THE
WIRELESS
ENGINEER

VOL. XVII. JUNE, 1940 No. 201

Editorial

A New Method of Measuring High Resistances at Radio Frequencies

IN the *Proceedings of the American Institute of Radio Engineers* for February, P. M. Honnell describes a new method of measuring high resistances at radio frequencies, which he calls a bridged-*T* method. It is stated that "the device is capable of measuring resistances ranging from 0.01 to 10 megohms with an accuracy approximating the precision of setting of the adjustable standard elements of the apparatus."

The method employed is shown diagrammatically in Fig. 1. The unknown resistance R_x is connected between 3 and 3′ in parallel with two exactly similar variable air condensers connected in series and ganged so that their capacitances are always equal. A standard resistance R of 100 ohms or less is connected between the junction of the condensers and earth. A source of radio frequency is connected between 1 and 1′, and a detector between 2 and 2′, the terminals 1′ and 2′ being earthed. The condensers are adjusted until the detector indicates a minimum p.d. between 2 and 2′. It can be shown that the value of the unknown resistance is then given by the formula $R_x = 1/\omega^2C^2R$; it is therefore necessary to know the frequency to as high a degree of accuracy as the capacitance, any error in either causing twice as great an inaccuracy in the value of R_x as would be caused by an equal error in the standard resistance R.

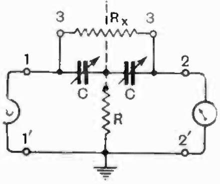


Fig. 1.

The method is a minimum and not a null one, and it is presumably a matter of some importance that the applied radio-frequency p.d. should be sinusoidal, since the minimum condition involves the frequency, and would be affected by the presence of harmonics.

To determine the conditions of balance we shall adopt an entirely different procedure from that employed by the author. If four impedances are arranged as shown in Fig. 2a it is well known that the mesh arrangement of Z_1, Z_2, Z_3 can be replaced by the star arrangement of z_1, z_2, z_3 shown in Fig. 2b, where $z_1 = \dfrac{Z_2Z_3}{