the limits over which he applies his integrations, and the functions he employs when integrating. These functions do not correspond with the known laws of electromagnetic fields, and therefore result in solutions for the macroscopic case which violate the principle of conservation of energy.

London, S.W.18. OWEN HARRIES.

Book Review

Glossary of Terms used in Telecommunication

British Standards Institution, 28 Victoria Street, London, S.W.1. Pp. 108. Price 3*s*. 6*d*. post free.

This is a revised and enlarged edition of B.S. 204, prepared in collaboration with the Post Office and other organisations connected with the Telegraph, Telephone and Radio Industry. It deals with the subject of section 9 (Telegraphs and Telephones) and section 10 (Radiocommunication and Television) of the 1936 edition of B.S. 205 (Glossary of Terms used in Electrical Engineering), which were also published separately as B.S. 204, and of the supplement (CF 4420) to B.S. 205 (Radio Direction-finding). There is also a short new section on Fire Alarms.

A considerable number of new definitions have been introduced, and the existing definitions have been extensively revised to keep pace with recent developments. Some regrouping of the subject has also been thought advisable. General terms used in all branches of telecommunication have been brought together in an introductory section, which is then followed by more specialised sections dealing respectively with Telegraphy, Telephony, Radiocommunication, Television, Direction-finding, and Fire Alarms. The volume concludes with a general index.

The framing of definitions and the choice of terms to be defined are subjects on which endless discussion is possible. One's own opinion is liable to undergo changes. For example, the second definition in the book is of "Frequency" and it is stated that it may be expressed in cycles per second, or in terms of the angular velocity ($\omega = 2\pi f$ radians per second), but it is not said that in the latter case it is sometimes referred to as the "angular frequency"; this term does not appear in the index. The "instantaneous frequency" of an oscillation (not necessarily sinusoidal) is defined as the rate of change of phase divided by 2π. Should it not have been explained that this is based on the assumption of a rotating vector *of constant length* which varies its angular velocity to suit the vagaries of the non-sinusoidal oscillation? The note on p. 5 that C.C.I.F. stands for "Comité consultatif international téléphonique" is somewhat mystifying, and the mystery is only increased by the note on p. 12 that the same four letters are an abbreviation for "Comité Consultatif International des Communications Téléphonique à Grande Distance." The letter F seems to be a very obliging abbreviation. On the same page the B.S.I. twice set a bad example by referring to "a capacitance of 0.054 microfarads" in the plural. Also on this page there are several references to the *nominal* impedance of a line or circuit, but it does not appear to be defined. On p. 7 within a few lines there are references to condensers and capacitors, but with no explanation of the difference, if any, between them. In defining the Q-factor of a conducting system as "2π times the ratio of the average value of the oscillating energy of the electric or magnetic fields of the system to the energy dissipated during half a cycle of the oscillation," the Glossary is following the example of the man who never used one word where two could be made to do. It is not only shorter but more scientific to define it as 2π times the ratio of the oscillating energy to the energy dissipated per cycle. Why take half the oscillating energy and the energy dissipated per half cycle? Phase velocity is defined and given the symbol ν, then follows group velocity but with no symbol. Would not v_p and v_g be preferable? They could hardly be confused with plate and grid voltages. If ν is preferred to v, then ν_p and ν_g could be employed.

These comments are not intended to belittle in any way the value of the Glossary, but merely to illustrate what we said above as to the possibility of endless discussion on terms and definitions. G. W. O. H.

Reactance and Effective Height of
SCREENED LOOP AERIALS*

By R. E. Burgess, B.Sc.

(Radio Department, National Physical Laboratory)

SUMMARY.—The paper constitutes an extension of the analysis of the screened loop aerial given in an earlier paper, and is based on the application of the transmission line equations with uniformly distributed constants. The conductors are assumed to be free from ohmic resistance, and the dielectric media are assumed to be loss-free. A symmetrical aerial with a single-turn loop conductor is considered, and the gap in the screen is taken to be narrow.

There are two modes of propagation corresponding to waves on the outside of the screen and to waves in the space between the loop and screen. The current and potential distributions on the loop and screen are determined when a given e.m.f. is applied to the loop terminals after reference to the boundary conditions at these terminals and at the gap.

The inductance and capacitance coefficients can be expressed in terms of the geometrical dimensions of the system and of the dielectric constants of the media inside and outside the screen.

The reactance, resonant and anti-resonant frequencies and self-capacitance are considered in detail for the loop in the balanced and unbalanced conditions for the case of the air-spaced loop, and the effect of a small capacitance across the gap is considered.

The effective height of a square screened loop is calculated for transmission in the equatorial plane and its variation with frequency is found to follow closely that of the reactance for frequencies up to the first anti-resonance. A comparison is made of the current and potential distributions in the transmitting and receiving conditions.

The paper concludes with an account of measurements of the reactance of a square loop of 150 cm. side; fair agreement between theory and experiment is obtained and the general reasons for any discrepancy are mentioned.

1. Introduction

In an earlier paper[1] a simple theory of the screened loop was developed on the assumption of negligible self and mutual capacitance between the conductors, which implied uniformity of current. It was pointed out that this theory represented only a first approximation and that it could be extended by taking into account the distributed self and mutual capacitances along the lines of the classical transmission line theory.

The present paper gives the formal analysis of this extension, and is analogous to the analysis by Colebrook[2] of the unscreened loop. It is assumed that the inductance and capacitance are uniformly distributed and their values are chosen to give exact agreement with the simple theory at low frequencies. Since two conductors are involved there are six coefficients of inductance and capacitance which are inter-related by (i) the requirement that the wave velocities for the two modes of propagation shall equal respectively those in the media outside the screen and between the screen and loop and (ii) the conditions of magnetic and static screening.

The conductors and the media are assumed to be free from loss and the single-turn loop only is considered. It appears reasonable to assume that the current and potential distributions are little affected by the presence of resistance except at frequencies in the neighbourhood of a resonance. The calculated values of reactance will be valid within the same limitations, and the displacement of the resonant and anti-resonant frequencies from those calculated, due to resistance, will only be a small effect.

On substituting the boundary conditions at the gap and at the loop terminals the current and potential distributions are found and thus the reactance is determined. This enables the resonant and anti-resonant conditions, the apparent self-capacitance and the effective height to be found for the balanced and unbalanced conditions.

The omission of resistance and leakance from the fundamental differential equations leads to a considerable simplification of the analysis and yet enables the essential features of the reactive behaviour of the screened loop to be deduced.

2. The Fundamental Equations for Current and Potential

The loop and screen are assumed to be planar and geometrically symmetrical about the line joining the gap in the screen to the point of entry of the loop conductors. The loop and screen conductors are assumed to be of uniform cross-section which is small compared with the wavelength, and the width of the screen gap and the

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* MS. accepted by the Editor, December, 1943.

separation of the loop conductors at their point of entry are taken as being small. Such a screened loop is illustrated in Fig. 1, where the contour is shown as being circular, which is a special case of the geometrical conditions specified above. The media surrounding the screen and between the screen and loop are uniformly distributed, and have zero leakance but are not necessarily identical. The conductors are assumed to be free from resistance.

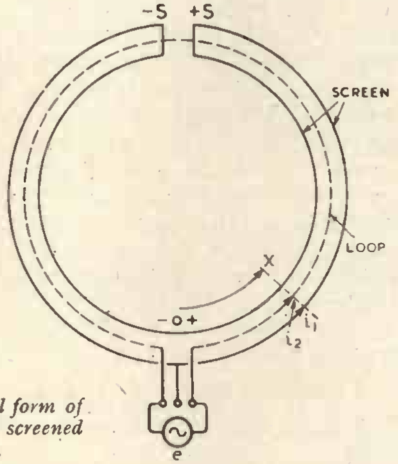

Fig. 1. *General form of the single-turn screened loop.*

The linear co-ordinate x is measured along the loop conductor, the origin being chosen at the point of entry of the loop into the screen. The sides of the gap have co-ordinates $\pm s$ where s is half the loop perimeter p.

Subscripts 1 and 2 refer to the screen and loop respectively, and the behaviour for sinusoidal currents of angular frequency ω is considered, so that $\partial/\partial t$ may be replaced by $j\omega$.

The symbols i and v refer to the rotating vectors which represent the current and potential. The zero of potential is conveniently chosen to be that of the screen at $x = 0$:

$$v_1(0) = 0 \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Now let L_{11}, L_{22}, L_{12} be the self and mutual inductances of the screen and loop per unit length, these coefficients being assumed uniform. The first pair of differential equations may be written

$$\frac{\partial v_1}{\partial x} = - j\omega L_{11} i_1 - j\omega L_{12} i_2 \quad \ldots \quad \ldots \quad (2a)$$

$$\frac{dv_2}{\partial x} = - j\omega L_{12} i_1 - jwL_{22} i_2 \quad \ldots \quad \ldots \quad (2b)$$

Since the screen encloses the loop but for a small gap the following relation between the inductance coefficients for magnetic screening will be valid to a close approximation.

$$L_{12} = L_{11} \qquad \ldots \quad \ldots \quad \ldots \quad (3)$$

and equations (2a, b) become

$$\frac{\partial v_1}{\partial x} = - j\omega (i_1 + i_2) L_{11} \quad \ldots \quad \ldots \quad (4a)$$

$$\frac{\partial v_2}{\partial x} = - j\omega L_{11} i_1 - j\omega L_{22} i_2 \quad \ldots \quad \ldots \quad (4b)$$

The equation for the difference of potential $(v_2 - v_1)$ between the loop and screen has the form $\frac{\partial}{\partial x}(v_2 - v_1) = - j\omega (L_{22} - L_{11}) i_2 \quad \ldots \quad (4c)$

Similarly if C_{11} C_{22} and C_{12} are the self and mutual capacitance coefficients per unit length, the second set of differential equations becomes

$$\frac{\partial i_1}{\partial x} = - j\omega (C_{11} v_1 + C_{12} v_2) \quad \ldots \quad \ldots \quad (5a)$$

$$\frac{\partial i_2}{\partial x} = - j\omega (C_{12} v_1 + C_{22} v_2) \quad \ldots \quad \ldots \quad (5b)$$

These capacitance coefficients must not be confused with the popular conceptions of capacitance per unit length, which are the reciprocals of the electrostatic potential coefficients P_{11}, P_{12} and P_{22}. The relations between these two sets of coefficients may be readily deduced from the fundamental electrostatic equations, with q_1 and q_2 denoting the charge per unit length on the conductors :

$$q_1 = C_{11} v_1 + C_{12} v_2 \qquad v_1 = P_{11} q_1 + P_{12} q_2$$

$$q_2 = C_{12} v_1 + C_{22} v_2 \qquad v_2 = P_{12} q_1 + P_{22} q_2$$

As the screen encloses the loop the relation for electrostatic screening is valid, viz. $P_{11} = P_{12}$ or

$$C_{12} = - C_{22} \qquad \ldots \quad \ldots \quad \ldots \quad (6)$$

For our case of one conductor enclosing the other the relations between the capacitance and potential coefficients are

$$C_{11} = \frac{P_{22}}{P_{11}(P_{22} - P_{11})} \qquad P_{22} = \frac{C_{11}}{C_{22}(C_{11} - C_{22})}$$

$$-C_{12} = C_{22} = \frac{1}{P_{22} - P_{11}} \qquad P_{12} = P_{11} = \frac{1}{C_{11} - C_{22}}$$

Equations (5a, b) become

$$\frac{\partial i_1}{\partial x} = - j\omega (C_{11} v_1 - C_{22} v_2) \quad \ldots \quad \ldots \quad (7a)$$

$$\frac{\partial i_2}{\partial x} = - j\omega C_{22}(- v_1 + v_2) \quad \ldots \quad \ldots \quad (7b)$$

from which the sum of the screen and loop currents $(i_1 + i_2)$ is related to the screen potential by

$$\frac{\partial}{\partial x}(i_1 + i_2) = - j\omega (C_{11} - C_{22}) v_1 \quad \ldots \quad (7c)$$

From equations (4a) and (7c) the second order differential equation for the mode of propagation determined by the screen and here termed the "outer mode" is

$$\frac{\partial^2}{\partial x^2} + \omega^2 L_{11}(C_{11} - C_{22}) = 0 \quad \ldots \quad \ldots \quad (8a)$$

which applies to v_1 and $(i_1 + i_2)$.

The term $(C_{11} - C_{22})$ is the reciprocal of the electrostatic potential coefficient P_{11} for the screen and is identical with what is usually regarded as the capacitance per unit length of the screen and is independent of the dielectric within the screen and of the loop conductor. When the medium surrounding the screen is of dielectric constant K_1 we have the following relation

$$\frac{K_1}{c^2} = \frac{L_{11}}{P_{11}} = L_{11}(C_{11} - C_{22})$$

where c is the velocity of electric waves in free space.

Thus the characteristic impedance Z_{01} and the propagation constant β_1 of the outer mode are functions of the screen alone, and are given by

$$Z_{01} = \sqrt{\frac{L_{11}}{C_{11} - C_{22}}} = \frac{cL_{11}}{\sqrt{K_1}} = \frac{\omega L_{11}}{\beta_1} = \frac{\beta_1}{\omega(C_{11} - C_{22})} \quad \ldots \quad \ldots \quad (8b)$$

$$\beta_1 = \omega\sqrt{L_{11}(C_{11} - C_{22})} = \frac{\omega}{c}\sqrt{K_1} \quad \ldots \quad (8c)$$

We can thus put $v_1 = A \sin \beta_1 x$ .. .. (9a)
bearing in mind equation (1), and hence from equation (4a) $i_1 + i_2 = -\dfrac{jA}{Z_{01}} \cos \beta_1 x$ .. (9b)

Similarly for the "inner" mode of propagation determined by the space between the loop and the screen, we have from equations (4c) and (7b)

$$\frac{\partial^2}{\partial x^2} + \omega^2 C_{22}(L_{22} - L_{11}) = 0 \quad \ldots \quad (10a)$$

which applies to $(v_2 - v_1)$ and i_2.

It is recognised that the differential equation for the inner mode is that for the concentric line formed by the loop and screen, having capacitance $C_{22}(= -C_{12})$ and inductance $(L_{22} - L_{11})$ per unit length, and if K_2 is the dielectric constant of the medium between the loop and screen

$$\frac{K_2}{c^2} = \frac{L_{22} - L_{11}}{P_{22} - P_{11}} = C_{22}(L_{22} - L_{11})$$

Thus the inner mode is independent of conditions outside the screen, and the characteristic impedance and propagation constant are given by

$$Z_{02} = \sqrt{\frac{L_{22} - L_{11}}{C_{22}}} = \frac{c(L_{22} - L_{11})}{\sqrt{K_2}}$$

$$= \frac{\omega}{\beta_2}(L_{22} - L_{11}) = \frac{\beta_2}{\omega C_{22}} \quad \ldots \quad (10b)$$

$$\beta_2 = \omega\sqrt{C_{22}(L_{22} - L_{11})} = \frac{\omega}{c}\sqrt{K_2} \quad \ldots \quad (10c)$$

We now have

$$v_2 - v_1 = B \sin \beta_2 x + C \cos \beta_2 x \quad \ldots \quad (11a)$$

and hence from equation (4c)

$$i_2 = \frac{j}{Z_{02}}(B \cos \beta_2 x - C \sin \beta_2 x) \quad \ldots \quad (11b)$$

To sum up: the outer mode corresponds to a current $(i_1 + i_2)$ flowing on the outer surface of the screen and associated with the screen potential v_1, while the inner mode corresponds to a circulating current flowing in the loop and returning along the inner surface of the screen and associated with the p.d. $(v_2 - v_1)$ between the screen and loop. There is thus a current i_2 which flows along the inner and outer surfaces of the screen conductor which is due to the eddy currents in the cross-section of the screen induced by the loop current i_2. It is pointed out later that this current system results in a reduction of the inductance of the loop to an extent given by $2 \log r_0/r_1$, e.m.u. per cm. where r_0 and r_1 are the radii of the outer and inner surfaces of the screen conductor.

From equations (9a) and (11a) the loop potential is given by

$$v_2 = A \sin \beta_1 x + B \sin \beta_2 x + C \cos \beta_2 x \quad (12)$$

and the screen current from equations (9b) and (11b).

$$i_1 = j\left[\frac{A}{Z_{01}} \cos \beta_1 x - \frac{B \cos \beta_1 x - C \sin \beta_2 x}{Z_{02}}\right] \quad \ldots \quad \ldots \quad (13)$$

It is now convenient to introduce the coefficient of coupling k between the screen and the loop which is defined by

$$k^2 = \frac{L_{12}{}^2}{L_{11}L_{22}} = \frac{L_{11}}{L_{22}} = \frac{C_{22}}{C_{11}} \cdot \frac{K_1}{K_2} \quad \ldots \quad \ldots \quad (14)$$

In practice the outer mode will have a velocity corresponding to the velocity c of light in free space, that is $K_1 = 1$, while the inner mode will have a smaller velocity V since $K_2 > 1$.

Thus if λ is the wavelength in vacuo corresponding to ω

$$\beta_1 = \frac{\omega}{c} = \frac{2\pi}{\lambda} = \beta, \quad \beta_2 = \frac{\omega}{V} = \beta\sqrt{K_2} \quad (15)$$

$$\frac{C_{11} - C_{22}}{C_{22}} = \frac{1 - k^2}{k^2 K_2} \quad \ldots \quad \ldots \quad (16a)$$

and $$\frac{Z_{02}}{Z_{01}} = \frac{1 - k^2}{k^2} \frac{1}{\sqrt{K_2}} = \frac{1 - k^2}{k^2} \frac{\beta_1}{\beta_2} \quad \ldots \quad (16b)$$

3. The Solutions for the Currents and Potentials

The boundary conditions which must be inserted in order to evaluate the integration constants A, B and C are those occurring at the gap $(x = \pm s)$ and at the loop terminals $(x = \pm 0)$. Since discontinuities occur at these points we require two sets of integration constants: A, B and C for the positive side $(x = +0 \text{ to } +s)$ and

A', B' and C' for the negative side ($x = -0$ to $-s$).

Since both i_1 and i_2 and their sum are continuous at the gap ($x = \pm s$) we have at once from equation (9b) that $A = A'$ .. .. (17)

(*a*) *Open Circuited Gap.*—It is first assumed that there is no lumped impedance across the gap. The screen current here must be zero. Hence from equation (13)

$$\left.\begin{aligned} 0 &= \frac{A}{Z_{01}}\cos\beta_1 s - \frac{B\cos\beta_2 s - C\sin\beta_2 s}{Z_{02}} \\ &= \frac{A'}{Z_{01}}\cos\beta_1 s - \frac{B'\cos\beta_2 s + C'\sin\beta_2 s}{Z_{02}} \end{aligned}\right\} \quad (18)$$

Furthermore the loop potential is continuous at the gap and thus from equation (12)

$$\begin{aligned} &A\sin\beta_1 s + B\sin\beta_2 s + C\cos\beta_2 s \\ &\quad = -A'\sin\beta_1 s - B'\sin\beta_2 s + C'\cos\beta_2 s \end{aligned} \quad .. \quad .. \quad (19)$$

It is assumed that an external e.m.f. e is applied to the loop terminals, and since from equation (12) the potentials of these terminals are C and C' we have $e = C - C'$ .. .. .. (20)

There are two conditions of loop termination which are of practical interest and will now be considered separately :—

Case 1 :—The Balanced Loop

For this case the potentials of the loop terminals are symmetrical with respect to the screen and thus $C = -C' = \frac{e}{2}$

which gives from equations (17) and (18) that

$$B = B'$$

From equations (18) and (19) we finally obtain for the balanced condition that

$$A = A' = -\frac{e}{2}\,\frac{Z_{01}}{Z_{01}\sin\beta_1 s\cos\beta_2 s + Z_{02}\sin\beta_2 s\cos\beta_1 s} \quad .. \quad .. \quad (21)$$

$$B = B' = \frac{e}{2}\,\frac{Z_{01}\sin\beta_1 s\sin\beta_2 s - Z_{02}\cos\beta_2 s\cos\beta_1 s}{Z_{01}\sin\beta_1 s\cos\beta_2 s + Z_{02}\sin\beta_2 s\cos\beta_1 s} \quad .. \quad .. \quad (22)$$

For the air spaced loop ($K_2 = 1$) we have more simply

$$A = -\frac{ek^2}{\sin 2\beta s} \quad .. \quad .. \quad (21a)$$

$$B = -\frac{e(\cos^2\beta s - k^2)}{\sin 2\beta s} \quad .. \quad .. \quad (22a)$$

Case 2 :—The Unbalanced Loop

In this case the negative side of the loop is joined to the screen and the potentials of the loop terminals are given by $C' = 0$ $C = e$

and it is found that $B' = B - e\tan\beta_2 s$

Again using equations (18) and (19) we find that A and A' have exactly the same values as for the balanced loop, given by equation (21). However B and B' are given by

$$B = \frac{e}{2\cos\beta_2 s}\;\frac{Z_{01}\sin\beta_1 s\sin 2\beta_2 s - Z_{02}\cos\beta_1 s\cos 2\beta_2 s}{Z_{01}\sin\beta_1 s\cos\beta_2 s + Z_{02}\cos\beta_1 s\sin\beta_2 s} \quad .. \quad .. \quad (23)$$

$$B' = -\frac{e}{2\cos\beta_2 s}\;\frac{Z_{02}\cos\beta_1 s}{Z_{01}\sin\beta_1 s\cos\beta_2 s + Z_{02}\cos\beta_1 s\sin\beta_2 s} \quad .. \quad .. \quad (24)$$

For the air-spaced loop these simplify to

$$B = \frac{e(\cos 2\beta s - k^2)}{\sin 2\beta s} \quad .. \quad .. \quad (23a)$$

$$B' = -\frac{e(1 - k^2)}{\sin 2\beta s} \quad .. \quad .. \quad (24a)$$

It is seen from equation (11b) that B and B' are simply related to the loop currents at its terminals and in fact

$$i_2(+0) = \frac{jB}{Z_{02}} \qquad i_2(-0) = \frac{jB'}{Z_{02}} \quad .. \quad (25)$$

In the case of the balanced loop these currents are equal, but for the unbalanced loop there is a difference which equals the current in the connection between the screen and the negative end of the loop. From the above equations this difference is

$$i_2(+0) - i_2(-0) = j\frac{B - B'}{Z_{02}} = \frac{je}{Z_{02}}\tan\beta_2 s$$

(*b*) *Loaded Gap.*—In practice there will be a finite impedance across the gap, generally in the form of a capacitance which will partly arise from the construction of the clamping and insulation at the gap.

For simplicity, we will consider the air-spaced loop ($\beta_1 = \beta_2 = \beta$) with an impedance Z_g connected across the gap.

The screen current will now no longer be zero at the gap and the ratio of the gap p.d. v_g to the gap current i_g must be put equal to Z_g.

From equation (17), which is still valid, and (9a) the gap p.d. is found to be given by

$$v_g = 2A\sin\beta s$$

It is eventually found that in place of equation (21a)

$$A = A' = -\frac{k^2 e}{\sin 2\beta s}\;\frac{1}{1 + \dfrac{2j\beta}{\omega C_{11} Z_g}\tan\beta s} \quad .. \quad .. \quad (21b)$$

When the loop is balanced

$$B = B' = -\frac{e}{2\sin\beta s}\,\frac{\beta\sin 2\beta s - j\omega C_{11}Z_g(\cos 2\beta s - k^2)}{2\beta\sin\beta s - j\omega C_{11}Z_g\cos\beta s} \qquad (22b)$$

while in the unbalanced case

$$B = -\frac{e}{2\sin\beta s}\,\frac{2\beta\tan\beta s\cos 2\beta s - j\omega C_{11}Z_g(\cos 2\beta s - k^2)}{2\beta\sin\beta s - j\omega C_{11}Z_g\cos\beta s} \quad \ldots \quad (23b)$$

$$B' = -\frac{e}{2\sin\beta s}\,\frac{2\beta\tan\beta s - j\omega C_{11}Z_g(1 - k^2)}{2\beta\sin\beta s - j\omega C_{11}Z_g\cos\beta s} \quad \ldots \quad (24b)$$

As before C and C' are the potentials of the loop terminals and are found directly from the applied p.d. e and the condition of balance of the loop.

Thus the impedance of the loop is found to be for the balanced loop

$$Z_2 = \frac{2j\beta\sin\beta s}{\omega C_{22}}\,\frac{2\beta\sin\beta s - j\omega C_{11}Z_g\cos\beta s}{\beta\sin 2\beta s - j\omega C_{11}Z_g(\cos 2\beta s - k^2)} \quad \ldots \quad (26)$$

and for the unbalanced loop :—

$$Z_2 = \frac{2j\beta\sin\beta s}{\omega C_{22}}\,\frac{2\beta\sin\beta s - j\omega C_{11}Z_g\cos\beta s}{2\beta\tan\beta s\cos 2\beta s - j\omega C_{11}Z_g(\cos 2\beta s - k^2)} \quad \ldots \quad (27)$$

In what follows, the gap will be assumed open-circuited except where otherwise stated, when the effect of a small capacitance across the gap is considered.

4. Evaluatión of the Inductance and Capacitance Coefficients

It was pointed out in Section 2 that L_{11} and L_{12}, C_{12} and C_{22} are interrelated by virtue of the screening conditions. There are further relations which may be deduced from equations (8c) and (10c). Usually the dielectric constant K_1 of the medium outside the loop is unity and thus

$$C_{11} - C_{22} = \frac{1}{c^2 L_{11}} \quad \ldots \quad \ldots \quad (28a)$$

$$L_{22} - L_{11} = \frac{K_2}{c^2 C_{22}} \quad \ldots \quad \ldots \quad (28b)$$

It may be noted that if the capacitance coefficients are in e.s.u./cm. (1 e.s.u. $= \frac{10}{9}$ pF) and the inductance coefficients in e.m.u./cm. (1 e.m.u. $= 10^{-3}\ \mu$H) the factor c^2 is not required.

L_{11} and L_{22} and Z_{01} can be calculated from the geometrical dimensions of the conductors, but a knowledge of K_2 is required in order that C_{11} and C_{22}, and Z_{02} may be found. The only requirement regarding the distribution of insulation between the loop and screen is that it should be uniform around the system (K_2 independent of x) and it is not necessary that it should be uniform proceeding radially from the loop to screen.

If the conductors are concentric, the loop having external cross-sectional radius r_2 and the screen inner and outer cross-sectional radii r_1 and r_0, we have

$$-C_{12} = C_{22} = \frac{K_2}{2\log\frac{r_1}{r_2}}\ \text{e.s.u./cm.} \quad \ldots \quad (29a)$$

and $$L_{22} - L_{11} = 2\log\frac{r_1}{r_2}\ \text{e.m.u./cm.} \quad \ldots \quad (29b)$$

The inductance coefficients are the ratio of the total inductances L_1 and L_2 to the perimeter p since these are the values, on the hypothesis of uniformly distributed constants which will give exact agreement with the simple theory at low frequencies.

Since the conductors are assumed to be perfect, the current will flow entirely in the surface and thus the internal inductance will be zero. In practice the depth of penetration of electric waves into good conductors at radio frequencies is so small that the departure from the condition of superficial current flow is negligible. For example in copper at a frequency of f Mc/s the thickness of the equivalent sheet of uniform current is given by $\delta = \frac{0.07}{\sqrt{f}}$ mm.

The inductance coefficient of the screen L_{11} is found from the known formulae for the inductance of cylindrical conductors at high frequencies. These are given for the circle and square and are expressed as functions of p/r_0, the ratio of the perimeter to the outer cross-sectional radius of the screen conductor.

Circle of radius R

$$L_{11} = 2(\log\frac{8R}{r_0} - 2) = 2(\log\frac{p}{r_0} - 1.76) \quad \ldots \quad \ldots \quad (30a)$$

Square of side a

$$L_{11} = 2(\log\frac{a}{r_0} - 0.77) = 2(\log\frac{p}{r_0} - 2.16) \quad \ldots \quad \ldots \quad (30b)$$

These formulae for L_{11} are plotted in Fig. 2 as functions of $\frac{p}{r_0}$ and $(L_{22} - L_{11})$ is given as a function of r_1/r_2. Combining these results say for the circle one finds for the inductance coefficient of the loop

$$L_{22} = 2(\log\frac{p}{r_0} + \log\frac{r_1}{r_2} - 1.76)$$

$$= 2(\log\frac{p}{r_2} - 1.76) - 2\log\frac{r_0}{r_1}$$

which has the same form as equation (30a) for the screen apart from the term in $-2\log\frac{r_0}{r_1}$. This reduction in self-inductance of the loop below the value for the unscreened loop is due to the eddy currents induced in the finite cross-section of the screen whose effect is to neutralise the field lying between the surfaces $r = r_1$ and $r = r_0$.

In practical units Z_{01} and Z_{02} are given by

$$Z_{01} = 30\ L_{11} \text{ ohm}$$

$$Z_{02} = \frac{30}{\sqrt{K_2}}(L_{22} - L_{11}) \text{ ohm}$$

with L_{11} and L_{22} in e.m.u./cm.

If the loop does not run centrally within the screen C_{22} will be greater than the value given by equation (29a) although the relation (28b) between $(L_{22} - L_{11})$ and C_{22} will still be valid.

If the loop is air-spaced with a minimum of insulation at the corners K_2 will lie in the range of 1.0 — 1.2 approximately, but if there is a considerable amount of solid insulation it may be as large as 6. From the point of view of low losses and a wide tuning range (i.e. low self-capacitance) it is desirable to keep K_2 as small as possible.

It is of interest to consider numerically two screened loops (square in shape) which represent roughly the upper and lower limits of k^2 and the characteristic impedances obtained in practice. The first case is that of a large air-spaced loop with a thin inner conductor, while the second is a small loop with solid insulation and a thick inner conductor. The relevant data are given in Table I, in which L_2 is the total inductance pL_{22} of the loop.

It may be concluded that k^2 and Z_{01}, both of which are independent of K_2, lie in fairly restricted ranges, while Z_{02} can vary between rather wider limits.

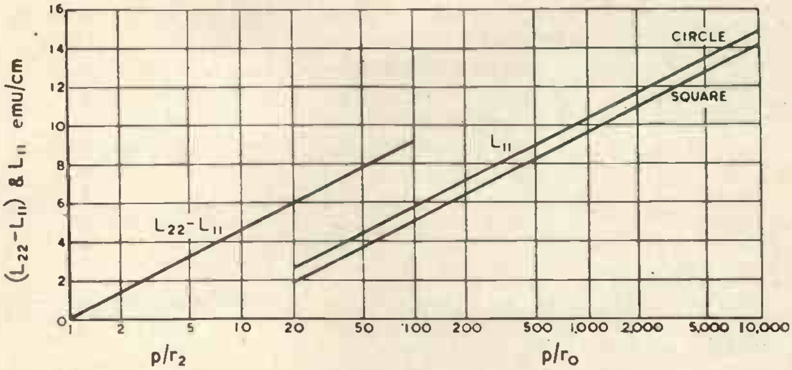

Fig. 2. *Relation between inductance coefficient and linear dimensions for concentric cylindrical conductors (equations 29b and 30). L_{11} = coefficient of self inductance of screen per unit length ; L_{22} = coefficient of self inductance of loop per unit length ; p = perimeter of loop ; r_0 = outer radius of screen conductor ; r_1 = inner radius of screen conductor ; r_2 = outer radius of loop conductor.*

5. The Balanced Loop

The impedance and resonance phenomena of the balanced loop will now be considered in detail. From equations (22) and (25) the impedance appearing at the loop terminals for the case of the open circuited gap is seen to be given by

$$Z_2 = \frac{e}{i_2(o)} = 2jZ_{02}\frac{Z_{01}\tan\beta_1 s + Z_{02}\tan\beta_2 s}{Z_{02} - Z_{01}\tan\beta_1 s\tan\beta_2 s} \quad \ldots \quad \ldots \quad (31)$$

which is the impedance of a transmission line of constants $2Z_{02}$ and β_2 terminated by a short-circuited line of constants $2Z_{01}$ and β_1, both being of length s.

TABLE I.

Data relating to two typical screened loops.

K_2	a (cm)	r_0 (cm)	r_1 (cm)	r_2 (cm)	L_2 (μH)	k^2	Z_{01}	Z_{02}
							ohms	ohms
1.0	200	2.5	2.0	0.05	11.6	0.50	220	220
2.0	25	1.25	1.0	0.25	0.7	0.625	135	55

At frequencies sufficiently low for the current in the loop to be sensibly uniform ($\beta_2 s \ll \frac{\pi}{4}$) Z_2 has the form $Z_{20} = 2jZ_{02}s\dfrac{Z_{01}\beta_1 + Z_{02}\beta_2}{Z_{02}} = j\omega L_2$ (32)

from equation (16b) where

$$L_2 \equiv pL_{22} = 2s(Z_{01}\beta_1 + Z_{02}\beta_2) \quad .. \quad (33)$$

is the loop inductance as measured at low frequencies.

Equation (31) for the general case is unsuitable for consideration of the resonance and anti-resonance conditions; only the case of the air-spaced loop ($K_2 = 1$, $\beta_1 = \beta_2$) will therefore be considered, and for this case the characteristic impedances are from equation (16b) related by

$$\frac{Z_{02}}{Z_{01}} = \frac{1 - k^2}{k^2} \quad .. \quad .. \quad (34)$$

Equation (31) becomes

$$Z_2 = j\frac{Z_{02}\sin 2\beta s}{\cos^2\beta s - k^2} = Z_{20}\frac{\sin 2\beta s}{2\beta s}\,\frac{1 - k^2}{\cos^2\beta s - k^2} \quad .. \quad .. \quad (35)$$

The resonant and anti-resonant frequencies are as follows :—

(*a*) *Resonant frequencies,* $Z_2 = 0$.

The condition for this is that $\sin 2\beta s = 0$ or $\beta s = n\frac{\pi}{2}$ where n is an integer. Thus the nth resonance is given by

$$\lambda = \frac{2p}{n} \qquad f = n\frac{c}{2p} \quad .. \quad .. \quad (36)$$

(b) *Anti-resonant frequencies,* $Z_2 = \infty$.

The condition is that $\cos^2\beta s = k^2$ or $\beta s = n\pi \pm \gamma$ where γ is the angle between 0 and $\frac{\pi}{2}$ satisfying

$$\cos\gamma = k \quad .. \quad .. \quad (37a)$$

Thus the nth anti-resonant frequency is given by

$$f = (n - 1)\frac{c}{p} \pm f_1 = \frac{c}{p}\left(n - 1 \pm \frac{\gamma}{\pi}\right) \quad (37b)$$

where $f_1 = \gamma c/2\pi s$ is the lowest anti-resonant frequency. The upper curve in Fig. 3 show γ as a function of k^2 for the balanced loop; for the practical range of k^2 (0.5 — 0.6) it is found that the first antiresonant wavelength is given by

$$\lambda_1 = 4.0p \text{ to } 4.6p \quad .. \quad .. \quad (38)$$

In Fig. 4 the variation of the reactance of the balanced screened loop with frequency is shown for the case of $k^2 = 0.6$. If the loop is to be tuned directly with capacitance, the upper limit of frequency occurs at a point somewhat below the first anti-resonant frequency, while if shunt inductance is added in order to be tunable through this frequency, it will be possible to tune to a frequency somewhat smaller than the first resonant frequency.

It is of interest to note that in the special case of $k^2 = 0.5$ as the characteristic impedances Z_{01} and Z_{02} are equal, the loop impedance is given by

$$Z_2 = j\omega L_2\frac{\tan 2\beta s}{2\beta s} = jcL_{22}\tan 2\beta s \quad .. \quad (39)$$

which is the reactive impedance of a short-circuited loss-free line of length $2s$ and characteristic impedance cL_{22} and is thus to a close approximation equal to that of an unscreened loop of twice the linear dimensions. The resonance and anti-resonance conditions occur when the perimeter is an even or odd multiple of a quarter wavelength.

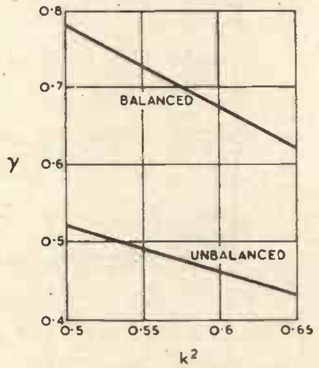

Fig. 3. *Relation between the anti-resonance factor* γ *and* k^2 *(equations* 37a *and* 37b).

A property of the screened loop which is of importance is the "self-capacitance," C_s, whose value is such that in parallel with an inductance L_2 the resulting impedance shall be a first approximation to Z_2, i.e.

$$\frac{Z_2}{Z_{20}} \sim \frac{1}{1 + j\omega C_s Z_{20}} \quad .. \quad .. \quad (40)$$

from which it is found after expanding Z_2 given by equation (35) up to terms in $(\beta s)^2$ that

$$C_s = pC_{22}\frac{1 + 2k^2}{12} \sim 0.17\,pC_{22} \quad .. \quad (41)$$

Thus the apparent self-capacitance is seen to lie in the region of one-sixth of the total mutual capacitance between the loop and screen.

The usual experimental method of determining C_s and L_2 is to measure the capacitance C to tune the loop to a frequency f and to plot $1/f^2$ against C. This should give a straight line whose intercepts are $1/f_1^2$ with the $1/f^2$ axis and C_s with the C axis. It is always found that the curve tends to bend upwards from the straight line as $C \to 0$, and this is due to the approximation in representing Z_2 as L_2 and C_s in parallel. The degree of approximation can be estimated as follows: the natural frequency given by the straight line intercept (deduced from L_2 and C_s) is found to correspond to

$$\beta_1 s = \frac{3(1-k^2)}{1+2k^2}$$

which on comparison with the exact value ($\beta s = \gamma \equiv \cos^{-1} k$) over the practical range of k^2 is found to be some 7 per cent. to 10 per cent. high.

We will now briefly consider the effect of a small capacitance C_g across the gap, such as will arise in its construction, and if we put

$$G = 2\beta C_g / C_{11}$$

we find from equation (26) that

$$Z_2 = Z_{20} \frac{\sin 2\beta s}{2\beta s} \frac{(1 - G \tan \beta s)(1-k^2)}{\cos^2 \beta s - k^2 - G \sin\beta s \cos \beta s}$$

The loop impedance is still zero when $\beta s = 2n\,\frac{\pi}{2}$ that is, the even resonant frequencies are unaltered but the odd resonant frequencies are modified to

$$\beta s = (2n+1)\frac{\pi}{2} - \tan^{-1} G$$

which for a small capacitance ($\tan^{-1} G \sim G$) corresponds to a fractional reduction in the first resonant frequency of $\frac{2Cg}{sC_{11}}$.

Similarly the anti-resonant frequencies are displaced and it may be deduced that the first anti-resonance will be reduced by the fraction $\frac{Cg}{sC_{11}}$.

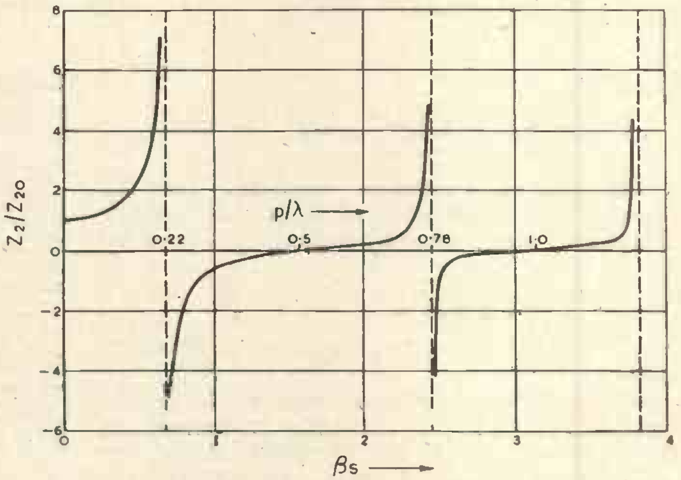

Fig. 4. *The reactance of the balanced screened loop* ($k^2 = 0.6$). Z_2 = *impedance of loop*; $Z_{20} = j\omega L_2$ *where* L_2 = *total inductance of loop*; p = *perimeter of loop*; $s = p/2$; λ = *wavelength*; $\beta = 2\pi/\lambda$.

To illustrate these results numerically, consider the first loop quoted in Table 1. With no capacitance across the gap the first resonant frequency is 18.7 Mc/s and the first anti-resonant frequency is 9.3 Mc/s. If the gap capacitance is 5 pF, then since C_{11} for the loop considered is 0.30 pF/cm., it is found that the first resonant frequency is lowered by 8 per cent. to 17.3 Mc/s, while the first anti-resonant frequency is lowered by 4 per cent. to 8.9 Mc/s.

6. The Unbalanced Loop

From equations (23) and (25) it is found that the impedance of the unbalanced screened loop for the case of the open-circuited gap is given by

$$\begin{aligned} Z_2 &= \frac{e}{i_2(+0)} \\ &= 2jZ_{02} \frac{Z_{01} \tan \beta_1 s + Z_{02} \tan \beta_2 s}{Z_{02}(1 - \tan^2 \beta_2 s) - 2Z_{01} \tan \beta_1 s \tan \beta_2 s} \quad \ldots \quad \ldots \quad (42) \end{aligned}$$

For the air-spaced loop this assumed the form

$$\begin{aligned} Z_2 &= jZ_{02} \frac{\sin 2\beta s}{\cos 2\beta s - k^2} \\ &= Z_{20} \frac{\sin 2\beta s}{2\beta s} \frac{1-k^2}{\cos 2\beta s - k^2} \quad \ldots \quad (43) \end{aligned}$$

The resonant and anti-resonant conditions are now

(a) *Resonant frequencies* : $Z_2 = 0$

For these $\sin 2\beta s = 0$ or $f = n\frac{c}{2p}$, $\lambda = \frac{2p}{n}$ (44)

exactly as for the balanced loop.

(b) *Anti-resonant frequencies* : $Z_2 = \infty$

For these $\cos 2\beta s = k^2$ requiring $\beta s = n\pi \pm \gamma$ where 2γ is the angle between 0 and $\frac{\pi}{2}$ satisfying

$$\cos 2\gamma = k^2 \quad \ldots \quad \ldots \quad (45a)$$

Thus the anti-resonant frequencies again have the general form

$$f = (n-1)\frac{c}{p} \pm f_1 \quad \ldots \quad \ldots \quad (45b)$$

where f_1 is the first anti-resonant frequency given by $\gamma c / 2\pi s$ the lower curve in Fig. 3 giving γ for the unbalanced loop which is lower than the corresponding value for the balanced loop by a factor of approximately 0.7. In practice

$$\lambda_1 = 6.0\,p \text{ to } 6.8\,p \quad \ldots \quad \ldots \quad \ldots \quad (46)$$

Fig. 5 shows the variation of the impedance of the air-spaced unbalanced screened loop for $k^2 = 0.6$ and the unequal separation of the resonant and anti-resonant frequencies is very marked.

The apparent self-capacitance of the loop can be deduced by the method used in the last section, and is found to be

$$C_s = pC_{22}\frac{2+k^2}{6} \sim 0.42\, pC_{22} \qquad (47)$$

On comparison with equation (41) for the balanced loop, the ratio of the self-capacitance in the two conditions is seen to be given by

$$\frac{C_s \text{ unbal.}}{C_s \text{ bal.}} = \frac{4+2k^2}{1+2k^2} \sim 2.5 \quad \ldots \quad \ldots \quad (48)$$

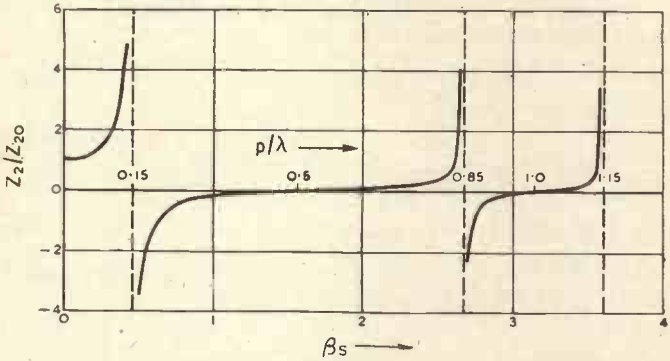

Fig. 5. *The reactance of the unbalanced screened loop* ($k^2 = 0.6$). Z_2 = *impedance of loop ;* $Z_{20} = j\omega L_2$ *where* L_2 = *total inductance of loop ;* p = *perimeter of loop ;* $s = p/2$ *;* λ = *wavelength ;* $\beta = 2\pi/\lambda$.

The first anti-resonant frequency for the unbalanced loop as deduced from the intercept method, i.e. determined by C_s and L_2 is given by

$$\beta_1 s = \sqrt{\frac{3}{2}\,\frac{1-k^2}{2+k^2}}$$

which is about 5 per cent. higher than the exact value.

It is of interest to note on comparing the general equations (31) and (42) that since the numerators have the same zeroes for the balanced and unbalanced cases the resonant frequencies are identical, and further that this is true even if the media outside and inside the screen are different.

Again considering the effect of a small gap capacitance C_g on the natural frequencies of the system, we have from equation (27) for the impedance of the unbalanced loop

$$Z_2 = Z_{20}\,\frac{\sin 2\beta s}{2\beta s}\;\frac{(1 - G\tan\beta s)(1-k^2)}{\cos 2\beta s - k^2 - G\tan\beta s\cos 2\beta s}$$

$$(\text{where } G = 2\beta C_g/C_{11})$$

As pointed out above, the resonant frequencies are the same as for the balanced loop, and they thus suffer the fractional reduction $\dfrac{2C_g}{sC_{11}}$. The first anti-resonant frequency, however, suffers a fractional reduction $\dfrac{C_g}{sC_{11}}\,\dfrac{k^2}{1+k^2}$ which is usually about a third of that for the balanced loop.

7. The Effective Height of the Screened Loop

The effective height of an aerial for transmission is defined as the length of a linear aerial, perpendicular to the direction of transmission which, when carrying a uniform current equal to the terminal current of the given aerial, produces the same field at a distant point as the latter. In general this effective height is a function of the direction of transmission and of the polarisation of the waves, though usually the orientation of the linear aerial is chosen so as to give the same polarisation as the given aerial.

The effective height of a single turn loop of area S for the direction of transmission in the plane of the loop at frequencies sufficiently low for the current to be sensibly uniform ($\beta s \ll \frac{\pi}{2}$) is given by

$$h_0 = \beta S \qquad \ldots \quad \ldots \quad (49)$$

At high frequencies the current distribution becomes non-uniform and the spacing between the sides becomes comparable with a wavelength, and it is necessary to specify the direction of transmission within the plane of the loop. The case of a square screened loop with an open gap will now be considered for transmission in the direction parallel to the "horizontal" side containing the gap.

If the loop current at its terminals is i_0 the effective height h is given by the vector sum of the integrals of the total current $(i_1 + i_2)$ in the two vertical sides when given a relative phase difference ϕ corresponding to the difference in space phase of the radiation from these two sides. Since the corners of the square have co-ordinates $\pm\frac{1}{4}s$ and $\pm\frac{3}{4}s$ the integration must be performed from $\frac{1}{4}s$ and $\frac{3}{4}s$ and the phase difference ϕ is given by $\beta s/2$.

$$\text{Hence } i_0 h = 2\sin\frac{\phi}{2}\int_{\frac{s}{4}}^{\frac{3}{4}s}(i_1 + i_2)\,dx$$

$$= 2\sin(\tfrac{1}{4}\beta s)\int_{\frac{s}{4}}^{\frac{3}{4}s}(i_1 + i_2)\,.\,dx \quad \ldots \quad (50)$$

Now the e.m.f. e which must be applied to the loop terminals to produce current i_0 at that point is

$$e = Z_2\, i_0$$

From equations (9b) and (21a) the sum of the loop and screen currents at any point x is for the air-spaced loop given by

$$i_1 + i_2 = -\frac{\beta A}{j\omega L_{11}} \cos \beta x = \frac{e\beta}{j\omega L_{22}} \frac{\cos \beta x}{\sin 2\beta s}$$
$$= i_0 \frac{Z_2}{Z_{20}} \frac{2\beta s}{\sin 2\beta s} \cos \beta x \quad .. \qquad .. \quad (51)$$

for the case of the open circuited gap. This shows that the summation current is distributed symmetrically about $x = 0$ and is co-phasal at all points. If the loop wire does not run centrally within the screen it might appear that the summation current $(i_1 + i_2)$ would not give the combined effect of the two currents unless the phase difference corresponding to the separation of the axes were taken into account. It may be shown, however, that the loop current i_2 sets up eddy currents in the screen such that, at high frequencies, the external effect is exactly that which would be produced by a uniform current i_2 in the screen and the external effect of the loop and screen currents is that of a current $(i_1 + i_2)$ in the screen independently of the configuration of the loop conductor.

Otherwise expressed it may be said that the external effects of the screened loop can be attributed to the circulating current $(i_1 + i_2)$ of the outer mode for the circulating current i_2 of the inner mode produces no external effect.

We now have from equations (50) and (51)

$$h = 2 \sin (\tfrac{1}{4}\beta s) \int_{\frac{s}{4}}^{\frac{3}{4}s} \frac{Z_2}{Z_{20}} \frac{2\beta s}{\sin 2\beta s} \cos \beta x \,.\, dx$$

and thus from equation (49)

$$\frac{h}{h_0} = \frac{Z_2}{Z_{20}} \frac{\sin^2 (\frac{1}{4}\beta s)}{(\frac{1}{4}\beta s)^2} \frac{2\beta s}{\sin 2\beta s} \cos (\tfrac{1}{2}\beta s)$$
$$= \frac{Z_2}{Z_{20}} \frac{\tan (\frac{1}{4}\beta s)}{\frac{1}{4}\beta s} \sec \beta s \quad .. \qquad .. \quad (52)$$

since $h_o = \frac{1}{4}\beta s^2$.

Fig. 6 shows $\frac{h}{h_0}$ and $\frac{Z_2}{Z_{20}}$ for the balanced and unbalanced screened loop with $k^2 = 0.6$. It is noted that the curves for reactance and effective height closely agree, and thus the increase of effective height can to a first approximation be simply attributed to the partial resonance of the loop with its self-capacitance producing a step-up in the terminal e.m.f.

It should be remembered that the effective height of an aerial does not alone indicate the efficiency for transmission or the signal/noise ratio it provides for reception, since both these quantities depend on the ratio of the effective height to the square root of the aerial resistance. As resonance is approached the increased effective height (which can never be infinite in a physical system) will be partially offset by the increase of resistance, and only when the radiation resistance predominates over other loss resistances will the efficiency of the aerial approach its upper limit. In all the preceding analysis, it is assumed that the screened loop is geometrically symmetrical about the line joining the gap to the point of entry of the loop conductors. Thus it is found that $A = A'$ and hence that the current distribution $(i_1 + i_2)$ is symmetrical, which implies that there is no radiation in a perpendicular to the plane of the loop.

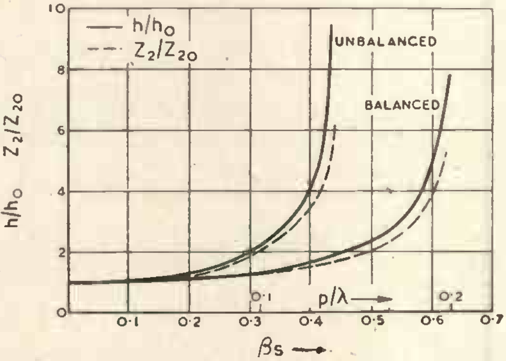

Fig. 6. *Behaviour of the effective height and impedance of a square screened loop* ($k^2 = 0.6$) *with frequency; h = effective height; $h_o = \frac{2\pi \times \text{area}}{\lambda}$; Z_2 = impedance of loop; $Z_{20} = j\omega L_2$.*

8. Comparison of Transmission and Reception

In the analysis of the previous sections, the current and potential distributions, the impedances and the effective height were deduced for the case when an e.m.f. is applied to the loop terminals, i.e. for the transmitting condition.

Now it is known from the Reciprocity Theorem that whatever the distribution of inductance, capacitance and resistance in an aerial the effective height is the same for reception as for transmission. Some writers have suggested that the radiation resistance may not be identical in the two conditions, the difference depending on the external impedance connected to the aerial, but it may be shown that this is incorrect, and that the aerial impedance is invariable, as a consequence of its behaviour as a linear network.[3]

Thus the equations found above for the

impedances and effective height will be valid for reception, although the current and potential distributions will be different. If the aerial is situated in a wave of electric intensity $E(x)$ at x in the direction of the conductors, equations (4a, b) must be re-written

$$\frac{\partial v_1}{\partial x} = -j\omega L_{11}(i_1 + i_2) + E(x) \quad \text{(4d)}$$

$$\frac{\partial v_2}{\partial x} = -j\omega(L_{11}i_1 + L_{22}i_2) + E(x) \quad \text{(4e)}$$

while equations (7a, b) are still valid.

On forming the second order differential equation, it is found that i_2 and $(v_1 - v_2)$ still satisfy

$$\frac{\partial^2}{\partial x^2} + \beta_2{}^2 = 0$$

and thus the inner mode will have a sine and cosine distribution whatever the distribution of the field.

The screen potential obeys the equation

$$\left(\frac{\partial^2}{\partial x^2} + \beta_1{}^2\right) v_1 = \frac{\partial E}{\partial x} \quad \text{(12a)}$$

while the summation current obeys the equation

$$\left(\frac{\partial^2}{\partial x^2} + \beta^2\right)(i_1 + i_2) = -j\omega(C_{11} - C_{22})E \quad \text{(12b)}$$

Thus in addition to a sine and cosine complementary function $(i_1 + i_2)$ and v_1 have particular integrals which are determined by the field distribution.

The open circuit loop e.m.f. e_2 appearing at the loop terminals due to a wave $E(x)$ can be calculated directly from the Reciprocity Theorem instead of proceeding to the detailed evaluation of the distribution of loop potential. Thus we have

$$e_2 = \int \frac{i_1 + i_2}{i_0} E(x) \,.\, dx \quad \text{(53)}$$

where the current $(i_1 + i_2)$ at x and i_o at the loop terminals are those which would be produced by a lumped e.m.f. applied to the loop terminals. For an air-spaced loop this assumes the form

$$e_2 = \frac{Z_2}{Z_{20}} \frac{2\beta s}{\sin 2\beta s} \int E(x) \cos \beta x \,.\, dx \quad \text{(54)}$$

from equations (9b) and (21a)

9. Experiments

Experiments were carried out on a screened loop of square shape having the following dimensions :—

$a = 150$ cm. $r_0 = 1.75$ cm.
$r_1 = 1.4$ cm. $r_2 = 0.045$ cm.

The loop wire was uninsulated and ran centrally within the screen. Measurements of the capacitance C required to tune the loop to a frequency f were made with the loop in the balanced and unbalanced condition, and the usual $(1/f^2, C)$ curve drawn to enable the inductance L_2 and the self-capacitance C_s to be found (intercept method). Corrections were made for the inductance and capacitance of the leads to the apparatus and the probable accuracy was about ± 2%. The first resonant and anti-resonant frequencies were determined by coupling the loop loosely to an oscillator with grid current indication and tuning this oscillator for an absorption dip. With the loop terminals open-circuited the anti-resonant frequency is found and with them short-circuited the resonant frequency is found.

The experimental values are given in Table II,

TABLE II.

Measured and calculated Data for a Screened Loop

Quantity	Loop Condition	Theoretical value for $K_2 = 1$		Measured value	
				Intercept Method	Absorption Method
L_2 (μH)	Balanced	8.5		8.35	—
	Unbalanced	8.5		8.50	—
Cs (pF)	Balanced	16.6		20	—
	Unbalanced	41		43	—
		Interc.	Absorp.		
$f_{\text{anti-res.}}$ (Mc/s)	Balanced	13.1	12.1	12.3	10.7
	Unbalanced	8.5	8.1	8.3	7.6
$f_{\text{res.}}$ (Mc/s)	Balanced	—	25	—	20
	Unbalanced	—	25	—	20

together with the theoretical values for the air-spaced loop ($K_2 = 1$) with no gap capacitance.

It is noticed that the inductance L_2 shows good agreement, but the self-capacitance is some $2 - 3$ pF high, and the frequencies low. These discrepancies are very probably due to the presence of insulation between the loop and screen which produces an increase in loop capacitance over the "free space" value and to the existence of a finite gap capacitance. A measurement was made of the loop to screen capacitance at a low frequency (0.2 Mc/s) which gave a value of 107 pF which, when compared with the theoretical $pC_{22} = 97$ pF, gives $K_2 = 1.1$.

In practice C_{22} will always be greater than the theoretical value for the air-spaced case ($K_2 = 1$) on account of the necessity for insulation between the loop and screen, and thus the general theory ($K_2 = 1$) must be used in place of the simpler theory for the air-spaced loop. The general theory is applicable if the insulation is uniformly distributed around the loop, but is not valid when the dielectric is lumped, e.g. in the form of insulating blocks at the corners of the loop as in the present experiment.

The inevitable presence of a capacitance across the gap will also need to be taken into account when accurate values are required. For example, in the present case, if this gap capacitance has a value of 5 pF, the fractional reduction of the first resonant frequency will be approximately 12% for either condition. In the balanced condition, the first anti-resonant frequency will be reduced by about 6% and in the unbalanced by about 2%.

It thus appears that any exact treatment of a practical loop is a complex matter on account of the various departures from the simple ideal conditions which can, only to a first approximation, be taken into account by means of a number of correcting terms.

In conclusion, it may be said that the principal departures from the ideal are

(a) Non-uniformity of the inductance and capacitance coefficients around the loop due, for example, to its shape and the distribution of insulation.

(b) The width of the gap may not be negligible.

(c) The ohmic and dielectric losses are not zero and thus the modes of propagation are damped.

10. Acknowledgments

The work described above was carried out as part of the programme of the Radio Research Board, to whom this paper was first circulated as a confidential report in June, 1942. It is now published by permission of the Department of Scientific and Industrial Research.

REFERENCES

[1] R. E. Burgess. "The Screened Loop Aerial." *Wireless Engineer*, 1939, Vol. 16, pp. 492–499.

[2] F. M. Colebrook. "The Application of Transmission Line Theory to Closed Aerials." *Journ. I.E.E.*, 1938, Vol. 83, pp. 403–414.

[3] R. E. Burgess. "Aerial Characteristics." *Wireless Engineer*, 1944 Vol. 21, p. 154.

May Meetings

DR. E. B. MOULLIN will speak on the contribution of Cambridge University to radio engineering at a meeting of the Cambridge and District Wireless Group of the I.E.E. on May 11th. The meeting will be held at 8.15 at the University Engineering Dept.

"Relaxation Oscillators and Trigger Circuits" is the title of the paper to be given by Dr. Emrys Williams at the Brit. I.R.E. Midland Section meeting at 6.30 p.m. on May 17th. The meeting will be held in the Latin Theatre of the University of Birmingham.

Dr. L. Hartshorn will lecture on "Foundations of Electrical Measurements" at a meeting of the Measurements Section of the I.E.E. at 5.30 on May 19th, at Savoy Place, London, W.C.2.

"Selenium Photocells" is the subject of the joint paper to be given by G. M. Tomlin and C. Wontner at the meeting of the North-West Branch of the Institution of Electronics at 7.0 on May 19th, at Reynolds Hall, College of Technology, Manchester.

At the meeting of the North-Eastern Section of the Brit. I.R.E. at 6.30 on May 24th, A. H. Hoult will deliver a paper entitled "Theory of Rectification." The venue is the Neville Hall, Newcastle-on-Tyne.

The first of two lectures on "The Electron Gun of the Cathode-Ray Tube" will be given by Dr. Hilary Moss at a meeting of the London Section of the Brit. I.R.E. to be held at 6.30 on May 25th, at the Institution of Structural Engineers, 11 Upper Belgrave Street, S.W.1.

R.M.A. Television Committees

IT was recently announced by the Radio Manufacturers' Association that the Equipment Makers' Section had appointed two television committees — the Television Policy Committee, which has also been constituted as the Television Policy Committee of the Radio Industry Council, and the Television Commercial Development Committee.

Institute of Physics

AT the request of physicists employed in industry in Scotland the Board of the Institute of Physics has authorised the formation of a Scottish Branch.

The inaugural meeting of the Branch, which is to be centred in Glasgow, took place on April 22nd, when E. R. Davies, a Vice-President of the Institute and Director of Research, Kodak Ltd., delivered an illustrated lecture on "High Speed Photography and its Applications in Science and Industry".

Further particulars of the Branch may be obtained from the Acting Honorary Secretary, Dr. R. S. Silver, c/o Messrs. G. & J. Weir Ltd., Cathcart, Glasgow, S.4.

Characteristic Impedance of TRANSMISSION LINES*

A Note on Certain Particular Cases

By *C. C. Eaglesfield*

(The Mullard Radio Valve Company)

SUMMARY.—Empirical formulae are given for the impedance of two shapes of uniform line where one conductor is a thin strip.

Some justification is given for the approximate estimation of the impedance, etc., of lines in terms of the perimeters of the conductors.

Introduction

THE use of transmission lines as convenient resonators at high frequencies can lead to cross-sectional shapes of line being of interest that would have little application for the transmission of power. It is, therefore, sometimes necessary to know, at any rate approximately, the characteristic impedance of lines of unusual shape; it is also desirable to know how to proportion the dimensions so that the line has minimum attenuation, corresponding to maximum selectivity as a resonator.

Exact expressions for characteristic impedance can be found for two concentric circles, or for any conformal transformation of two concentric circles. However, the inverse problem of finding a transformation that will fit a given configuration is extremely difficult and frequently impracticable.

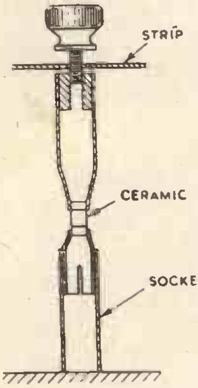

Fig. 1.

The problem of optimum proportioning of lines is naturally even more intractable.

Some kind of rough guide would therefore be very useful for estimating different lines; the following rule is suggested:—

Replace all conductors by conductors of circular section whose perimeter is equal to the perimeter of the original conductor. The new circles should be put in positions which seem to be reasonable†. The problem is then frequently reduced to one whose solution is known.

This rule must obviously be applied with discretion, and there are cases where it would lead to absurd results: as, for instance, for a conductor at the bottom of a deep trough, but in a number of cases it can be very useful.

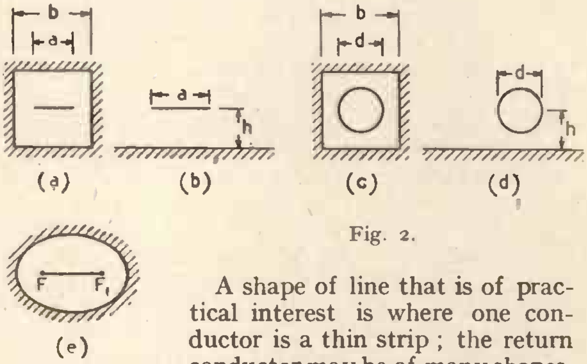

Fig. 2.

A shape of line that is of practical interest is where one conductor is a thin strip; the return conductor may be of many shapes, but only two are considered here, i.e. a hollow square symmetrically surrounding the strip, and an infinite plane parallel to the strip (Fig. 2(a) and (b)).

Measurements have been made of the impedance of these two types, whence empirical formulae are obtained. The "equal perimeter" rule was a useful guide to the form of the formulae, and it was noted that the rule gave reasonably accurate results.

Measurements were also made of the selectivity of the line of Fig. 2(a); here it was noted that the rule led to proportions giving a selectivity very little less than the maximum.

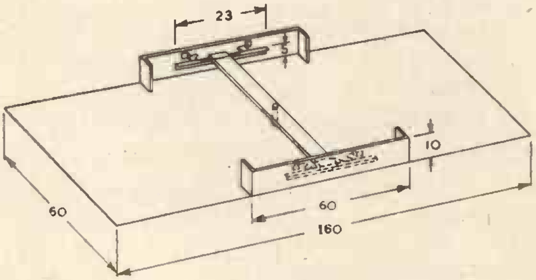

Fig. 3.

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* MS. accepted by the Editor, December, 1943.

† For example, the centre of the circle could be put at the centre of gravity of the conductor section.

Of course, the problem of estimating the optimum proportions is simplified by the fact that these are not usually very critical, so that even a rough rule may be sufficiently accurate.

Measurements

The measurement of characteristic impedance was made as follows :

The resonant frequency of a line short-circuited at each end was measured with and without a loading condenser at the centre. From these two frequencies the impedance is calculated from the following formula, which is easily derived from the usual equation for low loss lines :—

$$Z_0 = \frac{1}{\pi C f_1} \tan\left(\frac{\pi}{2}\,\frac{f_0 - f_1}{f_0}\right) \quad \ldots \quad \ldots \quad (1)$$

where f_0 is the frequency without the condenser

f_1 ,, ,, with ,, ,,

C ,, capacitance of the condenser.

By expressing Z_0 in terms of f_0 and f_1, the effect of small imperfections in the apparatus—e.g. at the short-circuited ends—is practically eliminated.

Equation (1) gives the impedance in terms of two frequencies and a capacitance. The frequencies are easy to determine but the value of a small capacitance is not so easy to decide, as it is complicated by end effects, and the effective value of a physical condenser depends on the surrounding objects. To get round this difficulty, the capacitance was in effect measured by using it with lines for which a formula is known for the characteristic impedance.

The same physical condenser was used in all measurements, its form being shown in Fig. 1. It consisted of a commercial ceramic condenser of nominal value 2 $\mu\mu$F, with brass tubes soldered to the end caps. It thus plugged into a socket at the bottom, and the strip conductor was bolted to the top. The effective capacitance was thus the lumped capacitance through the ceramic and, in addition, the capacitance to earth of the top brass tube. This latter capacitance depends on the shape of the earth conductor, and also partly on the size of the strip conductor, but the latter effect is probably small.

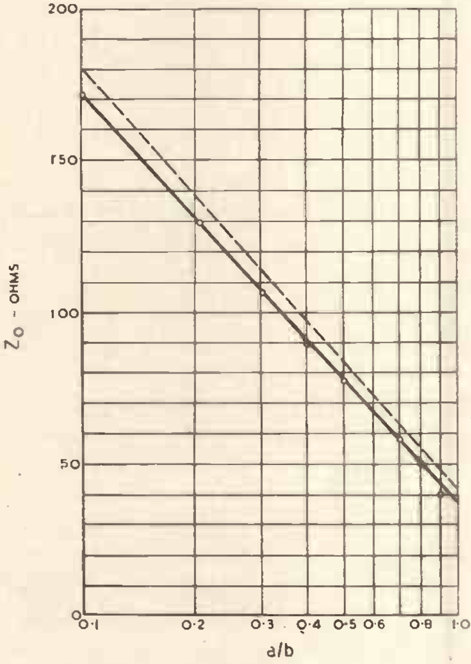

Fig. 4. *Points from Table 1 : dashed line from equation (4) ; full line from equation of (4′).*

The two types of line on which measurements were made are shown in Fig. 2(a) and (b).

TABLE 1.

Measured values of Z_0 for configuration of Fig. 2(a).

a	f_0	f	Z_0
(cm.)	(Mc/s)	(Mc/s)	(ohms)
1.00	250	205.5	171
2.07	249	213.9	129
3.02	248.5	218.8	106
4.01	248.5	223.0	89
5.00	248.2	226.0	76.5
7.00	248.2	231.0	58
8.03	248.0	233.0	50
9.03	248.0	235.8	40

b = 10 cm., length = 60 cm. Figures in last column calculated from equation (1), using C = 2.6 $\mu\mu$F ; this value of capacitance being deduced from measurement on a rod 0.62 cm. diameter.

TABLE 2.

Measured values of Z_0 for configuration of Fig. 2(b).

a	f_0	f	Z_0
(cm.)	(Mc/s)	(Mc/s)	(ohms)
1.00	249.5	199.0	210
2.07	249.0	207.0	167
3.02	248.0	210.2	148
4.01	247.5	213.0	133
5.00	247.0	215.8	124
7.00	247.0	219.5	102
8.03	247.0	220.8	96.5
9.03	247.0	222.0	91.5
12.0	246.5	224.5	80.0

h = 5.1 cm., length = 60 cm. Figures in last column calculated from equation (1), using C = 2.5 $\mu\mu$F ; this value of capacitance being deduced from measurement on a rod 0.62 cm. diameter.

Formulae are known for the impedance of the lines shown in Fig. 2(c) and (d). These are

$$Z_0 = 60 \log_\epsilon \frac{1.078\, b}{d} \quad \text{for Fig. 2 (c)} \quad .. \quad (2)$$

$$Z_0 = 60 \log_\epsilon \frac{4\, h}{d} \quad \text{,, ,, 2 (d)} \quad .. \quad (3)$$

Equation (3) is so well known as to need no comment ; equation (2) has been given by Frankel, *Proc. I.R.E.*, April, 1942. Both equations are subject to the condition that the inner conductor is small compared to the spacing, but there is an exact form of equation (3)

$$Z_0 = 60 \cosh^{-1} \frac{2\, h}{d} \quad .. \quad .. \quad .. \quad (3')$$

From what has been said above it is not surprising that the value of the capacitance as determined by measurements on the lines 2(c) and 2(d) was slightly different, but the difference was small, the values being 2.6 and 2.5 $\mu\mu$F respectively.

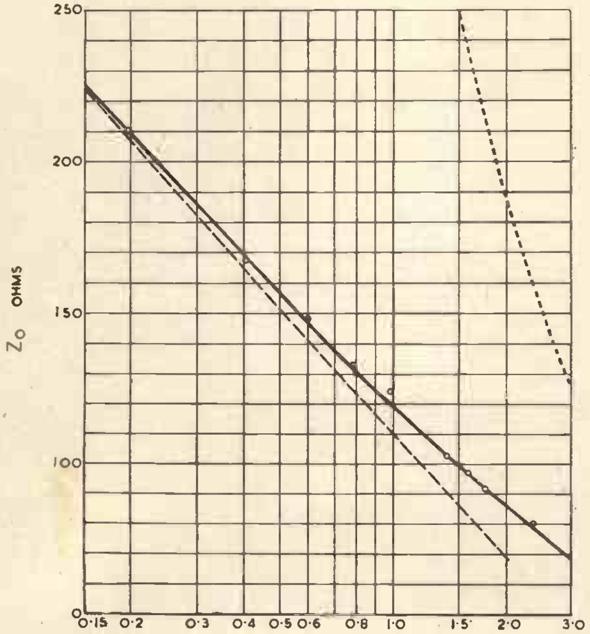

Fig. 5. *Points from Table 2 : dashed line from equation* (5) ; *dotted line from equation* (6) ; *full line from equation* (7).

A rough estimate of the capacitance of the top brass tube of the condenser to the earth conductor for the two cases showed a difference that corresponded approximately to the difference observed.

The capacitance determined by the Fig. 2(c) measurement was used for the impedance of Fig. 2(a) and Fig. 2(d) for Fig. 2(b). The impedance measurements were thus based effectively on equations (2) and (3).

Resonance was determined by connecting a modulated signal generator to an aperiodic detector and low frequency amplifier through a low impedance line broken to include a small coil loosely coupled to the line whose impedance was to be measured. The output from the amplifier at different frequencies was thus substantially uniform except for a sharp dip at the resonance of the test line.

TABLE 3.

Measured values of bandwidth for configuration of Fig. 2(a).

a	Bandwidth.	Selectivity as percentage of maximum.
(cm.)	(Mc/s)	
1.00	1.35	70.0
2.07	1.08	87.5
3.02	1.15	82.3
4.01	1.08	87.5
5.00	0.95	100.0
7.00	1.22	77.8
8.03	1.56	60.9
9.03	2.30	41.1

b = 10 cm., length = 60 cm. ; resonant frequency approximately 250 Mc/s ; material tin plate.

For the measurements on the line of Fig. 2(a), a metal box was constructed 60 × 10 × 10 cm., with a removable lid. Strips of different width were dropped into the box, and were held down on to ledges 5 mm. wide at the ends by springs. The length of these ledges was the full width of the box. This is the imperfection at the ends already referred to : the effect is to cause changes of "f_0" according to the strip width.

For the case of Fig. 2(b) the general arrangement is shown in Fig. 3. The end effects are somewhat worse than with the box. It was found that

TABLE 4.

Measured values of bandwidth for configuration of Fig. 2(b).

a	Bandwidth.	*a*	Bandwidth.
(cm.)	(Mc/s)	(cm.)	(Mc/s)
1.00	2.7	7.00	3.7
2.07	3.1	8.03	4.0
3.02	3.5	9.03	4.3
4.01	3.6	12.0	5.0
5.00	3.5		

h = 5.1 cm., length = 60 cm. ; resonant frequency approximately 250 Mc/s ; material tin plate.

increasing the width of the base plate made no detectable difference to the measurement, i.e. there was sufficient approximation to an infinite plane.

The selectivity measurements were made in a similar way, except that two coupling coils were used, one to the generator and one to the amplifier. There was thus no output except near resonance. The bandwidth given is for the usual 3 db. below the peak at either side of resonance.

Commercial tinplate was used in the construction of the lines. Its relatively high resistivity was an advantage in measuring the bandwidths.

The selectivity measurements were made with the condenser removed.

The result of measurements of Z_0 for the configuration of Fig. 2(a) is shown in Table I, and for Fig. 2(b) in Table 2.

The bandwidth measurements for Fig. 2(a) are shown in Table 3, and for Fig. 2(b) in Table 4.

Empirical Formulae

If for the configuration of Fig. 2(a) is substituted concentric circles whose perimeters are equal to the perimeters of the square and strip respectively, then since for the latter case

$$Z_0 = 60 \log_\epsilon \frac{\text{outer perimeter}}{\text{inner perimeter}}$$

the following formula is suggested for Fig. 2(a)

$$Z_0 = 60 \log_\epsilon 2\frac{b}{a} \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

For a more accurate formula, it seems reasonable to vary the numerical factors in equation (4).

Fig. 4 shows the values of Z_0 from Table 1 plotted against a/b; the dotted line represents equation (4) and the full line the rather better approximation :—

$$Z_0 = 124 \log_{10} 2.4\frac{b}{a} \quad \ldots \quad \ldots \quad (4')$$

It is noticeable in Fig. 4 that the equal perimeter rule is quite close to the measured results, even for high values of a/b; also that the points can be represented by equation (4′) for surprisingly large values of a/b. (Clearly $Z_0 = 0$ for $a/b = 1$). Thus, while it would be possible to construct an empirical formula that would fit the points and make $Z_0 = 0$ for $a = b$, it is hardly worth while.

The configuration of Fig. 2 (b) can be approached differently according as "a" is small or large compared to "h." For the first case the equal perimeter rule turns it into Fig. 2 (d) whence by equation (3) :—

$$Z_0 = 60 \log_\epsilon 2\pi\frac{h}{a} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

For the second case ($a \gg h$), the capacitance per unit length of line can be written down as $\frac{a}{4\pi h}$ e.s. units.

$$\text{Thus} \quad Z_0 = \frac{c}{a/4\pi h} \times 10^{-9} \text{ ohms}$$

$$= 60 \times 2\pi\frac{h}{a} \text{ ohms} \quad \ldots \quad \ldots \quad (6)$$

where "c" is the velocity, equal to 3×10^{10} cm/sec.

Clearly equations (5) and (6) can be combined :—

$$Z_0 = 60 \log_\epsilon\left(1 + 2\pi\frac{h}{a}\right) \quad \ldots \quad \ldots \quad (7)$$

since equation (7) degenerates into equations (5) and (6) for "a" small and large compared to "h."

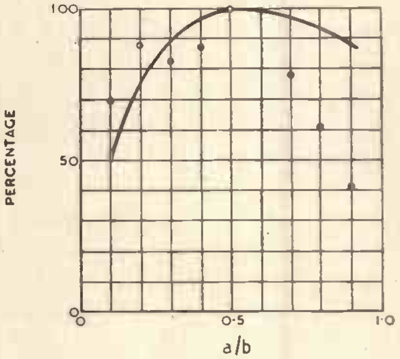

Fig. 6.
Points from Table 3: curve from equation 9.

Fig. 5 shows the measured points of Table 2 plotted against a/h; equations (5), (6) and (7) are shown as curves. Again it is noticeable that the equal perimeter rule agrees well with the measured values, and the modified formula (equation (7)) evidently holds with sufficient accuracy for all values of a/h: which is somewhat surprising for such a simple expression.

It may be remarked in passing that equation (7) is equivalent to a formula for the capacitance per unit length between two plates of width "a" and separation "h" :—

$$C = \frac{1}{2 \log_\epsilon\left(1 + \frac{2\pi h}{a}\right)} \text{ e.s. units} \quad \ldots \quad (8)$$

The selectivity measurements of Table 3 (for the configuration of Fig. 2(a)) are shown in Fig. 6. The maximum selectivity is taken as corresponding to the smallest bandwidth recorded.

The variation of selectivity with perimeter ratio is easily calculable for the case of two concentric circles. The selectivity is found to vary

$$\text{as} \quad A = \frac{(1 + S_1/S_2)}{\log_\epsilon S_1/S_2} \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

where S_1 is the perimeter of the outer circle and S_2 the perimeter of the inner circle. S_1 is assumed constant.

"A" is maximum for $S_1/S_2 = 3.6$ approximately. Taking $S_1/S_2 = \frac{2b}{a}$ the curve of A is shown on Fig. 6.

It can be seen that the points follow this curve fairly well up to the maximum selectivity, but fall away more sharply as the maximum selectivity is passed. It must be admitted, however, that the consistency of the points is not very good; the measurements were not easy with the methods used.

However, it is clear from the figure that little is lost in this case by taking a perimeter ratio of 3.6 : 1.

The bandwidths for the configuration of Fig. 2(b) (Table 4) are appreciably greater, and show no sign of an optimum. With this shape there is, of course, considerable radiation.

Acknowledgment

The author is grateful to the Mullard Radio Valve Company for permission to publish this article, and to several of his colleagues for helpful discussion and advice.

APPENDIX

It is interesting to compare the perimeter rule for estimating Z_0 on a configuration for which an exact formula can be found. Such a configuration is shown in Fig. 2(e), consisting of an ellipse and a strip between its foci.

This shape can be solved by the conformal transformation $\omega = \cosh^{-1} z$, which leads to the formula

$$Z_0 = 60 \cosh^{-1} (1/k) \text{ ohms} \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

where "k" is the eccentricity of the ellipse.

The perimeter ratio is $1/k\ E(k)$ where $E(k)$ is the complete elliptic integral of the second kind. The perimeter rule thus gives the formula

$$Z_0 = 60 \log_e \frac{E(k)}{k} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

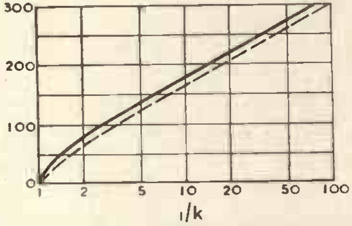

Fig. 7. *Full line from equation* (10); *dashed line from equation* (11).

Fig. 7 shows equation (10) and (11) plotted against $1/k$. Over most of the rage of k there is approximately a constant difference between the two values of about 14.5 ohms.

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

558 439.—Construction of the magnetic system of a microphone or telephone, designed to ensure a desirable rigidity and to facilitate assembly.

G. A. Barden and Goodman's Industries. Application date, 1st July, 1942.

558 614. Impedance-measuring device particularly suitable for supervising and regulating the load, say, on a transmission line carrying audible frequencies.

Rediffusion and P. Adorjan. Application date, 1st May, 1942.

558 645.—Impedance-measuring arrangement, particularly suitable for supervising the load on a communication line carrying audible frequencies (divided from 558 614).

Rediffusion and P. Adorjan. Application date, 1st May, 1942.

558 646.—Impedance-measuring arrangement, including a frequency-discriminating device, for supervising the load, say, on a telephone circuit (divided from 558 614).

Rediffusion and P. Adorjan. Application date, 1st May, 1942.

558 680.—Phonograph pick-up or microphone device suitable for generating or handling frequency-modulated signals.

Philco Radio and Television Corporation (assignees of R. B. Albright). Convention date (U.S.A.), 13th June, 1941.

558 704.—Phonograph pick-up device associated with the local oscillator of a superhet receiver for handling frequency-modulated signals (divided from 558 680).

Philco Radio and Television Corporation (assignees of R. A. Albright). Convention date (U.S.A.), 13th June, 1941.

558 709.—Permanent magnet containing an iron-cobalt alloy crystallized in directional columns, say, for a loudspeaker movement.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 24th October, 1941.

558 731.—Photo-electric amplifier circuit with a push-pull output and means to eliminate "cross-talk" effects.

Western Electric Co. Inc. Convention date (U.S.A.), 8th October, 1941.

558 749.—Telephone switching means for a two-way radio communication system.

Rediffusion and G. B. Ringham. Application date, 16th June, 1942.

558 923.—Low-frequency multi-stage amplifier in which thermally-sensitive resistance devices are utilized as the intervalve couplings.

Standard Telephones and Cables; P. K. Chatterjea; and C. T. Scully. Application date, 23rd July, 1942.

AERIALS AND AERIAL SYSTEMS

558 473.—Omni-directional short-wave frame aerial in which eight component arms are capacitance coupled at the four corners of the frame.

Standard Telephones and Cables (assignees of R. A. Hampshire). Convention date (U.S.A.), 12th July, 1941.

558 818.—Construction of a " base-loaded " aerial suitable for use in different positions on a portable or field radio set.

Rediffusion and G. B. Ringham. Application date, 17th July, 1942.

DIRECTIONAL WIRELESS

558 450.—Electrode assembly of a cathode-ray tube, particularly for use as an indicator in a radio direction-finding system.

Marconi's W.T. Co.; C. S. Cockerell; M. Esterton; and A. J. Young. Application date, 8th July, 1942.

558 486.—Aerial arrangement comprising two groups, one having a cusp of minimum reception lying within the area of omnidirectional response of the other in order to give a clear-cut directional result.

A. C Cossor; J. E. Godeck; and L. Jofeh. Application date, 21st February, 1941.

558 807.—Multi-phase circuit arrangement for indicating the strength and direction of a magnetic field.

E. L. Holmes; A. J. Hughes; and H. Hughes & Son. Application date, 14th August, 1942.

558 833.—Circuit in which the production of square-shaped waves is utilized to indicate the phase angle between two A.C. inputs.

Sperry Gyroscope Co. Inc. (assignees of E. L. Ginzton). Convention date (U.S.A.), 13th February 1942.

558 852.—Short-wave directional aerial system comprising a series of dipoles spaced apart in a common plane and associated with director and reflector elements.

Marconi's W. T. Co. and E. Green. Application date, 21st May 1942.

RECEIVING CIRCUITS AND APPARATUS

(See also under Television)

558 467.—Utilizing a locally-generated oscillation to facilitate the accurate tuning of a receiver for detecting amplitude- or frequency-modulated signals.

The Mullard Radio Valve Co.; C. E. G. Bailey; and G. I. A. Bywaters. Application date, 30th June, 1942.

558 482.—Receiver for frequency-modulated signals comprising a hexode valve in which the phase relation of the two grid voltage inputs varies with the signal modulation.

Sir L. Sterling. Convention date (U.S.A.), 15th August, 1941.

558 597.—Valve amplifier in which automatic compensation for fluctuations in the supply voltages is ensured by means of Thermistors or thermally-sensitive resistance devices.

Standard Telephones and Cables; P. K. Chatterjea; and C. T. Scully. Application date, 9th July, 1942.

558 598.—Receiver which is automatically muted against low-level signals by the action of a Thermistor or thermally-sensitive resistance device.

Standard Telephones and Cables; P. K. Chatterjea; and C. T. Scully. Application date, 9th July, 1942.

558 632.—Receiver with automatic signal-gain control derived from a Thermistor or thermally-sensitive resistance device.

Standard Telephones and Cables; P. K. Chatterjea; and C. T. Scully. Application date, 10th July, 1942.

558 633.—Auxiliary wedging devices for securing the control knob to the tuning spindle, say, of a wireless set.

Standard Telephones and Cables; M. M. Levy; and G. A. Heath. Application date, 10th July, 1942.

558 757.—Thermally-sensitive resistance device applied as a volume control in transmission or reception.

Standard Telephones and Cables; P. K. Chatterjea; and L. W. Houghton. Application date, 17th July, 1942.

558 826.—Receiver with means for isolating or separating signal voltages from interference or noise voltages and ensuring a higher amplification of the former.

D. L. Hings. Application date, 28th August, 1942.

558 877.—Automatic noise-suppressing or muting circuit for a receiver of phase- or frequency-modulated signals.

Marconi's W.T. Co. (assignees of B. Trevor). Convention date (U.S.A.), 22nd October, 1941.

558 314.—Means for maintaining a desirable phase relation between the signal waves and a local wave which is introduced to minimise selective fading.

Rediffusion and M. Exwood. Application date, 29th September, 1942.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

558 465.—Construction and composition of the photo-electric mosaic screen used in a cathode-ray television transmitter.

Western Electric Co. Inc. Convention date (U.S.A.), 1st May, 1941.

558 884.—Circuit wherein an oscillation generator is utilized to supply and regulate the high anode voltage required for a C.R. television receiver.

Hazeltine Corporation (assignees of L. R. Malling). Convention date (U.S.A.), 4th April, 1941.

558 927.—Preventing the undesired oscillations which tend to occur during the fly-back stroke in magnetic scanning systems for television.

Standard Telephones and Cables; P. K. Chatterjea; and D. M. Ambrose. Application date, 24th July, 1942.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

558 454.—Method of stabilizing or adjusting the frequency of a short-wave oscillation generator by regulating the dielectric constant of a Lecher wire or like feed-back circuit.

Standard Telephones and Cables and C. N. Smyth. Application date, 20th February, 1940.

558 511.—Frequency modulating system in which a single piezo-electric oscillator serves to define the two limits of the signalling frequency (addition to 556 852).

Marconi's W.T. Co. (assignees of M. G. Crosby). Convention date (U.S.A.), 29th October, 1941.

558 647.—Impedance measuring arrangement particularly suitable for supervising the load, say, on a carrier-wave transmission line (divided out of 558 614).

Rediffusion and P. Adorjan. Application date, 1st May, 1942.

SIGNALLING SYSTEMS OF DISTINCTIVE TYPE

558 343.—Signalling system in which intelligence is transmitted by varying the time interval between successive pairs of repeated pulses.

Standard Telephones and Cables (communicated by International Standard Electric Corporation). Application date, 16th October, 1942.

558 758.—Automatic gain-control circuit operated by pilot currents for a multi-channel carrier-wave transmission system.

Standard Telephones and Cables; A. M. Thornton; and W. F. Baly. Application date, 17th July, 1942.

CONSTRUCTION OF ELECTRONIC DISCHARGE DEVICES

558 446.—Electrode assembly designed to minimise the noise due to random electron velocities in the discharge stream, say, of a cathode-ray tube.

Western Electric Co. Inc. Convention date (U.S.A.), 8th July, 1941.

558 323.—Process for laying a smooth covering, say, of fluorescent material, over the curved surface of a cathode-ray tube.

The British Thomson-Houston Co., Convention date (U.S.A.), 27th June, 1941.

558 429.—Spacing and assembly of the electrodes of an electron discharge device to ensure constant operating characteristics over a wide range of temperature.

Standard Telephones and Cables (assignees of C. A. Bieling). Convention date (U.S.A.), 6th June, 1941.

558 962.—Electrode arrangement for stopping or intercepting electrons with undesirably large transverse velocities in a discharge tube of the cathode-ray type (addition to 542 496).

H. G. Lubszynski and Electric and Musical Industries. Application date, 20th July, 1942.

558 964.—Electrode arrangement designed to facilitate alignment and screening, in a short-wave power valve.

Marconi's W.T. Co. (assignees of A. K. Wing). Convention date (U.S.A.), 2nd January, 1941.

558 975.—Pump and circulating system for cooling the anode of a high-powered electron discharge tube.

Standard Telephones and Cables (assigness of J. B. Little and V. L. Ronci). Convention date (U.S.A.), 28th August, 1941.

SUBSIDIARY APPARATUS AND MATERIALS

558 300.—Composition and assembly of a multiple unit or battery of photo-electric cells of the blocking-layer type.

Evans Electroselenium; G. A. Veszi; and P. Markus. Application date, 20th July, 1942.

558 581.—Method of metallizing and mounting piezo-electric crystals, particularly for oscillation on the "thickness" mode.

Marconi's W.T. Co. (assignees of S. A. Bokovoy). Convention date (U.S.A.), 30th June, 1941.

558 686.—Process for preparing or conditioning metallized paper in the manufacture of condensers of the Mansbridge type.

A. H. Hunt; R. A. Grouse; and J. Rogers. Application date, 13th July, 1942.

558 693.—Method of constructing a fixed condenser to have a precise predetermined capacitance.

A. H. Hunt and E. Reinhardt. Application date, 17th August, 1942.

558 728.—Variable tuning inductance with a laterally sliding contact and a stop to limit its traverse.

The Plessey Co. Convention date (U.S.A.), 19th March, 1942.

558 738.—Composition and manufacture of iron-cobalt alloys with directional columnar crystallisation to give high permeability.

Philips Lamps (communicated by N. V. Philips' Gloeilampenfabrieken). Application date, 24th October, 1941.

558 756.—Process for the manufacture of electrical resistances by spraying metal on to a dielectric base.

Pilkington Bros. (communicated by Soc. Anon. de Saint-Gobain Chauney et Cirey). Application date, 6th July, 1942.

558 759.—Device to counteract any falling-off in the magnetic strength of an electric meter of the moving-coil type.

Standard Telephones and Cables; B. B. Grace; J. Handley; and G. Gilliver. Application date, 17th July, 1942.

558 761.—Circuit arrangement for increasing the normal response of Thermistors or thermally-sensitive resistances to an A.C. input.

Standard Telephones and Cables; P. K. Chatterjea; and C. T. Scully. Application date, 17th July, 1942.

558 762.—Thermostatic switch or relay operated by means of a Thermistor device having a high temperature coefficient of resistance.

Standard Telephones and Cables; C. T. Scully; and L. W. Houghton. Application date, 17th July, 1942.

558 767.—Means for stabilizing or conditioning the magnetic movement of an electric meter of the moving-coil type (divided from 558 759).

Standard Telephones and Cables; B. B. Grace; J. Handley; and G. Gilliver. Application date, 17th July, 1942.

558 861.—Arrangement in which an electromagnetic switch is controlled by a Thermistor or thermally-sensitive resistance device so as to generate saw-toothed or like wave-forms.

Standard Telephones and Cables; P. K. Chatterjea; and L. W. Houghton. Application date, 21st July, 1942.

Abstracts and References

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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

1490. THE MEASUREMENT OF THE DIELECTRIC CONSTANTS OF MATERIALS IN PLATE FORM BY MEANS OF WAVE-GUIDES IN THE CENTIMETRIC-WAVE REGION.—Ledinegg. (*See* 1636.)

1491. UNIVERSAL WAVE-GUIDE CHART [4-Curve Graph gives Phase Constant, Phase & Group Velocities, Attenuation Constant, & Wavelength for Rectangular & Circular Guides, Hollow or with Loss-Free Dielectric Filling, excited in TE or TM Mode].—A. Bronwell. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 147–148.)

1492. THE DIELECTRIC CONSTANT OF IONISED AIR IN A DISCHARGE TUBE IN THE RANGE OF WAVELENGTHS 80 CM TO 1500 CM.—N. Alam & S. R. Khastgir. (*Indian Journ. of Phys.*, Aug. 1943, Vol. 17, Part 4, pp. 204–215.)

Extension of the work dealt with in 2444 of 1937, where a much narrower wave-range was used. In the dielectric-constant measurements now made accurately (by a special Lecher-wire technique) over the wider range, three distinct minima in the ϵ values appeared in three different wavelength-regions, 175, 310, and 370 cm. Using the same discharge tube, with the same amount of current passing, feeble but distinct oscillations were obtained, of three different wavelengths which were found to correspond fairly closely to the wavelengths of the ϵ minima.

This multiple electron-resonance is attributed to the presence of different layers, having different electron densities, in the ionised medium. From Lorentz's equation giving the familiar curve of anomalous dispersion, "if there are groups of electrons each having a distinct characteristic frequency, then considering one after another all the dispersion curves corresponding to the various natural frequencies, it can be seen that the final curve would be a superposed effect and the resultant dielectric-constant curve could be of the type actually observed in our experiments. This is illustrated in Fig. 4." The experimental values of $N\lambda^2$ show a considerable departure from those given by the Tonks & Langmuir formula, while those for $N^{\frac{2}{3}}\lambda^2$ indicated a nearer approach to Gutton's equation.

1493. THERMAL DIFFUSION IN MIXTURES OF MOLECULES OF SMALL MASS DIFFERENCE [Experimental Investigation prompted by Chapman's Theoretical Results (701 of 1941, 289 of 1942)].—K. E. Grew: Chapman. (*Phil. Mag.*, Jan. 1944, Vol. 35, No. 240, pp. 30–36.)

1494. PHASE AND GROUP VELOCITY IN THE IONOSPHERE [Editorial: Treatment of Phase Velocity by Consideration of Infinite, Constant-Amplitude Wave superposed on Similar Wave of Slightly Different Frequency: Numerical Example of Penetration of Resulting Beats into Ionosphere, for Vertical Incidence: Calculation of Phase Velocities & Group Velocity for Various Values of N: Reflection: Case of Oblique Incidence: the More Complex Problem of the Pulse or Short Train: the Sommerfeld–Brillouin Treatment: the Velocity of the Modified Signal emerging from the Ionosphere].—G. W. O. H. (*Wireless Engineer*, Dec. 1943, Vol. 20, No. 234, pp. 577–580.)

1495. THE ZENNECK ROTATING FIELD IN THE NEIGHBOURHOOD OF RE-RADIATORS [Coasts, Hills, Reflector Aerials, & Counterpoises].—Grosskopf & Vogt. (*See* 1605.)

1496. METEORS AND THE EARTH'S UPPER ATMOSPHERE [Evidence concerning Construction & Temperature of Upper Atmosphere between 40 & 110 km: Observational Material, published & unpublished, for Photographic & Visual Meteors (including the Work of Öpik, and his "Energy Trap" Theory, & of Hoppe): the Theory used in determining Atmospheric Densities from Meteor Data: Results].—F. L. Whipple. (*Reviews of Modern Phys.*, Oct. 1943, Vol. 15, No. 4, pp. 246–264.)

For an earlier note *see* 996 of 1943. "The best solution appears to be one in which the height/log ρ curve corresponds to a flat temperature maximum of about 375° K near the 60-km level, a rapid drop to 250° K near 80 km, and a constant or slowly rising temperature at greater heights to about 110 km. The corresponding seasonal effect indicates that the upper atmosphere is raised 5.3 ± 1.0 km under average midsummer temperatures as compared to its height under average midwinter temperatures. It must be noted, however, that a constant atmospheric temperature of about 256° K from 60 km to 110 km is not entirely outside the range of solution. The corresponding seasonal effect is considerably greater than that given above.

" On the other hand, observations by Miss Hoffleit and Foster of the relative position of the point of maximum light in singly photographed meteor trails cannot be explained by the present theory in terms of a constant temperature in the upper atmosphere. The discussion in Section 5 shows that a high temperature zone near the 60-km level is required to account for these observations and that a conspicuous temperature minimum near 82 km is not indicated."

1497. On the Motion of a Charged Particle in a Magnetic Field, *and* On the Effect of a Vertical Magnetic Field in a Conducting Atmosphere.—H. Alfvén. (*Ark. Mat., Astron. och. Fys.*, Series A, No. 22, Vol. 27, 1941, Part 3, 20 pp: No. 11, Vol. 29, 1943, p. 1 onwards.)

(i) The deflection of a charged particle in the magnetic field of the earth is dealt with very simply by the perturbation method developed here, provided that the particle moves so slowly, *i.e.* its radius of curvature is so great, that over the whole path ρ . Grad $H \gg H$. The method of approximation then resolves itself into the calculation of the disturbance of a path in a homogeneous magnetic field. For all problems, except those of the high-velocity cosmic-ray particles, the condition is well fulfilled. Results are compared with Störmer's exact numerical solutions. Subsidiary disturbances through electric and gravitational fields are easy to take into account by this method. (ii) A six-page paper.

1498. A New Theory of the Zodiacal Light.—V. G. Fessenkoff. (*Nature*, 22nd Jan. 1944, Vol. 153, No. 3873, p. 114: summary only.)

" Fessenkoff finds that a dust cloud produced in this way [by collisions between sporadic meteors and the asteroids: *see* also 2300 of 1943] will form an oblate spheroid, with the sun at its centre surrounded by a dense ring of particles in the asteroid zone. The former is responsible for the conical zodiacal light; the latter for the uniform zodiacal band visible along the entire ecliptic throughout the night."

1499. Ice-Crystal Haloes [and the Bravais and Galle Explanations: Conclusions].—S. Melmore. (*Nature*, 5th Feb. 1944, Vol. 153, No. 3875, p. 166.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

1500. The Lightning-Measurement Station on Mount San Salvatore [near Lugano: Observations under More " Natural " Conditions than on Empire State Building: 70 m Tower (at 915 m above the Sea): Special Loop Oscillograph, with Its Light Source (Special Tungsten-Electrode Arc Lamp) set in action by the Lightning itself: New Type of Shunt: etc.].—K. Berger. (*Bull. Assoc. Suisse des Élec.*, 29th Dec. 1943, Vol. 34, No. 26, pp. 803–805: in German.)

1501. The Electric Discharge in Different Gases [Survey].—Allibone & Meek. (*See* 1676.)

1502. " Cloud Reading for Pilots " [Book Review].—A. C. Douglas. (*Nature*, 22nd Jan. 1944, Vol. 153, No. 3873, p. 96.) " . . . and meteorologists can study the photographs with advantage."

PROPERTIES OF CIRCUITS

1503. The Influence of Carrier Waves on the Noise on the Far Side of Amplitude-Limiters and Linear Rectifiers.—Fränz & Vellat. (*See* 1564.)

1504. Shot Noise and Valve Equivalent Circuits.—D. A. Bell. (*See* 1591.)

1505. The Limits of Amplification through the Noise of Valves and Circuits.—W. Graffunder. (*Ber. deutsche physik. Ges.*, Vol. 23, 1942, p. 63 onwards.) A three-page paper.

1506. The " Effective " Dielectric Properties of Concentric Lines with Discontinuous Dielectric.—Müller. (*See* 1576.)

1507. The Generation and Amplification of Decimetric and Centimetric Waves [Survey].—Hollmann. (*See* 1553.)

1508. Production Engineering at Ultra-High Frequencies [Some Problems & Possible Future Developments].—Meyerson. (*See* 1745.)

1509. Arrangement for the Loose Coupling of a Valve to a Pot-Type Cavity Resonator.—Licentia Patent Company. (*Hochf:tech. u. Elek: akus.*, July 1943, Vol. 62, No. 1, p. 29.)

Swiss Patent 222 661, with priority 28/8/40. The anode and grid of the valve R are connected to two " capacity " plates " P_1, P_2 (of unequal thickness) situated in the capacitance-gap between the " bolt " surfaces (*see* Fig. 10) of the pot: the mutual capacitance of these plates " is large compared with the working capacitance of the pot circuit."

1510. A Transformation [Matching] Section for Decimetric and Centimetric Waves, with Slight Dependence on Frequency.—A. Weissfloch. (*E.N.T.*, Aug. 1943, Vol. 20, No. 8, pp. 189–191.)

The commonest practice in these wavelength regions is to use a quarter-wave section; if an ohmic resistance R_1 is to be matched with an ohmic resistance R_2, a $\lambda_0/4$-long section of characteristic impedance $Z = \sqrt{R_1R_2}$ is inserted, λ_0 being the middle working wavelength (Fig. 1). But if R_1 and R_2 are very different, an inadmissibly large dependence on frequency will result. This defect is greatly reduced by the use of two quarter-wave sections, so chosen that the first transforms R_1 into $\sqrt{R_1R_2}$ and the second transforms the $\sqrt{R_1R_2}$ into R_2, as first suggested by Meinke [no reference is given, but *cf.* 3048 of 1942 and 2084 of 1943]. Even here a certain frequency-dependence persists. It is obvious that it could be reduced still further by using more than two suitable quarter-wave sections: the only difficulty lies in finding the correct characteristic-impedance values of these sections. The object of the present paper is to give a simple geometrical construction by which to obtain, without complicated calculation, the characteristic impedances of three such sections (Fig. 4) by which the frequency-dependence is considerably reduced.

The transformation of a quarter-wave section and its variation with frequency are easily made clear on the circle diagram (Fig. 2) for uniform lines (Schmidt, 1933 Abstracts, p. 222). To reduce the frequency-dependence as much as possible by using two sections, these must have characteristic impedances $Z_1 = \sqrt{R_1\sqrt{R_1R_2}}$ and $Z_2 = \sqrt{R_2\sqrt{R_1R_2}}$ (circle diagram Fig. 3). For the working wavelength, R_1 is transformed by Z_1 to $\sqrt{R_1R_2}$ and the latter, by Z_2, to R_2. For a 10% lower wavelength R_1 is transformed by Z_1 to $\tilde{\mathfrak{R}}$, and this by Z_2 to $\mathfrak{R}_2'$: similarly for a 10% higher wavelength R_1 is transformed to $\mathfrak{R}_2''$. It is seen that the locus curve from $\mathfrak{R}_2''$ by way of R_2 to $\mathfrak{R}_2'$, which is the curve passed over by the value of R_1 (transformed by the two quarter-wave sections) for a 10% change of frequency, is much shorter than the corresponding locus curve shown in Fig. 2 for the single-section transformation.

The best procedure for dealing with the three-section arrangement is different: it is advantageous to convert the right complex half-plane conformally into the unit-circle diagram of Fig. 5 by means of the function $w = (z - \sqrt{R_1R_2})/(z + \sqrt{R_1R_2})$, eqn. 1. Discussion of this diagram, in the course of which references are made to a paper by Smith (1372 of 1939) on a transmission-line calculator, and to the present writer's paper dealt with in 3286 of 1943, leads to the following conclusion: an ohmic resistance R_1 in a uniform line may be transformed, to a high degree without frequency dependence, into another ohmic resistance R_2 by the series connection of three quarter-wave sections (Fig. 4). For the middle section the characteristic impedance must be made $Z_2 = \sqrt{R_1R_2}$. For the section adjacent to R_1 a characteristic impedance Z_1 must be taken which is calculated from the relation $(\sqrt{R_1} - \sqrt{R_2})/(\sqrt{R_1} + \sqrt{R_2}) = (2\bar{w}_1^3 - 4\bar{w}_1)/(\bar{w}_1^2 - 3)$, where $\bar{w}_1 = (Z_1 - \sqrt{R_1R_2})/(Z_1 + \sqrt{R_1R_2})$. Finally, the last section must have Z_3 as given by the equation $\bar{w}_1 = (\sqrt{R_1R_2} - Z_3)/(\sqrt{R_1R_2} + Z_3)$. In the case of centimetric waves care must be taken to correct the lengths of the individual sections for the corner effects (Weissfloch, 711 of 1943).

1511. Transformation Elements with Transformation Ratio Independent of Wavelength.—W. Dällenbach. (*Hochf:tech. u. Elek:akus.*, Aug. 1943, Vol. 62, No. 2, pp. 33–38.)

"In a previous work (1844 [and 2663] of 1943) the characteristic impedances of n transformation elements, each a quarter-wavelength long and all connected in series, are so proportioned that for a prescribed resultant transformation ratio the quotient of the oscillating field energy stored up in the arrangement, by the energy flux in each period through a cross-section of the line, is a minimum. It might be thought that a series-connection of quarter-wave transformation sections thus proportioned must have a resultant tranformation ratio which would display the maximum possible independence of relative wavelength-variations $\Delta\lambda/\lambda$. In the present note it will be shown that this presumption is correct in the simple case of $n = 2$, but that for $n = 3$, $n = 4$, and in general, it cannot apply."

The writer deals first with general considerations on a series-connection of n quarter-wave sections of characteristic impedances $W_1, W_2 \ldots W_n$, used to match the characteristic impedance W_a (a = beginning) of a feeder line to the characteristic impedance W_e (e = end) of a reflection-free loaded line. By the use of eqns. 17, 18, and the table on p. 37 he finds that when $n = 1$ (one quarter-wave transformation section) the condition for maximum independence of $\Delta\lambda/\lambda$ is that $W_1^2 = W_aW_e$; when $n = 2$ it is

$W_1 = \sqrt{W_aW_e}(W_a/W_e)^{\frac{1}{4}}$, $W_2 = \sqrt{W_aW_e}(W_e/W_a)^{\frac{1}{4}}$; for $n = 3$ it is $W_1 = 1/\gamma \cdot \sqrt{W_aW_e}$, $W_2 = \sqrt{W_aW_e}$, and $W_3 = \gamma \cdot \sqrt{W_aW_e}$,

so that the three characteristic impedances form a geometrical progression with the common ratio γ (for γ *see* eqn. 33 and Fig. 1): the writer mentions that Weissfloch (1510, above) has given another method of calculation for the case of three quarter-wave sections; while the more complicated conditions for $n = 4$ are given in eqn. 50 (for γ_1 and γ_2, here involved, *see* eqns. 48, 51 and Fig. 2).

He then compares these results with the "conditions for smallest ballast" referred to at the beginning of this abstract. For $n = 2$ the equations are identical; for $n = 3$ the three characteristic impedances form a geometrical progression also in the "smallest ballast" case, but with a different common ratio γ_0 (eqn. 55 and lower curve of Fig. 1); for $n = 4$ it is the "smallest ballast" condition that gives the geometrical progression (eqn. 54, with common ratio $\gamma_1 = (W_e/W_a)^{\frac{1}{4}}$), whereas the condition for the maximum independence of frequency variation yields a geometrical progression only in the isolated case where $\gamma_1 = \gamma_2 = 1$.

1512. Cathode-Follower Circuits [as Highly Efficient Transformers coupling High-Impedance Sources to Low-Impedance Loads: with Special Consideration of Circuit with Cathode Resistor common to Two Valves in Parallel, Signal applied to One Grid: Analysis & Design Procedure, etc: Bibliography].—W. Richter. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 112–117 and 312.)

1513. High-Quality Coils with Dynamo Sheet Iron Type IV [as Substitutes for the Compressed-Powder-Core Toroidal Coils generally used for Oscillatory Circuits, Filters, Resonant Transformers, etc.].—H. Wilde. (*T.F.T.*, May 1943, Vol. 32, No. 5, pp. 97–101.)

Apart from the facts that the toroidal coils have to be wound by special machines, that the inductance values attainable are comparatively small, and that their exact adjustment is difficult, their supply at the present moment is well below demand. It therefore becomes important to know whether the ring cores of compressed powder cannot be replaced by ordinary laminated cores (with very large air-gaps) of "dynamo sheet iron IV", so that the powder cores could be reserved for applications where they are indispensable.

The writer, accordingly, has measured the losses in coils on various sizes of "E" type cores with various air-gaps, has divided these losses into their several components (iron-loss and copper-loss factors and the factor of dielectric loss in the winding), and has represented his results by curves. The usual practice with "E" cores, when it is desired to increase the air-gap, is to move the yoke away from the three limbs of the "E": in the present case, however, even a total removal of the yoke does not lead to a sufficient decrease in the loss factor, only to a field leakage which is liable to cause unwanted couplings, etc. It was found better to shorten the middle limb and to leave the yoke sitting in the ends of the two outer limbs (Fig. 2).

For many purposes it is not necessary to consider the exact loss factors, the important thing being to know the over-all behaviour of the coil over a range of frequencies. Figs. 11–14 therefore give curves for the variation of tan δ (the reciprocal of the figure of merit, ρ) for four sizes of "E" core, each with three different air-gap percentages, over the frequency range 0.1 to 10 kc/s. With increasing air-gap the curve minima move towards the higher frequencies, the loss angle tan δ itself becoming at the same time smaller when the field strength is kept at 50 mA/cm (full curves): at lower field strengths (tending to zero: dotted curves) the values of the minima are practically independent of the air-gap. For a fixed air-gap of 10%, Fig. 15 shows the loss angles for the four sizes of "E" coils, as a function of frequency, compared with the dotted curves for a toroidal coil and a Sirufer IV pot-type coil; the relative sizes are shown at the top of the figure. Figures of merit $\rho = 35$ and over are given by the "E60" core (winding cross-section 210 mm^2), while the small "E38" core gives a value around 20 at 6 kc/s. Although at the higher frequencies the much lower iron losses of the powder core lead to a better figure of merit, up to 5 kc/s the difference is "not too great," while the pot-type core "is even inferior, owing to its low permeability" [actual figures from Fig. 15, at 5 kc/s, are between 30 and 40 for the four "E" cores, over 200 for the powder core, and 50 for the pot core]. But a point which in many cases is of outstanding importance is the difference in the maximum inductance attainable with the various cores: an "E60" core wound with 0.1 mm wire will give 12 henries, a pot-type coil with the same wire only 0.9 henry, while the toroidal coil (with the thinnest practicable wire, 0.2 mm) gives less than one henry.

1514. THE INFLUENCE OF CAPACITANCES BETWEEN THE WINDINGS OF A TRANSFORMER ON ITS PROPERTIES.—H. Knapp. (*E.N.T.*, Aug. 1943, Vol. 20, No. 8, pp. 192–203.)

So far as iron-cored, fixed-coupling transformers are concerned, the many papers on the subject assume as a general rule that input and output are linked merely by a magnetic coupling, any capacitive coupling being neglected. In this way either a star or a delta circuit is obtained (Figs. 5, 6): for greater clarity it is usual to connect all values by a suitable "transformation ratio" on the part of the transformer, and to introduce, for voltage transformation, an ideal transformer in front of or beyond the equivalent circuit (Fig. 7). In this equivalent circuit it is usual to take into account all capacitive effects by supposing one single capacitance to be connected in parallel with the shunt inductance: its magnitude is determined from the position of the parallel-resonance point.

It is however known that the stray resonance frequency, calculated from the stray inductance and this capacitance, frequently fails to agree with that actually measured, and an obvious conclusion is that this discrepancy is due to a too rough estimate of the action of the capacitances. "Such capacitances occur not only inside the windings: there is a component between the windings, and the driving voltages on these capacitances are potential differences between different turns. In general, one particular pair of terminals of a four-terminal network is considered to be the input, the other pair the output. On the assumption that no connection exists between the input and output pairs of terminals other than that over the network itself, it is permissible to presume a resistance-free connection between one input terminal and one output terminal: in this way the star or delta connection is reached. The effect of capacitances between the transformer windings cannot be represented directly in this equivalent diagram. These capacitances, however, produce a series of effects generally unwelcome: it is only necessary to mention the words 'symmetry to earth,' in which they play a principal part." The representation of symmetry to earth by means of the normal equivalent diagram is, on the same grounds as before, impossible. Ways of improving the symmetry are known, the most effective being an electrostatic screen. But a penetration-free screening is not simple in construction and also may alter the transformer properties (by increasing leakage, for example): frequently, therefore, one "makes do" with screening foils between the windings. This, however, leaves a residual "penetration capacitance," and it is important to be able to estimate the effect of this. Hitherto no convenient method of calculation has been available, and the obtaining of a more complete equivalent circuit is obviously likely to involve considerable complications.

In the present paper it is shown that the symmetry relations of a transformer can only be considered with the help of an equivalent-circuit diagram of unusual form, namely that of a "complete" square with diagonals (six independent impedances: Figs. 1, 3): the application of such diagrams is dealt with in sections 2–5. If, however, it is only required that the transmission properties (*e.g.* stray resonance) should be represented correctly, it is seen (section 6 onwards) that it is possible to extend the previous star or delta circuit in such a way that the effect of the capacitances between the windings are taken into account.

1515. THE CALCULATION OF THE MAGNETIC FIELD STRENGTH [of the Leakage Field] NEAR TRANSFORMER WINDINGS [treated by the Technique of Undistorted Superposition of Elementary Fields: Strict Equations & Simplified Approximations useful for Rapid Estimates: Effect of the Yoke].—W. Knaack. (*Arch. f. Elektrot.*, 31st July 1943, Vol. 37, No. 7, pp. 317–346). An extension of Krämer's work, 1932 Abstracts, p. 162.

1516. POTENTIAL DISTRIBUTION IN TRANSFORMER WINDINGS ON THE ARRIVAL OF A SURGE, WITH SPECIAL ATTENTION TO THE SECOND [Passive] WINDING.—W. Knaack. (*Arch. f. Elektrot.*, 31st Aug. 1943, Vol. 37, No. 8, pp. 391–412.)

1517. ON THE CALCULATION OF THE CURRENT HARMONICS IN COILS WITH SATURATED IRON CORES [Comparison of Theoretical Results (especially by Writer's Method, 2687 of 1943) with Measurements].—W. Hartel. (*Arch. f. Elektrot.*, 31st May 1943, Vol. 37, No. 5, pp. 253–262.)

1518. CALCULATION OF THE CAPACITANCES REQUIRED FOR THE BALANCING OF THE REACTIVE LOAD IN SINGLE AND THREE-PHASE NETWORKS.—Heusser. (*See* 1712.)

1519. DIRECT READING OF THE FREQUENCY OF RESONANT CIRCUITS [Design of Condenser with Required Linear Law of Frequency & Required Range of Capacitance: Complications due to Edge Capacitance, etc.].—Griffiths. (*See* 1647.)

1520. UNWANTED NEGATIVE FEEDBACK DUE TO DEFECTIVE CONDENSERS.—K. Sternke. (*Funktech. Monatshefte*, No. 2/3, 1943, p. 28 onwards.)

1521. "VERSTÄRKER UND EMPFÄNGER" [Amplifiers & Receivers (for Wavelengths down to about 10 m): Book Review].—M. J. O. Strutt. (*E.N.T.*, Aug. 1943, Vol. 20, No. 8, p. 204.) Volume 4 of the Korschenewsky–Runge series "Lehrbuch der drahtlosen Nachrichtentechnik."

1522. A TREATMENT OF NON-LINEAR DEVICES BASED UPON THE THEORY OF RELATED LINEAR FUNCTIONS [with Application to Triode & Pentode Amplifiers, Large-Signal Detectors, Superheterodyne Converters, etc.].—H. Stockman. (*Journ. Applied Phys.*, Dec. 1943, Vol. 14, No. 12, pp. 645–658.)

"This treatment makes it unnecessary to use the vacuum-tube theory (with its predetermined meanings of the tube coefficients) as a foundation for rectification- and conversion-diagram methods—a rather artificial foundation in the case of crystal detectors and crystal converters. . . . The extension of the rectification-diagram method to frequency converters seems not to have been covered previously in the literature. This extension provides a short cut around extensive and difficult calculations and changes the nature of experimental investigation to a standardised procedure. Some of the difficulties in obtaining conversion diagrams are pointed out, and some hints are given for the practical measurement work.

"The contribution of this method is very similar to the contribution of the method of using $E_{g\max}$ $E_{p\max}$ diagrams and contours in the power-tube field. Diagrams are obtained for the tubes operating at a lower frequency, and it is possible to predict from these diagrams how the tubes will behave at a higher frequency and with a specified load. . . . The general theory is used for the development of a substituting 'model,' from which important information on the behaviour of a superheterodyne converter can be secured . . ."

1523. Attenuator Design for Amplifier Gain Controls [" to satisfy the Requirements of the Most Exacting Laboratory Equipment, as well as All Others needing Less Accuracy "].—P. B. Wright. (*Communications*, Oct. 1943, Vol. 23, No. 10, pp. 38..44 and 112..115.)

1524. Phase-Shift Oscillator Design Charts [Advantages of the Single-Valve Phase-Shift Oscillator (Fixed or Variable Frequency, *e.g.* 130–3200 c/s : Ginzton & Hollingsworth, 2161 of 1941) : Nomograms for Design].—W. W. Kunde. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 132–133.)

1525. The Consistent Relation between Sinusoidal Oscillations, Relaxation [" Kipp "] Oscillations, and " Kipp " Jumps.—W. Reichardt. (*E.N.T.*, Sept. 1943, Vol. 20, No. 9, pp. 213–225.)

Further development of the work dealt with in 59 of January. In an earlier paper (1931 Abstracts, p. 610, r-h column) it was shown that relaxation oscillations and sinusoidal oscillations are not essentially different, since a continuous transition from the latter to the former, and *vice versa*, is possible ; and that it depends mainly on the values of the circuit components whether this or that type of oscillation is excited. In the present paper the treatment is extended to singly-occurring " kipp " jumps and the transient currents resulting from them : for it depends simply on the elements of the external circuit associated with the negative resistance, and particularly on the value of the ohmic loading resistance, whether oscillations occur or only " kipp " jumps between different possible régimes of equilibrium. In special cases these régimes are not merely composed of two different stable points ; in one and the same circuit sinusoidal or relaxation oscillations are possible in addition to the stable points. The transient processes occurring at the transition from one state of equilibrium to the other are also of the same nature and merge continuously one into the other.

The writer takes the case of a " capacitive " negative resistance (for the distinction between the two types *see* 59 of January), whose characteristic is so chosen that the circuit (Fig. 1) represents to a high degree all organs of this group. Completely analogous relations can be obtained for " inductive " negative resistances. His treatment of this consistent relation between sinusoidal and relaxation oscillations and " kipp " jumps throws light on the problem of how far it is possible to deduce what processes will occur, from consideration of the instability conditions towards direct current on the one hand and towards alternating current on the other. In the case of stability towards d.c. and instability towards a.c., self-excited oscillations will always occur. With instability towards d.c. and stability towards a.c., of the three points of intersection between the characteristic and the " straight line of resistance " [$u = -iR$: the geometrical locus of all values for which no change of current occurs, so that $di/dt = 0$], the middle one is always unstable and the two outer ones always stable. A " kipp " transition from one repose position to the other may occur.

A whole multiplicity of relations, on the other hand, are to be found in the case when instability exists towards both d.c. and a.c. Here, relaxation oscillations, one or two sets of sinusoidal oscillations, and one or two stable final states alone or with persistent oscillations, may all occur simultaneously in the same circuit. Which of the possible final states will emerge in such circumstances depends only on the initial state ; an impulse from outside may produce a sudden transition from one stationary final state to the other. What final states are possible cannot be found from simple mathematical relations, only by graphical methods or by experiment. The much employed instability condition for d.c. instability, $-N < R$, and for a.c. instability, $-N < L/CR$, are strictly valid only in the immediate neighbourhood of the point of intersection in question. What happens over a wider region, when instability towards d.c. and a.c. exists, cannot be derived from these relations.

1526. Relaxation Oscillations in Power Plants.—W. Koch. (*E.T.Z.*, Vol. 64, 1943, p. 427 onwards.)

1527. Negative Resistance as a Machine Parameter [Series Generator possesses both D.C. Negative Resistance & Incremental Negative Resistance, the Latter leading to Possibility of obtaining Oscillations of order of 0.2–1.5 c/s : the Series Generator analysed as an Amplifier : etc.].—G. H. Fett. (*Journ. Applied Phys.*, Dec. 1943, Vol. 14, No. 12, pp. 674–677.) " As an interesting side-light, the oscillations provide an easy way for setting the brushes of the motor on the magnetic neutral . . ."

1528. Method of Measuring the Phase Displacement of High Frequencies variable in Frequency [by the Use of a Phase-Meter calibrated at a Low (*e.g.* 60 c/s) Frequency.].—F. Böttcher. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 30.) A Telefunken patent, D.R.P. 728 814. For Böttcher's work on sideband asymmetry *see* 2127 of 1943.

1529. The Phase-Control Circuit [for Thyratrons & Other Gas-Filled Tubes : Analysis of Basic Circuit].—S. R. Goldwasser. (*Communications*, Nov. 1943, Vol. 23, No. 11, pp. 78–79.)

1530. Phase-Controlled Rectifiers : an Analysis of Their Behaviour [primarily in connection with the Use of the Phase-Controlled Thyratron]—Murcek. (*See* 1788.)

1531. Investigation of the Stability Conditions in Delayed Control.—Stein. (*See* 1570.)

1532. Stability and Aperiodicity in Fourth-Order Processes of Motion.—Schmidt. (*See* 1813.)

1533. On the Damping Factor [$D = 0$, Undamped Oscillation : $D = 1$, Aperiodic Oscillation] of the Third-Order Differential Equation of Regulating Circuits [Complete Solution for Certain Initial Conditions: Superposition on the Wischnegradski Stability Diagram].—W. Oppelt. (*Arch. f. Elektrot.*, 31st July 1943, Vol. 37, No. 7, pp. 357–360.) *See* also a note in the issue for 31st October, p. 508.

1534. A General Equation for Bridge Circuits with Linear Resistances.—V. A. Bogomolov. (*Automatics & Telemechanics* [in Russian], No. 3, 1941, pp. 35–42.)

The following two types of bridge circuits with linear resistances, used in regulating systems, are considered: the potentiometer type utilising the Wheatstone principle, in which the winding of a three-position relay controlling a servo-motor is connected in the diagonal of the bridge (Fig. 1), and the balanced type in which two windings of a three-position balanced relay are connected between the arms of two variable rheostats (Fig. 2). For each type formulae are derived showing the relationship between the total power input P to the bridge, the power P_0 necessary for operating the relay, the sensitivity α of the bridge (minimum percentage change in the resistance of the arm to operate the relay), and the number n of the variable arms. A general equation (44) is then derived covering both types (m is the number of the relay windings). It is shown that for the same power input to the relay a much smaller total input is required in the case of the balanced-relay type.

1535. The Complex Variable and the Communications Engineer [Application to the Solution of Two-Dimensional Field Problems].—S. Frankel. (*Communications*, Sept. 1943, Vol. 23, No. 7, pp. 62..70 and 98, 106..109: Oct. 1943, No. 8, pp. 50..60 and 116.)

"In making use of a theorem the engineer must be fully aware of the restrictions imposed in deriving it, and must confine himself to the domain of these restrictions to avoid inevitable errors. . . ."

1536. Network and Four-Terminal-Circuit Calculations with "Wilberforce's Equations."—M. Skalicky. (*Arch. f. Elektrot.*, 31st May 1943, Vol. 37, No. 5, pp. 263–266.)

Wilberforce published his network equations in *Phil. Mag.*, Vol. 5, 1903: unfortunately, "they are too little known. Wallot [in his book, 979 of 1941] has been the first to employ them again. For completeness' sake these equations are reproduced here in a simplified form, and it is shown in particular how with their help the four-terminal-network equations and their determinant conditions can easily be derived." No assumptions need be made as to the construction of the four-terminal network, except that it should consist only of linear resistances and be governed by Kirchhoff's laws. Expressed in words, the fundamental equation (6) states that if the impressed terminal voltage in one current path of the one network is multiplied by the current in the corresponding path of the other network, and the sum is taken of these current–voltage products over all the current paths of the one network, this sum will be equal to the similarly obtained products-sum for the other network. For previous work by the same writer *see* 2385 of 1941.

1537. Networks with Predetermined Network Matrices [and the Predetermination whether, how, & in how many ways a Given Matrix can be developed into a Coupling-Free Network].—W. Bader. (*T.F.T.*, June 1943, Vol. 32, No. 6, pp. 119–125: to be concluded.)

Supplementary to 728 of 1943: some misprints in that paper are corrected on p. 119. In a later work the writer hopes to deal with the direct practical use of the whole calculation process, leading from the given operative attenuation, through the network matrix, to the actual values of the circuit component.

1538. Crystal Bridge Filters with Variable Band-Width [including the Differential-Bridge & Bridged-T Types: Simultaneous Displacement of Series-Resonance Frequencies and Parallel Capacitances & Terminating Resistance].—W. Herzog. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, pp. 29–30, Fig. 12.) A Telefunken patent, DRP.730 124, with priority 4/1/41.

1539. Quartz Band-Filters up to 10 Mc/s [Derivation of Formulae: Some Actual Filters & Their Characteristics].—W. Herzog. (*T.F.T.*, Feb. 1943, Vol. 32, No. 2 [wrongly printed as No. 3 on the first page], pp. 23–29.)

From the Telefunken laboratories. The first bridge-type filter to be described in the final section on actually constructed filters is a carrier-frequency filter with a middle frequency of 125 kc/s and a band width of ±19 c/s (this band width is taken at the attenuation $b = 0.35$ neper, corresponding to the voltage drop $1 : \sqrt{2}$: it is not identical with the spacing between the cut-off frequencies). It consists of a series connection of two differential filters each with two quartzes. The steepness of the two flanks is raised by the introduction of two infinite-attenuation points (*see* also 1540, below), derived from the condition of eqn. 3 ($X_1 = X_2$, and *see* also eqn. 61: a footnote on p. 24 points out that from eqn. 2, $X_1X_2/R^2 = -1$, it is also possible to produce null-points to help to make the pass-band part of the curve as rectangular as possible: the curve shape with the infinite-attenuation points is, however, of wider application and is therefore preferred: but *see* also section 7). The design calculations were carried out by the formulae derived in section 2. The measured attenuation curve is seen in Fig. 13, and shows excellent agreement with the theoretical curve (dotted lines).

The third example is a wide-band filter with a mid-point frequency of 3 Mc/s and a band width of ±6.8 kc/s: it takes the form of a complete bridge with four quartzes between push-pull arrangements, and here again two infinite-attenuation points are introduced to increase the steepness. Fig. 15 shows the excellent agreement between calculated and measured characteristics. The same filter was also constructed as a differential bridge type, and had a characteristic approximately as good.

The writer's method of adjusting his filters and taking their attenuation characteristics "differs from those hitherto published," and since it has given the best results it is described briefly in section 9. The filter, with the calculated adjustments of the condensers already marked, is connected between a warble-frequency generator and a cathode-ray oscillograph. By adjusting the condensers and varying the terminating resistance, a filter curve resembling in its outline the desired curve is obtained. Using the same generator with the warble device cut out, but with its frequency slowly varied by a motor-driven condenser, the attenuation characteristic is registered by a current-recording instrument: during this process a suitable number of nepers (according to the maximum attenuation which is to be reached) are introduced by means of a calibrated line connected between the filter and the amplifier feeding the recorder (Fig. 12): this is to furnish a picture of the outlying selectivity. The calibrated line also serves to calibrate the recorded attenuation curve in nepers, while the rotating condenser is calibrated by a precision wavemeter. After the adjustment of the filter has been tested by means of the recorded characteristic, the oscillographic image is used again to eliminate any faults, and the results confirmed by the use of the recording arrangement. The time taken by the whole process is short.

A point emerging from the various formulae to which special importance is attached, is that a comparison between the attenuation equations 34, 36, and 43 shows how the shape of the characteristic is more favourable with several quartzes in the bridge arms than with a series connection (giving the same number of quartzes in all) of several filters each having only a few crystals. This advantage can only be utilised within certain limits, since the difficulties in adjustment increase with the number of quartzes in a bridge-arm.

1540. ON THE PRODUCTION OF ARBITRARY BAND WIDTHS IN QUARTZ FILTERS [and the Problem of the Gap between Filters with Crystals only and Those with Crystals & Inductances].—W. Herzog. (*T.F.T.*, May 1943, Vol. 32, No. 5, pp. 105–113.)

A paper complementary to 1539, above. The severe limitation of band width in filters consisting only of oscillating quartz crystals was pointed out by Mason in 1934: with one quartz in each bridge arm the maximum relative band width is equal to the ratio C_k/C_p, where C_k is the series capacitance and C_p the parallel capacitance of the quartz. For longitudinally vibrating bars Mason found that this ratio could reach the value 1/125, which in the bridge-type filter considered would give a band width of 0.8%. This is a limiting value: taking into account the valve and lead capacitances, a relative band width around 0.5% may be regarded as attainable.

With transverse-mode crystals, which cover a much wider frequency band, the capacitance-ratio has upper limits (Bechmann, 3332 of 1942) varying, according to the particular cut, from 0.5% at frequencies up to about 5 Mc/s to 0.2% above 5 Mc/s. These values apply to crystals with their electrodes touching their surfaces: they become smaller with increasing spacing between crystal and electrode. For example, in the 10 Mc/s filter described in section 6 (Fig. 21) the ratio is only 0.05%. In filters where the quartzes of two equal bridge arms are replaced by condensers, the band widths are halved.

Now it is true that the band width can easily be increased by connecting inductances in series or in parallel with the quartzes. But a difficulty still exists, and now, contrariwise, it lies in obtaining a sufficiently *small* band width with such an arrangement. For it is a general law that the attainable relative band width must be larger than the loss angle (or the reciprocal of the figure of merit) of the circuit elements: Pohlmann showed this for a quartz filter with series coils, in his formula 61, $\beta G > 1$ (*see* 3540 of 1942). Inductances can be constructed with figures of merit ranging, according to frequency, from about 100 to 1000; according to this, the smallest possible band widths would range from 0.1% to 1%. But figures of merit of 500 to 1000 are optimum results, only attainable in the most favourable conditions and not often reached in filters, particularly when—as is so frequently the case—telephonic band widths are required. Even when the figure-of-merit condition is satisfied, the difficulty remains of too high attenuation in the pass-band.

As an example of the above difficulties, the design calculations for a short-wave filter with a coil (or coils) in parallel with the quartz (or quartzes) are carried out (Fig. 2): it is to have a band width of ± 7 kc/s at 20 Mc/s. The coil inductance required works out at 0.0042 μH, and its figure of merit must be at least $\rho = 1330$: "the construction of such an inductance is impossible". On the other hand, calculation shows that a filter with quartzes alone would have a band width of only ± 2.8 kc/s, so that with neither plan can a short-wave filter with telephonic band width be constructed. "The above difficulty, which shows the existence of a gap in band width between filters with quartzes only and those with quartzes and inductances, is overcome by a type of filter described in the following pages; it is to be noted that the resulting filters correspond in their properties with the type having quartzes only, above all in their low attenuation in the pass-band".

The description of this type of filter begins by a discussion of a filter with one quartz and high characteristic impedance, showing how a single quartz in the differential-bridge connection (where two bridge arms are replaced by a differential transformer: Fig. 3) gives in many cases a suitable attenuation curve. For the straightforward filter of this type the curves of the reactances of the two bridge-branches I and II, as a function of frequency, are as shown in Fig. 4, where the "stop" zones are shaded-in. The band width $f_2 - f_1$ is given by the separation $f_p - f_s$ between the parallel and series resonances of the quartz, the relation for which is $(f_p - f_s)/f_s = C_k/2C_p$. Now comes the special point: if, in each branch of the bridge, inductances (Fig. 5) are introduced in parallel with the quartz and with the condenser respectively, and are so chosen in value that the new resonance points in the two branches coincide, forming a point of infinitely high attenuation, the result will be to give the reactance curves of Fig. 6 or, alternatively, Fig. 7. The new resonance points are $f_{2p'}$ and f_{1p}, while f_{2p} is no longer identical with the parallel-resonance point f_p of Fig. 4. The auxiliary infinity-point in Fig. 6 is formed at f_{2p} and f_{1p}, in Fig. 7 at f_{2p} and f_{1p}. Thus the auxiliary infinity-points $f_{1\infty}$ in Fig. 6 and $f_{2\infty}$ in Fig. 7 can be set at that side of the filter, at will, where it is desired or where it is least disturbing.

A calculation (pp. 106–107) of the filter characteristics of the arrangement (Fig. 5) having the reactance characteristic of Fig. 6, and a comparison with the original arrangement (Fig. 3) having the reactance characteristic of Fig. 4, shows that for the same band width and other conditions the capacitances C_{11} and C_{01}, and also $C_{11'}$ and $C_{01'}$, of the new filter possess the enlarging factor $1/l$, where $l = 1 - f_{1\infty}^2/f_1 f_2$, whereas the data for the quartz, and also the terminating resistance, are unaltered except in the ratio l/m $(m = 1 - f_{1\infty}^2/f_1^2)$ which is practically unity and therefore negligible. If, therefore, the filter of Fig. 3 is unrealisable for a given band width because the calculated values of the capacitances C_{10}, C_{00}, $C_{10'}$, $C_{00'}$ are too small compared with the self-capacitance of the quartz plus the capacitances of the wiring, in the new filter they can be increased by the factor $1/l$ (as in eqn. 15) and, by a suitable choice of l, made practicable. It is also shown (eqn. 20 and adjacent text) that the effect of coil losses is much smaller in the new filter, and in most cases is negligible. The attenuation and phase characteristics of the new filters have already been dealt with in the preceding paper. Fig. 8 gives such an attenuation curve. The reactance characteristic of Fig. 7, on the other hand, would give an attenuation curve which would be the mirror-image (with respect to the mid-point of the filter) of this, so that a series connection of a Fig. 6-type filter with a Fig. 7-type would give a symmetrical attenuation curve. The phase characteristic of such a combination would be so shaped that it would be unaltered by a rotation of 180° about the filter-centre. Equations for the Fig. 7-type filter are given in eqn. 33.

The general principle of filter-construction described above has the additional great advantage of allowing band filters to be built up having low characteristic impedances which may, within limits, be chosen as required : this is of great importance for the direct connection of filters in lines. For such filters the inductances are connected in series, not in parallel, with the quartz and with the condenser (Fig. 9). On the other hand, for filters with a quartz in each branch of the bridge (differential bridge circuit, Fig. 12) the parallel-inductance scheme is returned to (Fig. 13) for a high-characteristic-impedance filter, the series-inductance connection being used again (Fig. 17) when such a two-quartz filter is required to have a low, selectable characteristic impedance.

Three examples of filters are worked out : a single-quartz type for 100 kc/s, band width ± 250 c/s, and two double-quartz types, one for 10 Mc/s and a ± 10 kc/s band width, the other for 20 Mc/s and the same band width.

1541. IMPEDANCE TRANSFORMATIONS IN BAND-PASS FILTERS.—A. S. Gladwin. (*Wireless Engineer*, Nov. 1943, Vol. 20, No. 242, pp. 540–547.)

From the G.E.C. laboratories. " By modifying the values of the elements of a filter, and/or by introducing new elements, band-pass filters may be made to behave like the original filter plus a perfect transformer [giving two main advantages]. The conditions necessary to permit this transformation, and the limitations on the types of impedance arms, ratio of transformation, and frequency range, are examined. A new equivalent circuit aids the analysis."

1542. THE CIRCLE DIAGRAM OF WAVE FILTERS : I—SIMPLE GRAPHICAL METHODS PROVIDE LUCID ANALYSIS OF WAVE-FILTER BEHAVIOUR : II—APPLICATION TO THE DESIGN OF A NARROW-CHANNEL BAND-PASS FILTER AT 500 KC/S.—P. J. Selgin. (*Communications*, Oct. 1943, Vol. 23, No. 10, pp. 20–25 and 78..82, 109 : Nov. 1943, No. 11, pp. 58..62 and 116.)

1543. THE CALCULATION OF THE CHARACTERISTIC IMPEDANCE OF A RIBBON CONDUCTOR IN AN OUTER CONDUCTOR OF CIRCULAR OR RECTANGULAR CROSS-SECTION [by the Method of Conformal Representation : with Table & Curves].—W. Magnus & F. Oberhettinger. (*Arch. f. Elektrot.*, 31st Aug. 1943, Vol. 37, No. 8, pp. 380–390.)

1544. THE MAGNETIC FIELD STRENGTH AND SELF-INDUCTION IN PLANE-PARALLEL CIRCULAR PLATES TRAVERSED RADIALLY BY ALTERNATING CURRENT [of Interest in connection with (*e.g.*) the Earthing of Circuits through a Common Chassis].—H. H. Wolff. (*Arch. f. Elektrot.*, 30th June 1943, Vol. 37, No. 6, pp. 302–316.) Following on 359 of 1943.

1545. MULTIPLE BRIDGING NETWORKS [Multiple or Splitting Pads] FOR SUPPLYING ANY NUMBER OF LINES OR UNITS OF EQUIPMENT FROM A COMMON SOURCE.—P. B. Wright. (*Communications*, Sept. 1943, Vol. 23, No. 9, pp. 34–40 and 96..98.) With graphs and tables. For supplementary diagrams *see* November issue, No. 11, p. 108.

1546. RSS AND PARALLEL R & X SLIDE RULES [for finding the Impedance of Series Reactance & Resistance, Effective Value of Superposed Currents or Voltages of Differing Frequency, etc : for Parallel Resistors & Condensers or Inductances].—W. G. Brown. (*Communications*, Oct. 1943, Vol. 23, No. 10, pp. 70, 72 and 120.) Prompted by Paine's paper, 1168 of April.

1547. AN ALIGNMENT CHART FOR FINDING THE TRUE INDUCTANCE OF A COIL WITH DISTRIBUTED CAPACITY.—R. C. Paine. (*Communications*, Sept. 1943, Vol. 23, No. 9, pp. 60–61 and 104.)

1548. PLEXIGLAS RULES FOR ALIGNMENT CHARTS [with Single Transparent Pivot & Cross Hairs for Nomograms with Two Known Variables : with Fixed & Sliding Pivots for Multiple Nomograms : also the Use of " Plasticele " instead of Graph Paper, and Its Advantages].—G. M. Mast. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 200..204.)

TRANSMISSION

1549. ARRANGEMENT FOR THE AMPLITUDE MODULATION OF CENTIMETRIC- AND DECIMETRIC-WAVE TRANSMITTERS.—Ch. Bachem. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 28.)

D.R.P. 729 194. " To modulate, with the least possible distortion of the field, the h.f. energy given out by the dipole *D* (Fig. 2) and led to the radiating point *A* by the wave-guide *R*, using as modulator the glow-discharge tube *G*, the electrodes are so shaped that they cut predominantly at right angles the electric lines of force of the unmodulated wave-guide oscillations. They may, for instance, consist of parallel strips like those of a polarising grating."

1550. ARRANGEMENT FOR THE MODULATION OR DEMODULATION OF ELECTRIC OSCILLATIONS.—G. Krawinkel & H. Salow. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 28, Fig. 4.)

D.R.P. 729 436. " The secondary-emissive electrode *E*, insulated by a condenser *C* or by a semiconductor, is struck by at least two electron-beams i_1, i_2 and gives up secondary electrons to the [curved] anode *A*. The one beam, whose intensity or velocity is controlled by the carrier wave, has such a velocity that for it the secondary-emission factor is greater than unity, so that the potential of the electrode *E* becomes positive from the giving-up of the secondary electrons. The second beam, on the other hand, controlled by the modulation voltage, produces a secondary-emission factor less than unity and therefore produces a shift of the potential of the electrode *E* in the negative direction. The resultant charging potential and the displacement current i_3 flowing through the condenser *C* are (if the working point is suitably chosen) dependent on the ratio of the two controlling quantities ".

1551. ULTRA-SHORT-WAVE OSCILLATOR OR FREQUENCY-MULTIPLIER WITH CIRCULARLY DEFLECTED CATHODE RAY AND SUBDIVIDED OUTPUT-ELECTRODE.—K. Fritz. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 28.) A Telefunken patent, D.R.P. 729 911 : Fig. 6.

1552. OSCILLATION GENERATOR, DETECTOR, OR FREQUENCY-CHANGER [with Velocity Modulation].—Philips Company. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 29, Fig. 9.)

French Patent 874 653, with priority 3/8/40. " To improve the efficiency of velocity modulation and to increase the extraction of output, the electron beam coming from the electron gun 2 is so deflected by the electrode system 4 that it enters obliquely the modulating system 3 (constructed like a magnetron or retarding-field system) and makes, in this, several spirallings or to-&-fro swings before it is led out into the drift chamber 8. Similarly, on leaving this it enters obliquely a similarly constructed ' catching ' system 10, before reaching the anode 14 ".

1553. THE GENERATION AND AMPLIFICATION OF DECIMETRIC AND CENTIMETRIC WAVES [Survey].—H. E. Hollmann. (*T.F.T.*, Jan. & Feb. 1943, Vol. 32, Nos. 1 & 2, pp. 12–21 & 37–44.)

The first paper of this long series was dealt with in

2353 of 1943, and the final part in 3333 of 1943. In these intermediate instalments the writer considers the split-anode magnetron (Habann oscillations & other types; back-heating; practical transmitters), electron multipliers, velocity-modulated tubes (and the mathematics of "phase focusing"; the klystron; Lüdi's modification with Lecher wires; the Hahn–Metcalf tube; the "retarding-field klystron"; the "reflection" generator. References concerning this last are to Hahn & Metcalf and to Gvosdover & others, 1554, below.)

1554. Investigations on Electron Beams in an Electrical Retarding Field [and the "Reflection Generator"].—S. L. Gvosdover, L. Loschakow, & J. Terlezki. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, Vol. 30, 1941, p. 613 onwards.) Referred to in 1553, above.

1555. Wide-Range Electronic Generator [*RC* Oscillator & Amplifier for Electro-Medical & Other Researches: Frequencies 1.8 to 180 000 c/s].—Mittelman, Grodins, & Ivy. (*See* 1792.)

1556. "Theoretische Grundlagen und Anwendungen der Modulation in der elektrischen Nachrichtentechnik" [Book Review].—E. Prokott. (*E.N.T.*, Aug. 1943, Vol. 20, No. 8, p. 204.)

1557. Arrangement for Measuring the Aerial Current and the Percentage Modulation with a Single Meter.—H. Tull. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, pp. 27–28.) A Lorenz patent, D.R.P. 729 193.

1558. Quartz Crystals: Types, Modes of Vibration, Methods of Manufacture.—M. A. A. Druesne. (*Communications*, Sept. 1943, Vol. 23, No. 9, pp. 46..50 and 109, 111.) From the James Knights Company.

1559. Automatic Transmitter Tuning with Push-Buttons [at a C.B.S. Short-Wave Station].—Federal Tel. & Radio Corporation. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 154..158.) From a recent issue of *Elec. Communication*.

1560. A Filament "Stepper-Downer" [Special Relay removing Filament Voltages in Three Steps, for 50 kW Valves & Rectifiers, to reduce Thermal Shock at Each Sign-Off Period].—H. B. Glatstein. (*Communications*, Sept. 1943, Vol. 23, No. 9, pp. 28 and 108.)

1561. Automatic Control Circuits for Broadcast Transmitters ["Four Man-Power-Saving Electronic Circuits"].—Sloat. (*See* 1709.)

RECEPTION

1562. "Verstärker und Empfänger" [Amplifiers & Receivers (for Wavelengths down to about 10 m): Book Review].—M. J. O. Strutt. (*E.N.T.*, Aug. 1943, Vol. 20, No. 8, p. 204.) Volume 4 of the Korschenewsky–Runge series "Lehrbuch der drahtlosen Nachrichtentechnik."

1563. Arrangement for the Modulation or Demodulation of Electric Waves [with the Help of Secondary-Electron Emission].—Krawinkel & Salow. (*See* 1550.)

1564. The Influence of Carrier Waves on the Noise on the Far Side of Amplitude-Limiters and Linear Rectifiers.—K. Fränz & T. Vellat. (*E.N.T.*, Aug. 1943, Vol. 20, No. 8, pp. 183–189.)

"Amplitude-limiters have attained a great practical importance through their use in frequency-modulation receivers. It has been known for a long time from tests that by the addition of a strong carrier to the natural noises of the receiver the noise at the output of the amplitude-limiter is reduced: measurements of this effect are given, for instance, by Plump (115 [and 491] of 1939). In the theory of the reception of frequency-modulated oscillations this behaviour of the limiter is explained by the following consideration: both the useful voltage and the natural noise of the receiver beyond the ideal amplitude-limiter are derived exclusively from the passages through zero of the input voltage of the limiter. Since, with increasing carrier-voltage, these passages through zero coincide to an arbitrary degree of exactness with those of the carrier, the addition of a strong carrier will suppress the noise, while conversely a preponderating noise at the input of the limiter will suppress the carrier in its output voltage: these remarks relate only to the effective values of carriers or noise at the output, while nothing is stated thereby as regards the ratio of signal voltage to noise voltage (Crosby, 2504 of 1937: Vellat, 79 of 1942).

"We give here a calculation of this suppression effect for arbitrary ratios of carrier-voltage to noise-voltage in front of the limiter, which appears hitherto to have been neglected, whereas for strongly predominating carriers it has been carried out in many papers on frequency modulation. It is readily accomplished by the use of methods developed for the calculation of the transmission of noise-voltages over bent characteristic curves, in a discussion of the behaviour of linear rectifiers to noise-voltages (Fränz, 3027 of 1941).

"Whereas the noise beyond a limiter is cut down by the addition of a carrier, such an addition makes it increase beyond a linear rectifier; in contrast to the square-law rectifier, beyond which the noise-voltage is (at any rate for strong carriers) proportional to the carrier-voltage, the noise increases only to a finite limiting value. This effect has been measured by Williams (1364 of 1937): the limiting value can also be calculated simply. In the present paper we propose to calculate the output voltage of the rectifier for arbitrary values of the carrier-voltage/noise-voltage ratio at its input, using for the purpose the methods, based on the theory of functions, already mentioned. The carrying through of the calculations proceeds quite similarly in the two distinct problems under consideration [having first dealt with the amplitude-limiter problem, the writer continues on p. 188: "The course of the calculation for the linear rectifier is analogous to such an extent—only the factor $(z_1z_2)^{-1}$ has to be introduced—that we shall dispense with carrying it out. Corresponding to eqn. 19 (for $\overline{Nf_af_a{}^*}$ in the case of the limiter) we now have eqn. 23 for the spectral distribution of the low frequency at the output of the rectifier. The individual terms of eqn. 23 have been represented in Fig. 3, to give a clear indication of the practicability of this formula for numerical calculation. It is seen, also, that the series 23 converges more rapidly than the corresponding series 19 for the amplitude-limiter"]. We shall consider our task to be accomplished when we have given the amplitudes and spectrum of the output voltage as functions of the carrier-voltage".

In addition to the two spectral-distribution equations, eqn. 20 for $\overline{v_a{}^2}$ gives the total fundamental-wave noise-voltage beyond the limiter (Fig. 4 shows the decrease as the carrier-addition is increased) and eqn. 24 gives the same for the linear rectifier (Fig. 2 showing the l.f. noise increasing to a limiting value as the carrier is increased). Other previous works by the first author, some results of which are embodied in the present calculations, were dealt with in 3026 of 1941 and 2124 of 1943.

1565. Suppressing Radio Noise in the Jeep.—F. E. Butler. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 96–99.)

1566. A Treatment of Non-Linear Devices [Large-Signal Detectors, Superheterodyne Converters, etc.] based upon the Theory of Related Linear Functions.—Stockman. (*See* 1522.)

1567. Superheterodyne Converter Terminology [Critical Analysis and Summary of Existing Accepted Terms, and Suggested Additions, *plus* a Systematic Treatment of Converter Theory which includes Some of the Latest Developments: Paper based on Teaching Experience at Cruft Laboratory].—H. Stockman. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 144–146 and 324..331.)

Suggested abolitions include "first and second detectors" (first detector does not detect) and "beat-frequency oscillator" for the c.w. oscillator used for code reception ("from the following description of a beat-frequency oscillator it is obvious that the c.w.o. is not a b.f.o."). Two main classifications suggested are "sliding Q-point or fixed path of operation (FPO) converters" and "shifting Q-point or changing path of operation (CPO) converters".

1568. Superheterodyne Tracking Charts: III—The Padded Signal Circuit.—A. L. Green. (*Wireless Engineer*, Dec. 1943, Vol. 20, No. 243, pp. 581–594.) Reprinted from *A.W.A. Tech. Review* (1877 of 1943).

1569. Simplified Calculation of the Oscillator Circuit in the Heterodyne Receiver.—O. Meisinger. (*Funktech. Monatshefte*, No. 2/3, 1943, p. 23 onwards.)

1570. Investigation of the Stability Conditions in Delayed Control [Delayed Automatic Gain Control].—D. Stein. (*E.N.T.*, Sept. 1943, Vol. 20, No. 9, pp. 205–213.)

The theoretical conditions of stability for undelayed control have been dealt with by Küpfmüller (1929 Abstracts, p. 104), Artus (3256 of 1941 [and 401 of 1942]), and Nyquist (1932 Abstracts, p. 279). Küpfmüller's treatment is summarised in section 2. The question of stability, however, has gained increasing importance in connection with the delayed control used now in so many applications, in which the control process only comes into action when the controlling amplitude (*e.g.* that of a carrier wave) passes a certain value: such a result being obtained, for example, by the application of a negative bias to the rectifier valve used to provide the rectified control voltage. For it has been found by experience that the stability obtained with delayed-control devices falls below that obtained with undelayed control: the physical reason for this is seen from Fig. 4.

In the present paper, therefore, the writer takes the integral equation (7) for the stability in undelayed control and examines how it must be modified so as to apply to delayed control. It is found that compared with undelayed control, where control factor and control time alone determine the stability, in delayed control there is a further possibility of influencing the stability, namely by varying the delaying (biasing) voltage (*see* Fig. 11, giving the curve of U_v, the biasing voltage, as a function of δ for four different control factors $R_0 = 0.1\,..0.5$). "This fact, which constitutes an important result for practical purposes, has never been dealt with before. . . . All previous writers have given, as the method for stabilising control systems (whether delayed or undelayed), the raising of the control time . . . by the introduction of more oscillatory circuits or damping sections in the transmission or control circuit. This process has the disadvantage of being rather complicated and more or less empirical, since it is generally impossible to determine directly the exact change in the transition period: as a rule, therefore, such a method does not lead to working with the most favourable parameters . . ."

In the new method the stability is adjusted simply, and without changing the circuit components, by varying the delaying voltage according to Fig. 11 by means of a potentiometer. In the great majority of control systems such a variation (within certain limits) of the delaying voltage is permissible. The theoretical results are confirmed in section 4 by experiments with the Telefunken EF11 variable-mu pentode.

1571. Squelch [Muting, Codan] Systems, their Design and Operation [Manual Methods: Automatic Squelching: Electronic Methods: Relay-Type Squelch: Electronic QAVC: QAVC for Frequency Modulation: QAVC in Emergency (Police & Fire Departments, etc.) Systems: Suggested Method, using the "Attention" Signal, of Avoiding Reduction of Sensitivity].—L. Pressman. (*Communications*, Sept. 1943, Vol. 23, No. 7, pp. 72, 74 and 102, 110.)

1572. A New Method of "Crack Killing".—O. Köhler. (*Funk*, No. 5/6, 1943, p. 65 onwards.)

1573. Harvey Unit Cell Communication Receiver.—Harvey Machine Company. (*Communications*, Sept. 1943, Vol. 23, No. 9, pp. 91 and 92: *Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 300 and 302.) For this "unitized" series *see* 2714 & 3371 of 1943.

AERIALS AND AERIAL SYSTEMS

1574. On the Action of Parabolic Reflectors on Very Short Electric Waves.—A. Esau & H. Scheffers. (*Luftfahrtforschung*, No. 3, 1942, p. 169 onwards.) This seventeen-page paper is the one referred to by Born in the work dealt with in 1193 of April.

1575. Ground Plane Antennas [Criticism of Hasenbeck's Formulae & Curves (104 of January): the Fundamental Difference between Impedances of Aerial operating with Four Ground Rods & Aerial operating over Semi-Infinite Sheet: Experimental Checks on 60 Mc/s].—G. H. Brown: Hasenbeck. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 338–339 and 344.)

1576. The "Effective" Dielectric Properties of Concentric Lines with Discontinuous Dielectric.—E. Müller. (*T.F.T.*, Jan. 1943, Vol. 32, No. 1, pp. 1–12.)

From the A.E.G. laboratories. Author's summary:—"In concentric lines for h.f. transmission there are two basically different types of insulation, representing the construction of the dielectric: the discontinuous and the continuous type of insulation, and various combinations of the two [in particular the cup-shaped bead series, section II, 3]. As the protagonist of discontinuous insulation may be taken the disc insulation well known in wide-band cable technique, and composed of alternate large air spaces and small dielectric portions. It is shown here how the effective dielectric properties of this type of construction can be calculated on the basis of simple relations [eqn. 1 for the effective dielectric constant, eqns. 6 a, b for the effective loss angle]. The results are applied to actual types of cable met with in practice, and give definite values for the effective dielectric constant and effective loss angle varying with the materials used and with the working frequency. These values are compared with the results of actual measurement [for ϵ', the effective dielectric constant, *see* Table 3 for calculated and measured values: for $\tan \delta'$, the effective loss angle, calculated by eqn. 6 at 1..10 Mc/s for frequenta and at 1..500 Mc/s for trolitul, *see* Table 6. For measurements on a cable with 8% by volume of frequenta, up to 8 Mc/s, *see* the curve of Fig. 11]. . . . It is found as a result that even at the larger diameters, in the regions of medium to ultra-high frequencies the difference between the two types of insulation [continuous and discontinuous] is not very great, if in the discontinuous type the ratio of insulating component to air-space component is made as small as possible by suitable design and choice of material. The solid insulation naturally gives larger energy-losses than the air-space insulation, but has compensating advantages in electrical strength, flexibility, and mechanical stability [special attention is given (section II, 2) to the use of the polyisobutylene, oppanol: *see* Rohde, 814 of March].

"In the region of ultra-short and decimetric waves the ceramic insulation shows rather larger dielectric losses. They remain, however, within such limits that the use of this construction is quite practicable where high temperatures have to be considered (tropical equipment). For normal temperatures it seems desirable, in these frequency regions, to turn to the use of trolitul discs for discontinuous insulation. Thanks to the small proportion of insulator, the energy losses for equal dimensions are rather lower even for decimetric waves than those given by the continuous type of insulation. This fact presents the possibility of decreasing the spacing between the discs, in this way raising the cut-off frequency, so that the cable would be useful right down to the centimetric wave region [*cf.* Riedel, 2716 of 1943]. Here, however, it would generally be better to discard the concentric construction and make use of the so-called wave-guides." For a longish summary, including tables, see *E.T.Z.*, 18th Nov. 1943, Vol. 64, No. 45/46, pp. 600–601.

1577. Coaxial Cable Expansion [with Temperature: Total & Differential Expansions (the Latter especially important in Buried Hard-Copper Types, where Friction prevents Movement of Outer Conductor): Ways of preventing Damage].—V. J. Andrew. (*Communications*, Nov. 1943, Vol. 23, No. 11, pp. 28 and 120, 121.)

1578. A Linear Aerial of Variable Length.—L Walter. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 31, Fig. 20.)

A Telefunken patent, D.R.P.730 130. The earthed lower end of the rigid, vertically movable conductor 1, whose projection beyond the counterpoise plate 4 acts as the radiator, is connected to a float 8 (immersed in a buried container) the upward force on which balances the weight of the aerial.

1579. Receiving Aerial composed of a Stretched Horizontal Wire carrying a Number of Short Vertical Wires connected at Their Lower Ends to a Common Horizontal Wire and thence to the Down-Lead.—J. Heinrich & K. Skotnicki. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 31, Fig. 19.) D.R.P. 730 108.

1580. Low-Frequency Radiation from Short Mobile Antennae: Discussion of Types of Antennae possible for Mobile Installations operating between 1500 and 5000 kc/s [Methods of Coupling for 7 ft Whip Aerials, based largely on Police Car Experience: the Base-Loaded, Marconi, Collins (Pi), "Curved Plate," & Other Systems].—K. A. Kopetzky. (*Communications*, Nov. 1943, Vol. 23, No. 11, pp. 66..73 and 118.)

1581. Short-Wave Beam Arrays for Transoceanic Services.—E. Schüttlöffel. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 31.)

A Telefunken patent, D.R.P.729 912, applied for 17/10/40. "The geometrical vertical spacing of the cophasally fed horizontal dipoles of a 'fir-tree' array and the equally great height of the lowest dipole above the ground are selected so much smaller than a half-wavelength (for four dipoles one above the other the value is $\lambda/5$) that the angle of elevation of the radiation-maximum is about 20° or larger, since this has been shown by experience to correspond to the arrival angle of the radiation of transoceanic stations."

1582. Comparative Merits of Different Types of Directive Aerials for Communications [Opening Paper & I.E.E. Wireless Section Discussion].—J. A. Smale & others. (*Nature*, 19th Feb. 1944, Vol. 153, No. 3877, pp. 228–229.) *See* also 1203 of April.

1583. Adjusting Unequal-Tower Broadcast Arrays [for a Non-Symmetrical Radiation Pattern: the Complications due to Fact that Magnitudes & Phases of Base Currents may differ from Those of the Radiated Fields: Necessary Relations obtained from Field Measurements and verified by Use of Model (Ultra-Short-Wave) Aerials].—G. H. Brown & J. M. Baldwin. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 118–123 and 288..296.)

1584. Tallest U.S. Broadcast Tower [New Radiator at WNAX, rising 927 Feet above Ground].—C. Todd. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 104–105.)

VALVES AND THERMIONICS

1585. The Dielectric Constant of Ionised Air in a Discharge Tube in the Range of Wavelengths 80 cm to 1500 cm.—Alam & Khastgir. (*See* 1492.)

1586. Effect of Space Charge on Electron Beams.—J. Aharoni. (*Phil. Mag.*, Jan. 1944, Vol. 35, No. 240, pp. 36–50.)

"The effect of the space charge on an electron beam as it emerges from an electron-optical system has been treated in a number of papers (Watson, 1927 Abstracts, p. 509: Thompson & Headrick, 136 of 1941). In the following, a new method of dealing with the subject is described and a few applications are carried out [plane diode and a very long slit (arriving at exactly the same result as that found by Thompson & Headrick by a totally different method), circular beam (again identical with T. & H.), rectangular slit of finite length]. The method may be regarded as a hydrodynamical method. As we are dealing with stationary beams the time can be eliminated in a convenient way from the calculation".

1587. Impulse Generator for testing High-Power Tubes [primarily for Rapid Determination of

Optimum Anode Voltages for Modern Valves, including Transit-Time Oscillators: Characteristic Curves obtained by applying Single High-Voltage Pulses at Widely Spaced Intervals, with help of Two-Beam C.R. Oscillograph: Use of Probe Electrode to investigate Transit Times: Marx-Type Generator for Pulses up to 75 Kilovolts].—J. H. Owen Harries. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 136–139 and 326..330.)

1588. Modifications of Appleton's Method of Measuring the Mutual Conductance of a Valve.—L. F. Bates & W. F. Lovering: Appleton. (*Phil. Mag.*, Jan. 1944, Vol. 35, No. 240, pp. 64–72.)

"Several new modifications of Appleton's method [which "in spite of its great simplicity appears to be very much less well known than it should be"] are described. Most of them require the provision of a c.r. oscillograph and are suitable for lecture demonstrations. The best so far devised gives a two-line trace on the c.r.o. screen and enables accurate measurements of ρ, μ, and g_m to be made."

1589. Report on the Noise of Some Radio Tubes with Floating Grid.—K. J. Keller & H. J. A. Vesseur. (*Physica*, Vol. 10, 1943, p. 273 onwards.) A six-page paper, in English.

1590. Noise Measurements in Vacuum Tubes.—J. J. DeBuske. (*Nature*, 22nd Jan. 1944, Vol. 153, No. 3873, p. 114.) Summary of paper dealt with in 110 of January.

1591. Shot Noise and Valve Equivalent Circuits [and the Two Physical Pictures of Shot Noise (in terms of Voltage or Current Fluctuations) parallel to the Two Modes of representing the Voltage Amplification of a Valve].—D. A. Bell. (*Wireless Engineer*, Nov. 1943, Vol. 20, No. 242, pp. 538–539.)

According to the second concept, both shot and thermal noise are expressed as fluctuations of current originating at a constant-current generator associated with the conductivity of the resistor concerned, as already explained for thermal fluctuations in metallic resistors (Bell, 2780 of 1938: Bakker & Heller, 1842 [and *cf.* 3081] of 1939): "although the calculation of the magnitude of the mean square fluctuation current is more difficult in a valve, there are grounds for believing that this is also a possible representation of the shot noise in a space-charge-limited valve . . . I suggest that the understanding of shot noise has progressed since Moullin wrote his book (for instance, it is now firmly established that the 'smoothing factor' in a space-charge-limited valve is a function of cathode temperature) so that we can determine the position, in the equivalent circuit, of the generator of shot voltage or current; but that this does not necessarily have any bearing on the equivalent circuits used to express the amplifying properties of valves."

1592. A Treatment of Non-Linear Devices [Large-Signal Detectors, Superheterodyne Converters, etc.] based upon the Theory of Related Linear Functions.—Stockman. (*See* 1522.)

1593. Investigations on Amplifier Pentodes with regard to the Estimation of Non-Linear Distortion.—H. Holzwarth. (*Wiss. Veröff. a. d. Siemens-Werken*, Vol. 21, 1943, p. 58 onwards.) A sixteen-page paper.

1594. On the Use of Receiving Valves in Electronic Automatic Circuits.—A. A. Sokolov. (*Automatics & Telemechanics* [in Russian], No. 3, 1941, pp. 159–161.)

The great demand for multi-electrode valves in automatics and telemechanics is pointed out and it is shown that the existing types are generally not suitable for this purpose. The main requirement imposed on the valves is that the electrodes should not be interconnected inside the bulb. This refers in particular to the cathodes.

1595. Grid Control of the Thyratron [taken as representing Any Gas- or Vapour-Filled Grid-Controlled Discharge Tube: Theoretical & Experimental Investigation: the Influence of Grid Design & the Utilisation of Special Instability Conditions]. J. Bednařik. (*Elektrot. u. Masch:bau*, 1st Oct. 1943, Vol. 61, No. 39/40, pp. 487–489: long summary only.)

The summary ends with an outline of a circuit by which, for $f = 1$ Mc/s and $E_a = 500$ v, a control input of 100 w enabled a power of 1.5 kw to be reached with an efficiency of 75%: "the life of thyratrons is in general shorter than that of electronic valves".

1596. Early Radio Inventions [Editorial on Hazeltine's Presentation Address to Edison Medallist, E. H. Armstrong (*see* also 1404 of April)].—G. W. O. H. (*Wireless Engineer*, Nov. 1943, Vol. 20, No. 242, pp. 521–523.)

1597. "Die Oxydkathode: Teil I—Physikalische Grundlagen" [Book Review].—G. Hermann & S. Wagener. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 32.) A favourable review by Zenneck.

1598. On the Influence of Adsorbed Oxygen on the Secondary Emission of Sublimated Metallic Films at 293° and 83° Absolute.—R. Suhrmann & W. Kundt. (*Zeitschr. f. Phys.*, Vol. 121, 1943, p. 118 onwards.) A fifteen-page paper.

1599. Controlled Crystal-Growth in Tantalum Ribbons [used for Studies of Work Function & Secondary Emission: the Effect of Heat Treatment (A.C. & D.C. Supply) on Surface Structure: Effect of Temperature & of Cold Working on Grain Growth: etc.].—B. A. Mrowca. (*Journ. Applied Phys.*, Dec. 1943, Vol. 14, No. 12, pp. 684–689.)

1600. Note on the Solubility of Hydrogen in Palladium [and Lacher's "Hysteresis" Effect].—E. A. Owen. (*Phil. Mag.*, Jan. 1944, Vol. 35, No. 240, pp. 50–57.)

1601. Hydrogen Gas Purifier.—Eisler Engineering. (*Electronics*, Nov. 1943, Vol. 16, No. 11, p. 294.)

1602. Uncooked Spaghetti helps make Vacuum Tubes.—W. A. Hayes. (*Electronics*, Oct. 1943, Vol. 16, No. 10, pp. 238..242.) *See* also 828 of March.

DIRECTIONAL WIRELESS

1603. The Frequency-Dependence of the Group Path Time in Resonance Amplifiers [for Image Transmission, Pulse Measurements, etc.].—Schaffstein. (*See* 1253 of April.)

1604. Bearing and Range Determination by Reflected Rays.—"Gema" Company. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 31.)

D.R.P. 729 831, applied for 15/12/33. The direct and reflected rays are led to the receiver with such a relative displacement in time that their recordings coincide when a "standard" distance is reached: a departure from this range produces a corresponding departure from the "standard" line.

1605. The Zenneck Rotating Field in the Neighbourhood of Re-Radiators [Hills, Sea-Coasts, Reflector Aerials, & Counterpoises].—J. Grosskopf & K. Vogt. (*T.F.T.*, May 1943, Vol. 32, No. 5, pp. 102–104.)

"In previous papers (1833 of 1941, 376 [and 3001] of 1942, & 2958 [and 1361] of 1943) we have already reported in various ways on the behaviour of the Zenneck rotating-field ellipse at ground irregularities. Among other things, the investigations covered the behaviour of the rotating field in front of and behind hill obstructions, at the edges of woods, at sea-shores and river banks, and over stratified ground. These points of discontinuity in the ground properties, for the most part narrowly limited in space, are in our opinion responsible for a whole series of ray deflections, for example the well-known effect of coastal refraction. These, so far, have always been explained in the literature (Eckersley, 1920; Bäumler & Zenneck, 1926; and various text-books, ref. "6") in a way which cannot be reconciled with the latest results in propagation research.

"On the basis of Zenneck's theory (*Ann. der Physik*, 1907), coastal refraction is attributed to the differing phase-velocities over sea and land, the fact being overlooked (*see* Grosskopf, 964 of 1942) that the Zenneck theory gives a deviation opposite to the deviation actually observed. According to the theory, the ray passing from sea to land is bent away from the normal at incidence, whereas most observations (Eckersley; Bäumler & Zenneck) lead to the opposite result. But according to the latest propagation research (Grosskopf, 964 of 1942: Al'pert, Migulin, & Ryazin, 1885 of 1942) the phase-velocity at sufficiently great distances from the transmitter (greater than about 5λ) is practically equal to the velocity of light, whatever the ground properties may be, so that a true refraction of electromagnetic waves at the transition from one medium to the other cannot take place. It must rather be assumed that the points of discontinuity are to be regarded as diffraction zones which lead to ray deflections only in their immediate neighbourhood. If both transmitter and receiver are far enough away from the diffraction zone, no d.f. errors will be produced even when the d.f. ray cuts the diffraction zone. If the receiver moves into the zone, it comes under the influence of diffracting secondary radiators, and d.f. errors will occur. If the transmitter is in the zone, the distant observation point will receive not only the rays coming directly from the transmitter but also the rays from the secondary radiators. In all cases the various ray paths (apart from those in closest proximity to the transmitter, $d < \lambda$) are rectilinear on account of the constancy of the phase-velocity, and undergo no bending or refraction.

"For the first explanation of the processes taking place at points of discontinuity, the following experiments have been carried out, having for their object the determination of the spatial dimensions of the diffraction zones occurring at these points, on the basis of the observed distortions of the Zenneck rotating field. It has already been found (2958 of 1943) that the observation of the rotating field [by the "rotating dipole" method] represents a far more sensitive means of investigating inhomogeneities than any field-strength or d.f. measurements".

Ellipse measurements at a hill, reported in 1833 of 1941, yield the curves of Fig. 1 b, c for a/b and γ. Using the same frequency (841 kc/s), measurements were made on a "model" hill represented by a tuned vertical reflector aerial, and Fig. 1e shows the γ curves obtained. Fig. 1d shows the results in the neighbourhood of a tuned vertical short-wave aerial (14 Mc/s). "These model tests show that qualitatively, and to a certain degree quantitatively also, the diffracting effect of the hill may be simulated by the action of a reflector". Figs. 2 and 3 give the results of a full investigation of the rotating field near the short-wave and medium-wave reflector aerials respectively, along the line of propagation. In the first case the interference effect is particularly well marked (results with the medium-wave reflector are somewhat interfered with by capacitive effects on the measuring dipole, due to the greater height of the aerial, and by other incidental conditions): in front of the short-wave reflector, periodic fluctuations of field strength, of ellipse inclination γ, and of α ($1/\sin\alpha = a/b$, the ratio of the ellipse axes) all occur, while beyond the reflector there appears a monotonic asymptotic descent to the values holding in the absence of a reflector. These curves of Fig. 2 are to be compared with those for γ and α in Fig. 4, calculated by the theory given on p. 103 for the behaviour of the rotating field in the interference field of a reflector aerial. The slight differences are attributable to the theory being developed for a loss-free aerial of very small effective height.

The final section describes an experimental investigation of the behaviour of the rotating field at points of discontinuity in flat ground, by artificially representing a transition from one set of ground properties to another by means of a set of 30 m-long parallel wires laid 1 m apart on flat homogeneous ground. The ellipse measurements (using signals from a 50 km distant broadcasting station) were carried out first with the 30 (29 ?) wires lying in the direction of propagation, and the test line was along the middle wire. Fig. 5 shows the γ and α values plotted against the distance from the mid-point of the wire system: in spite of the smallness of the "diffraction zone" compared with the wavelength, the effect on the rotating field is very marked. Fig. 5 also shows that instead of the expected monotonic increase of the "effective" conductivity towards the middle of the wire system, minima occur at the borders of the network. A simultaneous measurement of the vertical component of the rotating field, that is of the normal field strength, showed that this was practically constant, so that the diffraction was affecting only the horizontal component: here, as in many other cases, the normal field-strength method is unsuited to the investigation of diffraction processes. Finally, it can be deduced from Fig. 5 that the "effective" conductivity at the middle of the network is 7.5 times that of the uncovered ground.

In the next tests the conductivity meter was kept at the centre of the network and (with the wires still parallel to the direction of propagation) the number of wires was reduced symmetrically, in steps, from 29 to 0. The full-line curves of Fig. 6 show that the rotating-field parameters γ and α have practically reached their limiting values with 29 wires: on the other hand the dotted curves show that when the spacing between the wires is reduced to 0.5 m the limiting values are not reached with the full number of 29 wires, but that when they *are* reached the "effective" conductivity will be much greater than for the wider spacing. Fig. 7 deals with tests in which the direction of the wires with respect to the incoming signals, and also their number, were varied: curve 1 (with the wires of 90°) shows that γ remains perfectly constant as the number of wires is reduced from 29 to 0: for this transverse position there is no trace of any effect on the rotating field. For the two 45° orientations (curve 2) the curves were identical, and for the 0° orientation, as would be expected, the effect was greatest. Of special interest was the influence of small inhomogeneities of diffraction on the ray direction. In the 90° position no bearing errors occurred: in the 0°

position errors were absent provided that great care was taken in laying the wires, but small displacements of individual wires produced quite serious errors. In the 45° position there was a considerable bearing error varying with the width of the wire system, as is seen in Fig. 8. If the error is plotted as a function of the position of the wires relative to the direction of arrival, the well-known quadrantal error curve is obtained.

The writer concludes: "To sum up it may be said that the measurements reported above show that the dipole measuring method is particularly well suited to the tracing of diffraction zones, even in such cases where the diffraction effect is too small to be noticeable in the behaviour of the vertical component of the field strength or in any d.f errors. Later papers will investigate the influence of natural discontinuities in the ground properties (geological dislocations, land and water boundaries) on direction finding and on the rotating-field parameters, especially in the case of coastal refraction".

1606. Visual Direction Finders: Part I—Principles [Two-Signal Balanced Modulators: Single-Frequency Balanced Modulators: Carrier & Sideband Relations: Motor Control Circuits: System Limitations]: Part II—The RCA-Sperry Mark I Automatic Direction Finder for Aircraft.—D. S. Bond. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 140–143: Dec. 1943, No. 12, pp. 140–146 and 324, 325.) Condensed from a chapter of the forthcoming book "Radio Direction Finders".

1607. Gyro Flux Gate Compass.—Bendix Aviation. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 166 and 168.) *See* also 833 of March.

1608. The Army Airways Communications System: an Analysis of Its Purpose, Operation, and Equipment employed.—W. W. Fawcett, Jr. (*Communications*, Nov. 1943, Vol. 23, No. 11, pp. 38–42). *See* also October issue, No. 10, pp. 36, 37 (photographs).

ACOUSTICS AND AUDIO-FREQUENCIES

1609. High-Quality Coils with Cores of Dynamo Sheet Iron Type IV.—Wilde. (*See* 1513.)

1610. Factors affecting Pre-and-Post-Equalisation [in Sound Transmission & Recording Systems, for Reduction of Noise].—J. K. Hilliard. (*Communications*, Sept. 1943, Vol. 23, No. 9, pp. 30–31 and 110.) "A more general application . . . will result in a substantial increase in signal-to-noise and quality improvement".

1611. Multiple Bridging Networks for supplying Any Number of Lines or Units of Equipment from a Common Source.—Wright. (*See* 1545.)

1612. A Crystal Pick-Up with Crystal Plate protected against Breakage, and a Sapphire Stylus.—E. Gerlach. (*Akust. Zeitschr.*, Vol. 8, 1943, p. 81 onwards.) An eleven-page paper from the Telefunken laboratories.

1613. Hearing Aid Circuits [840 of March: Letter on the Use of the Word "Bimorph"].—Brush Development. (*Electronics*, Dec. 1943, Vol. 16, No. 12, p. 338.)

1614. Wire Recorders for Army [including a Portable Model].—General Electric. (*Electronics*, Oct. 1943, Vol. 16, No. 10, pp. 234 and 236.) *See* also Camras, 1228 of April.

1615. An All-Electronic Sound Reproducer [to replace "Clumsy & Antiquated Mechanical Methods": Letter prompted by 478 of February: a Spiral-Scanning Scheme].—B. Seamon: Parry. (*Electronics*, Nov. 1943, Vol. 16, No. 11, p. 348.)

1616. Electronic Megaphones ["Loud-Hailers" for the Navy: General Specifications: the Megaphone & Amplifier Units: Post-War Possibilities].—(*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 125–127.) For an earlier type *see* de Boer, 1052 of 1940.

1617. Lip Microphone for Gunfire-Noise Cancellation.—Electro-Voice Mfg. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 152 and 154.) *See* also 1222 of April.

1618. Automatic Frequency Control for Mechanical Vibrators [Sound Generators].—E. V. Potter. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 194..198). *See* 3450 of 1943.

1619. Human Susceptibility to Vibration.—F. Postlethwaite. (*Engineering*, 28th Jan. 1944, Vol. 157, No. 4072, pp. 61–63.)

1620. The Subjective Measurement of the Quality of Telephone Circuits: III.—H. Panzerbieter & A. Rechten. (*Bull. Assoc. Suisse des Élec.*, 29th Dec. 1943, Vol. 34, No. 26, pp. 805–808: in French.) For previous parts *see* 1706 (and 1442) of 1943. The present instalment is from *Arch. f. Tech. Messen*, Dec. 1942.

1621. Automatic Frequency-Response Recorder [for Use with General Radio's Audio Beat-Frequency Oscillator, by Unskilled Personnel].—Sound Apparatus. (*Electronics*, Dec. 1943, Vol. 16, No. 12, p. 312.)

1622. Direct-Reading Frequency Meter [as "Wow" Meter, Speed Counter, etc.].—North American Philips. (*See* 1648.)

1623. Phase-Shift Oscillator Design Charts [and the Advantages of the Single-Valve Phase-Shift Oscillator].—Kunde. (*See* 1524.)

1624. Mixer and Fader Control Circuit Design: a Thorough Analysis, with Tables to facilitate Application and Design.—P. B. Wright. (*Communications*, Nov. 1943, Vol. 23, No. 11, pp. 44..56 and 76: to be concluded.)

1625. Wartime Master Control Console [for a Six-Studio Plant, feeding Standard Broadcasting Station, a F.M. Station, Recording Room, & Other Stations].—A. J. Ebel & K. Guge. (*Communications*, Sept. 1943, Vol. 23, No. 9, pp. 42–44.)

PHOTOTELEGRAPHY AND TELEVISION

1626 Post-War Television [Paper at S.M.P.E. Conference, Hollywood].—K. Landsberg. (*Communications*, Oct. 1943, Vol. 23, No. 10, pp. 48 and 104.) By the Director of Television, W6XYZ, Television Products, Inc. (subsidiary of Paramount Pictures, Inc.). Also in *Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 258..262.

1627. Post-War Frequency Modulation and Television [including the Replacement Market as a means of providing Stop-Gap Production].—B. Dudley. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 94–97 and 190, 191.)

1628. Objectives for Post-War Television.—W. Miner. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 100–103.)

From the manager of the Television Department, C.B.S. "Television, under present standards, is not good enough. It can be good enough (and very quickly) if we do not wantonly dissipate, but use intelligently, the advantages the present hiatus affords us . . ."

1629. The Silver-Sulphide Photocell with a Barrier Layer.—D. S. Geykhman & M. E. Soroka. (*Automatics & Telemechanics* [in Russian], No. 3, 1941, pp. 49–56.)

Photocells of high integral sensitivity and with sensitivity to infra-red rays are of considerable importance in many branches of industry. Silver sulphide deserves attention in this respect, and accordingly in 1937, in one of the Laboratories of the Academy of Sciences of the Ukranian Soviet Socialist Republic, methods were evolved for producing silver-sulphide photocells with a barrier layer. A report on this was published by Geykhman in the Physics Records of the Academy (Vol. VII, No. 1, 1938, and Vol. VII, No. 3, 1939). In the present paper the properties of the cell are discussed, with a number of experimental curves, under the following headings: sensitivity; volt/ampere characteristic; the effect of light intensity on the photocurrent and photo-e.m.f.; spectral sensitivity; the effect of temperature; stability; efficiency. Various possible applications of the cell are also indicated.

1630. Fluctuations due to Thermoelectric Emission from the Photoelectric Layer in a Modulated-Light Amplifier.—A. Blanc-Lapierre. (*Comptes Rendus* [Paris], Vol. 216, 1943, p. 42 onwards.)

MEASUREMENTS AND STANDARDS

1631. Natural Limit of measuring Radiation with a Bolometer.—J. W. M. Milatz & H. A. van der Velden. (*Physica*, Vol. 10, 1943, p. 369 onwards.) A twelve-page paper, in English.

1632. Arrangement for the Measurement of Voltage, Frequency, and Power on Short Waves [by the Heat generated in a Dielectric and measured by a Thermocouple].—F. W. Gundlach. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 30, Fig. 14.)

1633. A Method of measuring Very Small and Very Large Impedances in the Decimetric- and Centimetric-Wave Region.—A. Weissfloch. (*E.T.Z.*, Vol. 64, 1943, p. 377 onwards.) This is the paper referred to in 3465 of 1943.

1634. Method of measuring Small Voltages in the Decimetric- and Centimetric-Wave Region [using a Lecher-Wire System & an Auxiliary Signal-Generator, combined with an Uncalibrated Voltmeter].—R. Seiler. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 30, Fig. 15.) D.R.P. 730 298.

1635. Resistance Measurement on Decimetric Waves.—L. Brück. (*Telefunken-Röhre*, No. 27/28, 1943, p. 60 onwards.) A paper of 26 pages.

1636. The Measurement of the Dielectric Constants of Materials in Plate Form by means of Cavity Resonators [Wave-Guides] in the Centimetric-Wave Region.—E. Ledinegg. (*Naturwiss.*, 19th Nov. 1943, Vol. 31, No. 47/48, pp. 569–570.)

When Borgnis (3435 of 1941 & 3644 of 1942) used a cavity-resonator method for measuring dielectric constants and loss angles, his test specimens took the form of cylinders introduced axially into a cylindrical resonator: the theory of the axial double layer, given in his later paper (2306 of 1942), provided the necessary formulae for obtaining the required values from the change in resonance frequency. "Now it is of practical as well as theoretical interest to calculate the natural frequency and the field distribution of a *horizontal* dielectric stratification of a circular-sectioned cylindrical cavity resonator" [assumed to be arranged with its axis *vertical*], so as to furnish a precise method of measuring dielectric constant and loss angle of disc-shaped specimens. In this way the dielectric constant could be determined not only by measuring the difference in tuning between the empty resonator and the resonator with the specimen introduced, but also (as with a Lecher-wire system) by keeping the frequency unaltered and observing the change in length of the cylinder. In calculating the loss angle it would be necessary to allow for the inhomogeneity of the field.

The writer obtains eqn. 5 for the case of a cylindrical resonator filled to a height h with a homogeneous dielectric ϵ: he refers to Lamont's papers (3281 & 4373 of 1940) for the treatment of a similar problem by the superposition of "right- and left-running waves". When $\epsilon = \epsilon_0$ or $h = 0$ or l (the length of the cylindrical resonator), eqn. 5 becomes the known equation for the axially symmetrical natural oscillations of the homogeneous cylinder. A full discussion of eqn. 5, and the development of simple approximate formulae for small thicknesses of plate, will be given elsewhere.

1637. The Dielecometer: a Versatile Instrument for Dielectric Constant Determination, and Some of Its Applications.—Jupe: Simons. (*See* 1807.)

1638. The Rupturing Strength of Insulated Wire as a Statistical Problem [Frequent Inconsistencies in Results with the DIN VDE 6450 Standard Test & with the "Twisting-Together" Test: Satisfactory Comparative Results (for Different Enamels, Influence of Moisture, etc.) require Increase of Number of Tests to at least 50–60 & 20 respectively].—E. Greulich. (*Arch. f. Elektrot.*, 31st May 1943, Vol. 37, No. 5, pp. 221–240.)

1639. Method of Measuring the Phase Displacement of High Frequencies variable in Frequency.—Böttcher. (*See* 1528.)

1640. Procedure for the Measurement of Small Coupling Factors [down to less than 1‰].—H. Heckmann. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 30.)

A Löwe Radio patent (*cf.* 1765, below), D.R.P. 730 133, applied for 16/1/40. Each inductance is first separately made into an oscillatory circuit by the addition of a condenser, and tuned to the test frequency, which is so chosen that the inductive reactance is of the order of 10^2–10^4 ohms. Then the natural damping d_1 of the first circuit, with the second circuit open, is measured, and also that of the second circuit, d_2: finally the damping d_1' of the first circuit, with the second circuit closed, is measured, the e.m.f. taken from the signal generator being kept unchanged throughout. The required coupling factor is given by $k = \sqrt{d_2(d_1' - d_1)}$.

1641. Impulse Generator for testing High-Power Tubes [primarily for Rapid Determination of Optimum Anode Voltages for Modern Valves].—Harries. (*See* 1587.)

1642. Modifications of Appleton's Method of Measuring the Mutual Conductance of a Valve.—Bates & Lovering. (*See* 1588.)

1643. An Impedance Meter on the Differential Substitution Principle.—A. Klemt. (*Funktech. Montashefte*, No. 2/3, 1943, p. 36 onwards.) For another paper by the same writer *see* 3086 of 1943.

1644. Coil and Condenser Measurements at Audio Frequencies without Commercial Instruments specifically designed for the Measurement.—I. G. Easton. (*Communications*, Sept. 1943, Vol. 23, No. 9, pp. 21–27 and 99..101.) From the General Radio Company. With descriptions of various bridge circuits—Schering, Series-Resistance, Hay, Owen, Sinclair, and their various advantages.

1645. An Alignment Chart for finding the True Inductance of a Coil with Distributed Capacity.—R. C. Paine. (*Communications*, Sept. 1943, Vol. 23, No. 9, pp. 60–61 and 104.)

1646. Type MW-60 Resonance Meter [for Frequencies 130–600 Mc/s: for Installation & Maintenance of Absolute Altimeters, etc: with Provision for Optimum Impedance Matching, etc.].—Erco Radio. (*Electronics*, Nov. 1943, Vol. 16, No. 11, p. 296.)

1647. Direct Reading of the Frequency of Resonant Circuits [with Special Reference to the Writer's 0.01% Wavemeter–Oscillator & Its Scale (100 kc/s to 15 Mc/s): the Design of a Condenser with the Required Linear Law of Frequency & Required Range of Capacitance: the Complications due to Edge Capacitance, to the Association with a Plurality of Range Coils, to Plate Wobble, to Condenser Self-Inductance, etc: the True "Series-Gap" Condenser and the Difference between It & the Erroneously Termed "Series-Gap" Condenser with Two Variable-Condenser Units in Series: etc.].—W. H. F. Griffiths. (*Wireless Engineer*, Nov. & Dec. 1943, Vol. 20, Nos. 242 & 243, pp. 524–538 & 595–603.)

1648. Direct-Reading Frequency Meter [Accurate within 2% from 0 to 50 000 c/s, driving a Recorder without Auxiliary Amplifiers: as Laboratory Instrument, "Wow" Meter, F.M. Indicator, Speed Counter for Centrifuge, etc.].—North American Philips. (*Electronics*, Oct. 1943, Vol. 16, No. 10, pp. 280 and 282.)

1649. Temperature Coefficients of Quartz Crystals [Charts for determining the T.C. of Frequency when Nominal Operating Frequency & Frequency-Change for a Given Temperature are known].—N. L. Chalfin. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 147 and 148.) From Crystal Research Laboratories, Inc.

1650. Quartz Wafers and Optical Glass Etching Fluid ["Quartz Etch": effective for Finishing Quartz Crystals to Required Frequency: No Appreciable Fumes].—G. W. Gates & Company. (*Electronics*, Oct. 1943, Vol. 16, No. 10, p. 292.)

1651. Topography of a Quartz Crystal Face [by Multiple-Beam Interference Method].—Tolansky. (*See* 1827.)

1652. Inspection, Grading, and Classification of Quartz: a Study of Some Procedures in Current Use in Crystal Manufacture: Orientation of *BT*-Cut Crystals.—S. X. Shore. (*Communications*, Oct. 1943, Vol. 23, No. 10, pp. 28–32 and 110, 111: Nov. 1943, No. 11, pp. 30..37 and 115, 117.) From the North American Philips Company.

1653. Quartz Crystals: Types, Modes of Vibration, Methods of Manufacture.—M. A. A. Druesne. (*Communications*, Sept. 1943, Vol. 23, No. 9, pp. 46..50 and 109, 111.) From the James Knights Company.

1654. Mass Production of Quartz Crystals.—(*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 254 and 256.)

1655. Line Voltage in Middle West and South [Important Factor of Line-Voltage Stability too often Overlooked in Design of Electrically Operated Devices: Extreme Importance for Electronic Apparatus required to perform "Miracles of Precision": Startling Results of Recent Survey: Danger of Relying on Short-Time or Periodic Readings: etc.].—C. H. Humes. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 204..210.)

1656. Care and Maintenance of Test Equipment [Cleaning, Lubrication, etc.].—H. H. Dawes. (*Communications*, Nov. 1943, Vol. 23, No. 11, pp. 97..100.) By the Service Manager, General Radio Company.

1657. Shock Tester for Meters [Bouncing Apparatus for Meters destined for Aircraft, Tanks, etc.].—Radio Frequency Laboratories. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 184..188.)

1658. Vibrating Machines [for Vibration Testing of Radio Apparatus, etc.].—(*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 302–303.)

1659. Symbols for Meter Dials [and the Desirability of a Similar System for American Manufacturers].—(*Electronics*, Nov. 1943, Vol. 16, No. 11, p. 192.) *See* Edgcumbe, 542 of February.

1660. "Elektrische Messgeräte: Genauigkeit und Einflussgrössen" [Book Review].—R. Langbein & G. Werkmeister. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 32.) An enthusiastic review was referred to in 2788 of 1943. Here Zenneck is equally full of praise for this, the second volume in Sewig's series "Technisch-physikalische Monographieen."

1661. Temperature Compensator 30 Alloy [Applications in Stabilising Magnetic Fields, etc.].—Carpenter Steel. (*See* 1699.)

1662. *B/H* Curve Tracer for Lamination Samples [for Rapid Checking of Small Samples (for A.F. Transformers or Chokes): Special 4-Valve Amplifier, Test Jig, & C. R. Oscilloscope].—R. Adler. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 128–131 and 314..317.)

1663. Magnetic Meters [Three Types of Magnetometer, for Aircraft Tests, etc.].—Waugh Laboratories. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 298 and 300.)

1664. A High-Sensitivity Magnetic Null-Current Amplifier for Measuring & Control Technique.—W. Geyger. (*Wiss. Veröff. a. d. Siemens-Werken*, Vol. 21, 1943, p. 47 onwards.) An eleven-page paper: for previous work *see* 123 & 1472 of 1943.

1665. Technique for Measurement with the Resistance Thermometer in a Wheatstone Bridge [for Very Exact Measurements of Small Temperature Changes (Freezing- or Boiling-Point Changes, etc.): Improved Results with the Three Bridge Resistances permanently in Thermostat, and Balance obtained by a Shunt Resistance across One of Them].—H. Diesselhorst & J. Lange. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 24, 1943, pp. 162–166.)

1666. Teletypewriter Test Sets.—W. Y. Lang. (*Nature*, 5th Feb. 1944, Vol. 153, No. 3875, p. 161: summary of a paper in *Bell Lab. Record*, Aug. 1943.) For a pulse-distortion measuring set *see* Rea, 1274 of April.

SUBSIDIARY APPARATUS AND MATERIALS

1667. Effect of Space Charge on Electron Beams [treated by a Hydrodynamical Method].—Aharoni. (*See* 1586.)

1668. The Strict Calculation of the Electron-Optical Aberration Curves of a Typical Magnetic Field [closely representing That used in the Objective of the Ruska–von Borries Supermicroscope: Rigorous Calculation, for the First Time, of Third-Order Aberrations for the Field $H = H_0/\{1 + (z/a)^2\}$].—Glaser & Lammel. (*Arch. f. Elektrot.*, 31st July 1943, Vol. 37, No. 7, pp. 347–356.) *Cf.* Marton & Hutter, 1296 of April.

1669. A Compact High-Resolving-Power Electron Microscope [Selection of the Most Useful Magnification, from Experience with the Conventional Type B Microscope: the Desirability of Two Values: Choice of Between 500 & 600 and 6000 (Bright Image at 100 000 with 20 × Eye Lens): Small Rigid Unit tilted at 20° to Horizontal].—Zworykin & Hillier. (*Journ. Applied Phys.*, Dec. 1943, Vol. 14, No. 12, pp. 658–673.) *See* also 2473/4 of 1943, and for Mahl & Pendzich's small "reflecting" microscope *see* 3116 of 1943.

1670. Magnification-Calibration of the Electron Microscope [to Compensate for Calibration Errors caused by Mechanical & Electrical Variations of the Instrument: Method using Microscopic Glass Spheres of Predetermined Size: also useful for checking Image Distortion at Different Points of the Field, and for making Approximate Calibration Curve for All Instrument-Settings & Specimen-Planes, etc.].—Fullam. (*Journ. Applied. Phys.*, Dec. 1943, Vol. 14, No. 12, pp. 677–683.)

1671. First Official Meeting of the Electron Microscope Society of America.—(*Sci. News Letter*, 22nd Jan. 1944, Vol. 45, No. 4, p. 62: paragraph only.)

1672. Variable B-Voltage Supply for Laboratory or Classroom [Variable High-Voltage Circuit using Low-Plate-Resistance Valve as Variable Resistor, controlled by Grid Bias: used in Naval Training School].—Brolly & Lahey. (*Electronics*, Oct. 1943, Vol. 16, No. 10, pp. 156..164.)

1673. The Phase-Control Circuit [for Thyratrons & Other Gas-Filled Tubes: Analysis of Basic Circuit].—Goldwasser. (*Communications*, Nov. 1943, Vol. 23, No. 11, pp. 78–79.)

1674. Grid Control of the Thyratron.—Bednařik. (*See* 1595.)

1675. Characteristics of the Positive Column of Gaseous Discharge [and a Comparison between Theoretical & Experimental Results].—Klarfeld. (*Journ. of Phys.* [of USSR), No. 2/3, Vol. 5, 1941, pp. 155–175: in English.)

1676. The Electric Spark Discharge in Different Gases [Survey].—Allibone & Meek. (*Journ. of Scient. Instr.*, Feb. 1944, Vol. 21, No. 2, pp. 21–27.) (1) Breakdown of the nearly uniform field (constant and l.f. voltage breakdown, impulse voltage breakdown): (2) breakdown of the diverging field (including surface flash-over).

1677. The Systematic Treatment of Arc Types [Six Equations for Every Gaseous-Discharge Plasma: Discussion of Boundary Condition leads to Three Types of Arc (Wall-Stabilised, Electrode-Stabilised & Convection-Governed Arcs): Transitional Forms: Example of Transition (at Critical Electrode Gap) of Second to Third (Flaming Arc) Type].—Weizel. (*Zeitschr. f. tech. Phys.*, No. 4, Vol. 24, 1943, pp. 90–92.)

1678. The High-Frequency Breakdown of Compressed Gases [Air, Nitrogen, & "Frigen" ("Freon") at Pressures up to 40 Atmospheres: Comparison of Results for 105–125 & 345 kc/s with Those for D.C. & 50 c/s, for Various Electrode Forms].—Gänger. (*Arch. f. Elektrot.*, 30th June 1943, Vol. 37, No. 6, pp. 267–286.) Further development of the work dealt with in 1196 & 1783 of 1941.

1679. The Rupturing Strength of Insulated Wire as a Statistical Problem.—Greulich. (*See* 1638.)

1680. Coaxial Cable Expansion [with Temperature].—Andrew. (*See* 1577.)

1681. Thermoplastic Cables [with Particular Reference to P.V.C. (Polyvinyl Chloride) Cables: Summary of Paper & Discussion].—Barron & others. (*Electrician*, 18th Feb. 1944, Vol. 132, No. 3429, pp. 145–147.)

1682. High-Altitude Oil Capacitors [with One Terminal in form of Tall Insulator Post with Corona Shield].—Aerovox. (*Communications*, Nov. 1943, Vol. 23, No. 11, p. 84.)

1683. Automatic Forming of Electrolytic Capacitors [Circuit automatically Increasing the Applied Voltage as Current Decreases: Aging Process carried out in Shortest Possible Time].—Fishberg. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 186 and 188.)

1684. Modern Insulating Materials for High-Frequency Technique [Address to "H.F." Meeting of the S.E.V: Long Survey, with Tables, Curves, & Diagrams: Inorganic (Crystalline; Amorphous; Mixed) & Organic (Liquid; Solid, including Polymerisates & Polycondensates): the Problem as a Whole].—Stäger. (*Bull. Assoc. Suisse des Élec.*, 29th Dec. 1943, Vol. 34, No. 26, pp. 783–802: in German.) *See* also 1685 & 1686, below, and for an earlier paper *see* 3374 of 1942.

1685. Paper on Investigations into the Dielectric Properties of Various Types of Glass.—Strutt & van der Ziel. (*Physica*, Vol. 10, 1943, p. 445 onwards.) Referred to by Stäger, 1684, above.

1686. Paper on the Stereochemical Structure of Mica, Chrystobalite, Quartz, etc.—Niggli. (*Vierteljahresschrift der Naturforschenden Ges. Zürich*, Vol. 88, 1943, p. 5 onwards.) Diagrams are reproduced and discussed in Stäger's paper, 1684, above.

1687. Machining Standards for Glass-Bonded Mica.—(*Electronics*, Oct. 1943, Vol. 16, No. 10, pp. 252 and 254.)

1688. War Production Board acts on Mica Conservation.—W. P. B. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 250 and 252.) *See* also p. 254, and *Elec. Engineering*, Dec. 1943, p. 559.

1689. "Striatube" Plastic Tubing for Electrical Insulation [with Colour Stripes, for Easy Identification, extruded into Body of Tubing].—Carter Products. (*Electronics*, Nov. 1843, Vol. 16, No. 11, p. 292.)

1690. "Emeloid", an Alloy Plastic [and Its Properties].—(*Electronics*, Nov. 1943, Vol. 16, No. 11, p. 294.) "With characteristics similar to those brought about in steels which have been treated with different alloys".

1691. Synthetic Shellac available for Civilian Use after the War.—(*Sci. News Letter*, 22nd Jan. 1944, Vol. 45, No. 4, p. 64: paragraph only.) "One of its important constituents is the corn by-product known as zein".

1692. Plating on Plastics [Method now Ready for Wide Use].—Metaplast Corporation. (*Electronics*, Dec. 1943, Vol. 16, No. 12, p. 298.) *Cf.* 1268 of 1943.

1693. Stellite Alloy for Small Mechanisms [Tungsten–Chromium–Cobalt Alloy, for Pivots, Gramophone Needles, etc: Stainless, Low Friction-Coefficient].—(*Communications*, Nov. 1943, Vol. 23, No. 11, pp. 84 and 104.)

1694. On the Calculation of the Current Harmonics in Coils with Saturated Iron Cores.—Hartel. (*See* 1517.)

1695. *B/H* Curve Tracer for Lamination Samples [for Rapid Checking of Small Samples].—Adler. (*See* 1662.)

1696. High-Quality Coils with Cores of Dynamo Sheet Iron Type IV.—Wilde. (*See* 1513.)

1697. The Calculation of the Magnetic Field Strength near Transformer Windings.—Knaack. (*See* 1515.)

1698. Potential Distribution in Transformer Windings on the Arrival of a Surge, with Special Attention to the Second [Passive] Winding.—Knaack. (*Arch. f. Elektrot.*, 31st Aug. 1943, Vol. 37, No. 8, pp. 391–412.)

1699. Temperature Compensator 30 Alloy [Iron–Nickel Alloy with Curie Point near Room Temperature: Applications in Stabilising Magnetic Fields, etc.].—Carpenter Steel. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 232 and 234.) *Cf.* Ackermann, 3556 of 1943.

1700. Permanent-Magnet Design [Required Characteristics often obtainable in First Trial Design by Use of Empirical Data based on Practical Experience & Fundamental Equations: Graphs, Nomograms, etc.].—Underhill. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 126–131 and 316..321.) From the Chief Engineer, Cinaudagraph Corporation.

1701. War Solder Technique [Hints issued by Metallurgy Committee].—General Electric. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 152 and 154.)

STATIONS, DESIGN AND OPERATION

1702. Post-War Frequency Modulation and Television [including the Replacement Market as a means of providing Stop-Gap Production].—Dudley. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 94–97 and 190, 191.)

1703. New Data on Captured German Radio Sets [including Transceiver with Luminous Quartz Calibrating Device].—(*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 242..250.) *Cf.* 1301, 1771, & 2861 of 1943 and 611 of February.

1704. Aircraft Radio Design [Insulation, Vibration, Sense-of-Touch Controls, etc.].—Trumbull. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 98–101 and 220, 222.)

1705. Two-Way Lifeboat Radio: Receiver–Transmitter powered by Hand-Driven Generator affords Telephony or Modulated-Telegraphy Transmission.—Byrnes. (*Communications*, Sept. 1943, Vol. 23, No. 9, pp. 17–20 and 94, 95.) From the Radiomarine Corporation of America.

1706. Women as WERS Operators: How Erie, Pa., solved its WERS Man-Power Problem.—Jordon. (*QST*, Dec. 1943, Vol. 27, No. 12, pp. 40–41.)

1707. "Fernschreibtechnik" [Teletype Technique (by Wire & Wireless): Book Review].—Schiweck. (*Hochf:tech. u. Elek:akus.*, July 1943, Vol. 62, No. 1, p. 32.) Zenneck's review concludes: "The inventions embodied in the apparatus and circuits of teletype technique contain a large number of original ideas which are of value also in other fields".

1708. Short-Wave Marine Unit: "Plug-In" Equipment for Ships [the "H.F. Marine Unit," 3178 of 1943].—(*Wireless World*, Jan. 1944, Vol. 50, No. 1, p. 19.)

1709. Automatic Control Circuits for Broadcast Transmitters ["Four Man-Power-Saving Electronic Circuits," providing Protection against Arcs during Storms, Automatic Restoration of Carrier after an Overload, Automatic Starting after Breakdown, & Automatic Timing of Interruptions].—Sloat. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 102–105 and 274..278.)

1710. Wartime Master Control Console [for a Six-Studio Plant, feeding Standard Broadcasting Station, a F.M. Station, Recording Room, & Other Stations].—Ebel & Guge. (*Communications*, Sept. 1943, Vol. 23, No. 9, pp. 42–44.)

1711. Volume Compressor for Radio Stations ["Unique Audio Compressor Circuit that permits boosting the Average Percentage Modulation of a Short-Wave Transmitter up to 90%: Response is Flat to 14 000 c/s": primarily for O.W.I. Foreign-

Language Programmes, with Their "Sudden Volume Peaks"].—Herrick. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 135 and 323.)

1712. Calculation of the Capacitances required for the Balancing of the Reactive Load in Single- and Three-Phase Networks [often required at Wireless Transmitting Stations, where the Numerous Motors tend to spoil the Power Factor: with Formulae & Curves].—Heusser. (*T.F.T.*, May 1943, Vol. 32, No. 5, pp. 116–117.)

GENERAL PHYSICAL ARTICLES

1713. Thermal Diffusion in Mixtures of Molecules of Small Mass Difference.—Grew. (*See* 1493.)

1714. A Note on the Oscillating Rotator [Problem solved by Use of Sonine's Polynomials].—Basu. (*Indian Journ. of Phys.*, Aug. 1943, Vol. 17, Part 4, pp. 193–196.) This is the problem dealt with by Chakravarti for his calculation of the dissociation energy for diatomic molecules (N_2, etc.).

1715. Statistical Mechanics of Fields, and the "Apeiron."—Born & Peng. (*Nature*, 5th Feb. 1944, Vol. 153, No. 3875, pp. 164–165.)

"In view of the difficulties encountered in the quantum theory of fields, we have developed a new approach to this subject which bears a much closer resemblance to ordinary quantum mechanics of particles than the existing theories (Heisenberg and Pauli). . . . The case of the electronic field can be treated in such a way that the contribution to the energy of each electron and positron is positive. . . . Investigations on the application of this theory to the elementary particles, their masses and their mutual collision cross-sections are in progress." The word "apeiron" was introduced by Anaximander for the boundless and structureless primordial matter.

1716. An Unambiguous Method of Avoiding Divergence Difficulties in Quantum Theory.—Stueckelberg. (*Nature*, 29th Jan. 1944, Vol. 153, No. 3874, pp. 143–144.)

1717. The So-Called Plücker's Plane [Falsity of Usual Explanation as Effect of Magnetic Field on Supposedly Paramagnetic "Ions": Wholly Explained by Ordinary Magnetic Deflection of Slow Cathode Rays].—Parson. (*Nature*, 22nd Jan. 1944, Vol. 153, No. 3873, p. 112.)

1718. "Magnetic" Current [Repetition of Ehrenhaft's Experiments, as reported in Daily Press (937 of March), to look for More Probable Interpretations of His Results: Demonstration of Motional Effects due to Action of Strong, Non-Uniform Magnetic Field on Non-Uniform Concentration of Paramagnetic Ferrous Ions: etc.].—Kendall: Ehrenhaft. (*Nature*, 5th Feb. 1944, Vol. 153, No. 3875, pp. 157–158.) Incidentally, this result "may possibly form the basis of a method for separating the rare earth elements. . ." by "magnetic diffusion," parallel to the separation of gaseous isotopes by thermal diffusion. For a letter from Trubridge, suggesting a "magnetic-current" motor, see *Electrician*, 18th Feb. 1944, p. 150.

1719. Units and Dimensions [Critical Survey of the Recent Discussion in *Phil. Mag.* and *Proc. Phys. Soc.*].—Jeffreys. (*Phil. Mag.*, Dec. 1943, Vol. 34, No. 239, pp. 837–842.) *Cf.* 1308 of 1943.

1720. Theory of Units [Appendix 2 to 1307 of 1943, to correct Error and to give Better Account of the Giorgi System].—Bedford. (*Journ. British I.R.E.*, Sept./Oct. 1943, Vol. 3, No. 6, pp. 250–251.)

MISCELLANEOUS

1721. Note on Tables of an Integral [quoting Books by Spence and Newman, and confirming Accuracy of Powell's Table (621 of February): a Forthcoming "Index of Mathematical Tables"].—Fletcher: Powell. (*Phil. Mag.*, Jan. 1944, Vol. 35, No. 240, pp. 16–17.) A letter prompted by Powell's paper on the integral $\int^{x} [\log \xi \, d\xi/(\xi - 1)]$.

1722. The New Algebras and Their Significance for Physics and Philosophy [Presidential Address, Royal Society of Edinburgh: Hamilton's Quaternions, Boole's "Investigation of the Laws of Thought," Peirce's Work: Heaviside and Willard Gibbs: the New Importance of Quaternions].—Whittaker. (*Phil. Mag.*, Jan. 1944, Vol. 35, No. 240, pp. 1–15.) *See* also Piaggio, "Significance and Development of Hamilton's Quaternions," *Nature*, 13th Nov. 1943, pp. 553–555.

1723. Invariant Theory, Tensors and Group Characters [and a New Method involving "New Multiplication of *S*-Functions"].—Littlewood. (*Phil. Trans. of Roy. Soc.*, Series A, 4th Feb. 1944, Vol. 239, No. 807, pp. 305–365.)

1724. Erratum: The Approximate Mathematical Methods of Applied Physics as exemplified by Application to Saint-Venant's Torsion Problem [954 of March].—Higgins. (*Journ. Applied Phys.*, Dec. 1943, Vol. 14, No. 12, p. 705.) A wrong periodical was referred to.

1725. The Complex Variable and the Communications Engineer [Application to the Solution of Two-Dimensional Field Problems].—Frankel. (*Communications*, Sept. 1943, Vol. 23, No. 7, pp. 62..70 and 98, 106..109: Oct. 1943, No. 8, pp. 50..60 and 116.)

1726. Quantized Probability [Suggested Theory of Finite Unit of Probability ("Chance-Quantum")].—Goldsmith. (*Phys. Review*, 1st/15th Dec. 1943, Vol. 64, No. 11/12, pp. 376–377.)

"Thus if the probability of an event is equal to or greater than one cq., it may ultimately occur. If its probability is less than one cq., it will never occur. The latter statement constitutes a break with classic probability theory. . . ."

1727. Rate of *n*-fold Accidental Coincidences [with Application to Geiger–Müller Counters: Derivation of Correct Formula].—Jánossy. (*Nature*, 5th Feb. 1944, Vol. 153, No. 3875, p. 165.)

1728. Efficient Computation of the Latent Vectors of a Matrix [in Statistics, Quantum Mechanics, & Study of Dynamical Oscillations, for Cases where Iteration & Perturbation-Variation Methods are Tedious: Direct Algebraic Process giving Latent Vectors & Roots after Multiplications increasing with only Third Power of *n*].—Samuelson. (*Proc. Nat. Acad. Sci.*, Dec. 1943, Vol. 29, No. 11, pp. 393–397.)

1729. A Simple Method of Interpolation [in Statistics: Simplification by Methods analogous to Those used in solving Differential Equations: Resulting Procedure admirably suited to Numerical Computation: Comparison with Aitken's Method].—Samuelson. (*Proc. Nat. Acad. Sci.*, Dec. 1943, Vol. 29, No. 11, pp. 397–401.)

1730. Discussion of Paper on a Method of Interpolation [2875 of 1943].—Fry. (*ASTM Bulletin*, Dec. 1943, No. 125, pp. 23–24.)

1731. A New Form of Representation of Harmonic Analysis and a New Mechanical Curve-Analyser.—Grützmacher. (*Akust. Zeitschr.*, Vol. 8, 1943, p. 49 onwards.) For remarks on this paper, by W. Kallenbach, *see* pp. 63–65 of the same volume.

1732. "Treatment of Experimental Data" [Book Review].—Worthing & Geffner. (*ASTM Bulletin*, Dec. 1943, No. 125, p. 43.) "This book is in part a consequence of a long series of irritations . . . tables of unsmoothed values . . . blind faith in a least-squares computation regardless of the assumptions and limitations. . . ."

1733. "A First Guide to Quality Control for Engineers" [Book Review].—Ministry of Supply. (*BEAMA Journal*, Jan. 1944, Vol. 51, No. 79, p. 17.)

1734. "Mathematics Essential to Electricity and Radio" [Book Review].—Cooke & Orleans. (*Electronics*, Dec. 1943, Vol. 16, No. 12, p. 336.)

1735. "Mathematician's Delight" [Book Notice].—Sawyer. (*Journ. of Scient. Instr.*, Feb. 1944, Vol. 21, No. 2, p. 35.) ". . . to dispel the fear of mathematics." *Cf.* Courant & Robbins, 964 of March.

1736. Science Book in Braille for the Blind.—Westinghouse. (*Electronics*, Oct. 1943, Vol. 16, No. 10, pp. 236 and 238.)

1737. "Electricity and Radio Transmission" [Book Review].—Townsend. (*BEAMA Journal*, Jan. 1944, Vol. 51, No. 79, p. 17.) "Written with a refreshing simplicity."

1738. "Radio-Technology" [Book Review].—Weller. (*Nature*, 12th Feb. 1944, Vol. 153, No. 3876, p. 180.)

1739. "Foundations of Wireless" [Completely Revised 4th Edition: Book Notice].—Scroggie. (*Wireless World*, Feb. 1944, Vol. 50, No. 2, p. 61.)

1740. "Worked Radio Calculations" [Book Review].—Witts. (*Electronic Eng:g*, Nov. 1943, Vol. 16, No. 189, p. 262.) *See* also *Wireless World*, Jan. 1944, Vol. 50, No. 1, p. 20.

1741. "Reference Data for Radio Engineers [Notice & "Contents" Pages of Handbook].—Federal Telephone & Radio. (*Elec. Communication*, No. 3, Vol. 21, 1943, pp. 205–206.) Edited by H. T. Kohlhaas, Editor of that journal. *See* also *Electronics*, Dec. 1943, Vol. 16, No. 12, p. 333, for a very favourable review.

1742. "Experiments in Electronics and Communication Engineering" [suitable for Accelerated War-Training Programmes: Book Review].—Schulz & Anderson. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 334–335.)

1743. "Aircraft Electrical Engineering" [Book Review].—Spreadbury. (*Engineering*, 17th Dec. 1943, Vol. 156, No. 4066, p. 483.)

1744. "Trail Blazers to Radionics and Reference Guide to Ultra-High Frequencies" [Book Notice].—Kelsey. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 236 and 238.) Issued by Zenith Radio Corporation.

1745. Production Engineering at Ultra-High Frequencies [100–200 Mc/s: Some Problems & Possible Future Developments].—Meyerson. (*Communications*, Oct. 1943, Vol. 23, No. 10, pp. 17–19 and 108, 109.)

From the New York Fire Department's Radio Laboratory: *see* also 433 of February. "The logical termination of these efforts should be straight-line frequency calibration in terms of kilocycles. But we must not necessarily be tied down to frequency variation by the present accepted methods of capacity or inductance variation. For example, while not efficient, variation of the dielectric constant in condensers might offer possibilities as a tuning method . . . Some simplified form of band change . . . working in conjunction with a calibrated dial movement, the band change to indicate the frequency in megacycles and the dial in kilocycles. . . Remove that bugaboo of band-switching contact resistance—the band-switch point could become . . . a capacitive coupler between circuit elements and the tube . . . A capacitor of 100 $\mu\mu F$ has a reactance at u.h.f. of only a few ohms, and by constructing it as an elongated cylindrical form may be used to couple circuits which, by lay-out, would require several inches of wiring. . . . Some thought may produce new ideas on *aperiodic* antenna construction [to avoid the difficulties due to the sharp aerial tolerances] . . . A method of fundamental u.h.f. frequency control without doubling or tripling is a necessity if broadcast selectivity is to be attained at u.h.f."

1746. Science Review for 1943 [Short Paragraphs on Discoveries & Inventions: including a New Zinc-Oxide–Vanadium-Pentoxide Phosphor (p. 391) and a Radiolocator using a Single Detector only (p. 393)].—Science Service Staff. (*Sci. News Letter*, 18th Dec. 1943, Vol. 44, No. 25, pp. 389–395.)

1747. The Rochester Fall Meeting, *and* A Report on the Rochester Fall Meeting [I.R.E.–R.M.A.: with Summaries].—(*Communications*, Oct. & Nov. 1943, Vol. 23, Nos. 10 & 11, pp. 26–27 and 84, 105, 106: pp. 20–27 and 114.) *See* also *Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 196 . . 212.

1748. "Wissenschaftliche Veröffentlichungen aus den Siemens-Werken" [Vol. 19, Nos. 1 to 3, and Vol. 20, Nos. 1 & 2: Survey of Contents].—Siemens Company. (*Naturwiss.*, 21st May 1943, Vol. 31, No. 21/22, pp. 252–254.) All the relevant papers have been dealt with in these Abstracts.

1749. Electrical Research: Work of the E.R.A. during 1943.—E.R.A. (*Electrician*, 4th Feb. 1944, Vol. 132, No. 3427, pp. 104–106: *Elec. Review*, 4th Feb. 1944, Vol. 134, No. 3454, pp. 161–162.)

1750. British Industrial Invention [and the Need for an Enquiry by Experienced Industrial Leaders to find how "Fifty Years of Leeway" may be made up].—Eccles. (*Sunday Times*, 5th March 1944,

p. 4.) Such an enquiry "would help industrial invention to its proper place as potentially one of our most valuable invisible exports."

1751. Regional Planning and Research in the United States [and a Recent Report on New England].—(*Nature*, 12th Feb. 1944, Vol. 153, No. 3876, p. 200.) *See* also L. W. Bass, *Elec. Engineering*, Nov. 1943, Vol. 62, pp. 496-497.

1752. R.T.P.B. holds First Meeting: Dr. Baker appointed Chairman [Radio Technical Planning Board (326 of January)].—I.R.E. & R.M.A. (*Communications*, Oct. 1943, Vol. 23, No. 10, pp. 102, 103.)

1753. Incentive to Invent [Criticism of Mittelman's View that Successful Modern Inventions have Not been prompted by Desire to Make Money].—de Forest: Safford. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 342, 343, 348.)

1754. Early Radio Inventions [Editorial on Hazeltine's Presentation Address to Edison Medallist, E. H. Armstrong (see also 1404 of April)].—G. W. O. H. (*Wireless Engineer*, Nov. 1943, Vol. 20, No. 242, pp. 521–523.)

1755. The Auer von Welsbach Prize Competition for 1943 [Subject: New Applications for Rare Earths, Thorium, Zirconium & Similar Elements].—Auer Research Foundation. (*Zeitschr. f. tech. Phys.*, No. 7, Vol. 24, 1943, pp. 166–167.) Open to "all Reichs-citizens in the sense of the Nuremberg racial laws".

1756. "Werkstoffsparen bei Tragkonstruktionen, Grundplatten und Rahmen im Maschinenbau und Feingerätebau" [Economy in Material, including in Precision-Apparatus Design: Book Review].—Mayr & Wögerbauer. (*E.N.T.*, Sept. 1943, Vol. 20, No. 9, p. 226.) No. 7 in the material-economy series edited by F. Wunderlich.

1757. Solving War-Time Shortages [at WGN].—Batt, (*Communications*, Oct. 1943, Vol. 23, No. 10, pp. 46 and 122.)

1758. Production Aids [War Production Drive Awards: Condenser Testing Jig, Valve Sealing, Filament Redesign, Salvaging Cracked Valves, Hydrogen for Cathode-Ray Tube Sealing, etc.].—(*Communications*, Oct. & Nov. 1943, Vol. 23, Nos. 10 & 11, pp. 74, 75, 106, & 74, 119.)

1759. WPB Reorganisation of Radio and Radar Division [so that Spheres of Activity of Production & Organisational Units are More Clearly Defined].—(*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 224..230.)

1760. Office of War Information reviews War Communications [Portions of Report dealing with Radio & Electronics].—O. W. I. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 242..260.)

1761. The Army Airways Communications System: an Analysis of Its Purpose, Operation, and Equipment employed.—Fawcett. (*Communications*, Nov. 1943, Vol. 23, No. 11, pp. 38–42.) *See* also October issue, No. 10, pp. 36, 37 (photographs).

1762. Anti-Nazi Communications [Messages from YTG (Mihailovich Forces, Jugoslavia) received at Hicksville].—Press Wireless, Inc. (*Electronics*, 1943, Vol. 16, No. 12, p. 278.)

1763. Memorandum VDE 0297/X.42 on the Laying of Communication Lines for Temporary Purposes in the Vicinity of Overhead Power Lines and Electric Railways [prepared by Collaboration between Post Office, War Department, etc.].—Machens. (*T.F.T.*, May 1943, Vol. 32, No. 5, p. 118: summary only.)

1764. New Data on Captured German Radio Sets.—(*See* 1703.)

1765. Opta Radio A.G. for Radio Apparatus, Television, Valves, etc. [formerly Löwe Radio A.G.].—Löwe Radio. (Advertisement in *E.N.T.*, Aug, 1943, Vol. 20, No. 8, Advt. p. 1.)

1766. Self-Checking Carrier Tone Alarm [correcting for Different Receiving Conditions and giving Alarm at Failure of Any Part].—Berg. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 174..178.)

1767. Electronic Plane Pilot [on American Heavy Bombers].—(*Electronics*, Nov. 1943, Vol. 16, No. 11, p. 154.) *See* also p. 232.

1768. Machine-Gun Trainer with Sound Effects.—(*Electronics*, Oct. 1943, Vol. 16, No. 10, p. 234.)

1769. Microphotography and Photomicrography, and other Terminological Inexactitudes [Need for Standardisation, not only for Tidiness' Sake but to avoid Real Confusion: including the "-scope, -graph, -gram" Convention].—Chilton. (*Journ. of Scient. Instr.*, Feb. 1944, Vol. 21, No. 2, p. 33.) *See* also 1770, below.

1770. Scientific Terminology [Lack of Precision, Hybrid Etymology, Ugliness & Unwieldiness of Many New Words: Need for Action by (preferably) Royal Society].—(*Nature*, 19th Feb. 1944, Vol. 153, No. 3877, p. 218.) Reflections prompted by Chilton's letter, 1769, above.

1771. Now is the Time to Standardise Symbols [of Component Parts in Power, Communications, & Electronic Control Fields: Editorial, with Invitation for Suggestions].—(*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 94–95.) *See* also 1035 of March.

1772. Simplifying Symbols: Proposals for a Simplified Universal Method of Drawing Radio Circuits and Symbols [" Previous Attempts at Standardisation still involved the Draughtsman in Unnecessary Work"].—Shannon. (*Electronic Eng:g*, Dec. 1943, Vol. 16, No. 190, pp. 290–292 and 294.)

1773. Specify the Units [in which Formulae are expressed: a Difficulty besetting the Student of Radio Literature].—Simmonds. (*Wireless World*, Feb. 1944, Vol. 50, No. 2, p. 60.)

1774. "Basic English and Its Uses," *and* "Basic for Science" [Book Reviews].—Richards: Ogden. (*Nature*, 19th Feb. 1944, Vol. 153, No. 3877, pp. 205–206.) "It is to be hoped that it may soon become the general practice for research abstracts to be written in Basic so that they may be more widely read all over the world . . ." (comment by reviewer, Maxwell Garnett).

1775. A Few Words on Russian Names [and a Plea for Adherence to the Library of Congress Rules (even if Imperfect) for the sake of Uniformity].—Asmous. (*Science*, 19th Nov. 1943, Vol. 98, No. 2551, p. 450.) Continuation of the correspondence referred to in 1031 of March. In one library the writer found the works of Zheleznov distributed under " G," " J," and " Z."

1776. An Idealist View of Special Publications [Review of a Paper entitled " Streamlining Production & Distribution of Current Periodical Articles," which points out the Drawbacks of Inter-Library Loans, Film & Photostat Copies, etc., and suggests a Scheme for " Minimising the Mechanics of Publication & Distribution "].—Troy. (*Nature*, 29th Jan. 1944, Vol. 153, No. 3874, p. 134.)

1777. A New Form of Microfilm Reader [at National Institute for Medical Research].—Schuster. (*Nature*, 5th Feb. 1944, Vol. 153, No. 3875, pp. 155–157.)

Points specially attended to include ease in reading (image thrown downwards on to opaque screen, rather than viewed as transparency) and automatic indexing, for immediate winding to near the correct point in a long film.

1778. Library Resources of Great Britain [Leading Article].—(*Nature*, 19th Feb. 1944, Vol. 153, No. 3877, pp. 203–205.)

1779. " Engineering and Scientific Graphs for Publications " [Book Review].—A.S.A. Subcommittee. (*Electronics*, Dec. 1943, Vol. 16, No. 12, p. 336.)

1780. Sensitometry of Drawing-Office Photo-Printing Processes.—Heywood. (*Engineering*, 14th Jan. 1944, Vol. 157, No. 4070, pp. 21–24.) " It is hoped that the above notes will help operators to set the printing machine correctly without preliminary trials, and thereby eliminate waste of paper and time."

1781. Training Draughtsmen with Slide-Films.—Metcalfe. (*Communications*, Oct. 1943, Vol. 23, No. 10, pp. 35 and 122.) For previous papers on slide-films *see* 1410 of April.

1782. Ink *versus* Pencil Tracings [Further Correspondence (1022 of March)].—(*Engineering*, 31st Dec. 1943, Vol. 156, No. 4068, p. 534.)

1783. Plexiglas Rules for Alignment Charts [also Use of " Plasticele " instead of Graph Paper].—Mast. (*See* 1548.)

1784. Electronic Circuit for High-Frequency Welding [using Two Two-Element Mercury-Pool Discharge Tubes, One as Rectifier, the Other as Spark Discharger: only One-Fifth to One-Tenth Usual Power required: Successful Welding of Silver/Steel, Magnesium/Cast-Iron, etc.].—Vang. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 168 and 170.)

1785. Electronic Control developed for Helium-Shielded Arc Welding, *and* Electronic Welding-Fume Remover [Precipitron Unit: 712 of February].—General Electric: Westinghouse. (*Electronics*, Oct. 1943, Vol. 16, No. 10, pp. 146 and 148: p. 148.)

1786. Arc-Welding [of Thin Aluminium & Alloy Steels, where Low Currents are necessary] Speeded by Use of High-Voltage " Trail Blazer ".—Westinghouse. (*Scient. American*, Dec. 1943, Vol. 169, No. 6, p. 274.)

1787. Found: the " Lost-Wax " Process [Application of Lost-Wax Centrifugal Process to Precision Casting of Small Metal Parts].—(*Scient. American*, Dec. 1943, Vol. 169, No. 6, pp. 259–261.)

1788. Phase-Controlled Rectifiers: an Analysis of their Behaviour [primarily in connection with the Use of the Phase-Controlled Thyratron as the Only Completely Satisfactory Organ for the Lag-Free Automatic Control of Certain R.F. Heating Processes (*e.g.* Production of Tinned Steel Strip)].—Murcek. (*Communications*, Oct. 1943, Vol. 23, No. 10, pp. 62..68 and 120..122.) Also applicable, for instance, to voltage-regulated plate-supply rectifiers in transmitters.

1789. Industrial Applications of Radio-Frequency Methods of Heating [Opening Paper at Informal Meeting of I.E.E.].—Bligh. (*Elec. Review*, 4th Feb. 1944, Vol. 134, No. 3454, p. 163: *Electrician*, 4th Feb. 1944, Vol. 132, No. 3427, p. 96: summaries only.)

1790. A Radio-Frequency Gun for Spot-Gluing Wood.—Taylor. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 106–111 and 310.) *See* also 1070 (and 1072/3) of March. From RCA Victor Division, RCA. The frequency used is 200 Mc/s.

1791. Thermal Insulation for Electrostatic Heating [Technique in Manufacture of Pregwood Propeller Blocks].—Formica Insulation. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 180 and 182.)

1792. Wide-Range Electronic Generator [*RC* Oscillator & Amplifier for Electro-Medical & Other Researches: Frequencies 1.8 to 180 000 c/s: Provision for Varying the Wave-Form and for obtaining Exponentially Rising Currents & " Surging " Direct Currents: Oscillator Frequency Adjustment by Variation of Resistance Branches of Frequency-Determining *RC* Bridge, giving Wide (100 : 1) Range on Each of Four Scales].—Mittelman, Grodins, & Ivy. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 132–134 and 322.)

1793. Medical Shock Machine [for Electric-Shock Therapy for Mental Disorders: Defects of Older Timing Systems: an Electronic Timer].—Traugott. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 166 and 170..174.)

1794. Human Susceptibility to Vibration.—Postlethwaite. (*Engineering*, 28th Jan. 1944, Vol. 157, No. 4072, pp. 61–63.)

1795. Vibration Displacement Indicator [Small Mirror-&-Light-Spot Instrument]—Dimond. (*Gen. Elec. Review*, Dec. 1943, Vol. 46, No. 12, pp. 687–688.)

1796. Pipe Leak Locator [Vibrations caused by Liquid escaping under Pressure used as Guide].—Fisher Laboratories. (*Electronics*, Dec. 1943, Vol. 16, No. 12, p. 194.)

1797. Marine Propulsion Gears (of 50-Ton Weight) controlled during Balancing by Electronic Means.—(*Scient. American*, Nov. 1943, Vol. 169, No. 5, p. 216.) *Cf.* 2033 of 1943.

1798. Governor Tester [for Delicately Balanced Governors for Propeller-Blade Pitch Adjustment] is Accurate to within Two-Tenths of One Percent [Electronically Controlled Testing Set].—Nash–Kelvinator Corporation. (*Scient. American*, Dec. 1943, Vol. 169, No. 6, pp. 275–276.)

1799. The "Talysurf" [Stylus-Type Instrument for measuring the Roughness of Surfaces].—(*Engineer*, 26th Nov. 1943, Vol. 176, No. 4585, p. 434.) *Cf.* 2040 of 1941 and 3819 of 1942.

1800. Reactance-Type Gauges [for Thicknesses as small as One-Millionth of an Inch: Various Types, for Plating Thickness, Eccentricity, etc.].—General Electric. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 158..164.)

1801. Strain Gauges [Wire Resistance Gauges for Stresses in Structures & Machines: with Suitable Electronic Circuits for Indicating & Recording].—Nielsen. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 106–111 and 192, 194.)

1802. Electronic Metal Tester [Du Mont "Cyclograph," for Non-Destructive Testing of Variations in Properties of Metal Parts or Stock: a Two-C.R.O. Instrument].—Du Mont Laboratories. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 156 and 161.) *See* also 1480 of April.

1803. Exploding Gunpowder makes Record of Uniformity on Cathode-Ray Tube.—(*Scient. American*, Nov. 1943, Vol. 169, No. 5, p. 216.) *Cf.* 332 of January.

1804. The Cathode-Ray Tube in Mechanical Testing [and the Various Pick-Up Devices, including Developments in the Application of Pressure-Sensitive Metal Alloys].—Cattanes. (*Electronic Eng:g*, Dec. 1943, Vol. 16, No. 190, pp. 277–280 and 295.)

1805. Line Voltage in Middle West and South [Startling Results of Recent Survey: Importance for Industrial Electronic Devices].—Humes. (*See* 1655.)

1806. On the Use of Receiving Valves in Electronic Automatic Circuits.—Sokolov. (*See* 1594.)

1807. The Dielecometer: a Versatile Instrument for Dielectric Constant Determination, and Some of Its Applications [including to Industrial Purposes—Moisture Determination, Gas Analysis, etc.].—Jupe: Simons. (*Elec. Review*, 27th Aug. 1943, Vol. 133, No. 3431, pp. 271–273.) The article includes a discussion of L. Ebert's work in "enlarging the scope of permittivity as an important factor in science and engineering." *See* also *Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 220..230.

1808. Mass Spectrometer aids Research [in tracing Stable Isotopes, Gas Analysis, Monitoring of Heat-Treating Furnaces, etc.].—Hipple. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 120–124.) For previous work *see* 2280 of 1943, 718 of February, and 1060 of March.

1809. Electronic Temperature Indicator [with Switching Arrangements for 5 Thermocouples, which may have as much as 100 Ft of Connecting Wire].—North American Philips. (*Communications*, Sept. 1943, Vol. 23, No. 9, p. 88.)

1810. Technique for Measurement with the Resistance Thermometer in a Wheatstone Bridge [Freezing- or Boiling-Point Changes, etc.].—Diesselhorst & Lange. (*See* 1665.)

1811. On the Damping Factor of the Third-Order Differential Equation of Regulating Circuits.—Oppelt. (*See* 1533.)

1812. A General Equation for Bridge Circuits with Linear Resistances [in Regulating & Control Systems].—Bogomolov. (*See* 1534.)

1813. Stability and Aperiodicity in Fourth-Order Processes of Motion [as in Regulating & Control Systems].—Schmidt. (*Arch. f. Elektrot.*, 30th April 1943, Vol. 37, No. 4, pp. 217–220.)

For a motion ϕ following a differential equation of the third order $a_3\phi''' + a_2\phi'' + a_1\phi' + \phi = 0$, the regions of unstable and aperiodic motions are already known. "In the treatment of multipartite control systems, however, equations mostly of the fourth order at least are concerned, which no longer allow the neglect of the fourth differential quotients. The question therefore arises how the curves of the third-order characteristic regions pass into those of fourth order. In the present paper both boundary curves are derived together [Fig. 1, top left, for third order ($a_4 = 0$): other diagrams show the effect of a gradually increasing influence of the fourth differential coefficient]. From these diagrams [which may be regarded as an extension of the well-known Wischnegradski diagram for a third-order differential equation] the forms of motion of all possible cases may be obtained." It is seen that the stable-aperiodic region completely vanishes as soon as $a_4 = 0.1579$: the derivation of this critical value is shown in a footnote on p. 219.

1814. Negative Resistance as a Machine Parameter [Properties of Series Generator].—Fett. (*See* 1527.)

1815. The Flashtron, an Electronic Automatic Control Unit [*e.g.* for Control of Steam Pressure by Bourdon Tube with Contacts].—Thordarson Company. (*Communications*, Oct. 1943, Vol. 23, No. 10, p. 88.) *See* also *Electronics*, Oct. 1943, Vol. 16, No. 10, p. 280.

1816. The Amplidyne.—Felix. (*Communications*, July 1943, Vol. 23, No. 7, pp. 72..75.) *See* also 679 of February.

1817. A High-Sensitivity Magnetic Null-Current Amplifier for Measuring & Control Technique.—Geyger. (*Wiss. Veröff. a. d. Siemens-Werken*, Vol. 21, 1943, p. 47 onwards.) An eleven-page paper: for previous work *see* 123 & 1472 of 1943.

1818. Metal Locators: Brief Survey of Electronic Methods for Locating Ore Bodies, tracing Buried Pipes and Cables, and finding Other Buried Metal Objects [including the Writer's Radio Beat-Frequency Locator Circuit without Any Detector or Mixer: Buffer Stage to prevent Interlocking].—Blankmeyer. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 112–115 and 236..240.)

1819. Locating Buried Cables Electrically.—Greenidge. (*Nature*, 5th Feb. 1944, Vol. 153, No. 3875, pp. 173–174.) Summary of the paper referred to in 1078 of March.

1820. High-Frequency Electronic Flaw-Detector for Non-Magnetic Metal Tubing.—General Electric. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 188 and 190.)

1821. Electronic Stop for Textile Machines [Usual "Stop Motion" Direct Electrical Contacts are Unreliable in Humid, Dust-Laden Atmosphere: Electronic Stop replaces Magnetic Relay and gives Perfect Operation even when Contact-Circuit Resistance is as much as 500 000 Ohms].—General

Electric. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 161–162.)

1822. Natural Limit of Measuring Radiation with a Bolometer.—Milatz & van der Velden. (*Physica*, Vol. 10, 1943, p. 369 onwards.) A twelve-page paper, in English.

1823. Standardisation of Non-Ionising Radiations [Infra-Red, Visible, & Short-Wave Wireless (possibly also Ultra-Violet & Supersonic): Committee appointed].—Medical Research Council. (*Nature*, 19th Feb. 1944, Vol. 153, No. 3877, p. 219.)

1824. Four-Microsecond Flash Unit.—Bellinger: General Electric. (*Electronics*, Oct. 1943, Vol. 16, No. 10, pp. 144 and 146.) *See* also 381 of January.

1825. Modern Spectrochemical Analysis.—Jaycox. (*Journ. Applied Phys.*, Dec. 1943, Vol. 14, No. 12, pp. 619–631.) From the Murray Hill laboratories.

1826. Micro-Thermal Analysis of Organic Two-Body Systems [with the "Hot Microscope."]—Kofler. (*Naturwiss.*, 19th Nov. 1943, Vol. 31, No. 47/48, pp. 553–557.)

1827. Topography of a Quartz Crystal Face [by Multiple-Beam Interference Method, functioning " in a Region intermediate between That available to Study by X-Rays and by the Microscope respectively "].—Tolansky. (*Nature*, 12th Feb. 1944, Vol. 153, No. 3876, pp. 195–196.) *See* 1450 of April.

1828. A Photoelectric Phase-Impulse System [for Precision Measurements].—Telishevski. (*Automatics & Telemechanics* [in Russian], No. 3, 1941, pp. 57–65.)

It is well known that owing to their instability photocells cannot be used for precision measurements. To overcome this difficulty a method is proposed based on the following principle :—The output from the cell is amplified and the peak output voltage used to control a thyratron. A narrow beam of light directed towards the cell is intercepted by a spirally slotted disc rotating in synchronism with the alternating anode voltage of the thyratron, the disc being mounted in such a manner that the beginning of illumination coincides with the beginning of the voltage half-wave applied to the thyratron. A screen capable of lateral movement is interposed between the source of light and the disc, and its movement is presumably controlled by the factor to be measured. The instant at which the cell becomes illuminated, and therefore the phase of the working impulse applied to the thyratron, can thus be varied. In this method the measurement of light intensity is replaced by the variation of the instant (phase) of illumination. The operation of systems with one thyratron, two thyratrons of the same polarity, and two thyratrons of opposite polarities is discussed and some experimental oscillograms are shown.

1829. Fluctuations due to Thermoelectric Emission from the Photoelectric Layer in a Modulated-Light Amplifier.—Blanc-Lapierre. (*Comptes Rendus* [Paris], Vol. 216, 1943, p. 42 onwards.)

1830. The Silver-Sulphide Photocell with a Barrier Layer.—Geykhman & Soroka. (*See* 1629.)

1831. Densitometer for measuring Transparent Materials [Films, Filters, Plastics, Gases, etc.].—Photoswitch, Inc. (*Electronics*, Oct. 1943, Vol. 16, No. 10, pp. 286 and 288.)

1832. Electric Eye " Sees " Gas [Ultra-Violet Photometer used for Detection of Injurious Gases, particularly Carbon Disulphide].—du Pont de Nemours. (*Sci. News Letter*, 22nd Jan. 1944, Vol. 45, No. 4, p. 58.)

1833. Electronic Control of Gas-Cutting Machines [Photoelectric Equipment guiding Machine around Simple Template composed of Pencil Drawing on Paper].—McComb. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 172..186.)

1834. Photoelectric System for Flame Failures [" Fireye Type F28C " for Oil, Gas, or Pulverised-Coal Burners].—(*Electronics*, Dec. 1943, Vol. 16, No. 12, p. 308.)

1835. Phototubes control Perforating of U.S. Stamps [Rolls accurately Perforated & Cut into 400-Stamp Sheets at rate of 200 Sheets per Minute].—Hall. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 124–125 and 315.) From the Director, Bureau of Engraving & Printing, Treasury Department.

1836. A Thermostatic Control System [Phototube/Galvanometer Arrangement (Weinland, 4126 of 1935) modified].—Roof. (*Electronics*, Oct. 1943, Vol. 16, No. 10, pp. 166..172.)

1837. X-Ray checks Hand-Grenade Fuses [Automatic (Moving Belt) Equipment with X-Ray Screen watched by Phototube].—General Electric. (*Electronics*, Nov. 1943, Vol. 16, No. 11, p. 152.)

1838. Radiography and X-Ray Tube Design [for Inspection Purposes on Factory Production Lines].—Lampert. (*Electronics*, Nov. 1943, Vol. 16, No. 11, pp. 135–139 and 318..323.) From the Westinghouse Company.

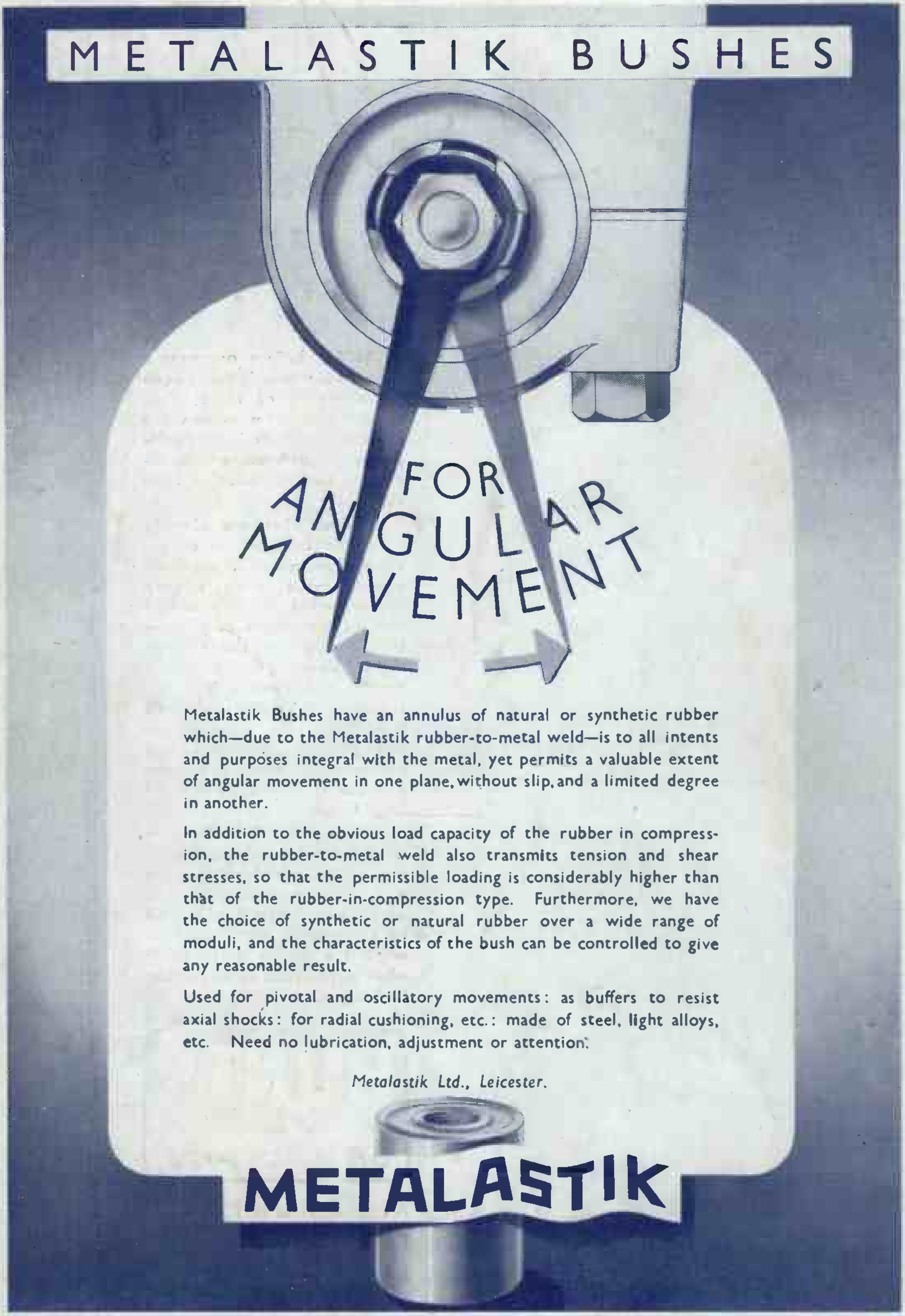
1839. A New Direct Method of Indexing Single-Crystal X-Ray Photographs : the " Tilted-Crystal " Method.—Bunn & others. (*Journ. of Scient. Instr.*, Jan. 1944, Vol. 21, No. 1, pp. 10–15.) From the I.C.I. laboratories.

1840. X-Ray Study of the Hysteresis Effect observed in the Palladium–Hydrogen System, *and* Note on the Solubility of Hydrogen in Palladium [and Lacher's " Hysteresis " Effect].—Owen & Williams : Owen. (*Proc. Phys. Soc.*, 1st Jan. 1944, Vol. 56, Part 1, No. 313, pp. 52–63 : *Phil. Mag.*, Jan. 1944, Vol. 35, No. 240, pp. 50–57.)

1841. The Effect of Adsorbed Gas on the Contact Electrification of Quartz on Nickel.—Debeau. (*Phys. Review*, 1st/15th Sept. 1943, Vol. 64, No. 5/6, p. 187 : summary only.)

1842. Water Purity Tester.—Barnstead Company. (*Electronics*, Dec. 1943, Vol. 16, No. 12, pp. 162 and 164.) Already referred to in 1064 of March.

1843. Carrier System for the Spiral-4 Cable [361 of January].—Jacobs. (*Bell Lab. Record*, Dec. 1943, Vol. 22, No. 4, pp. 168–172.)



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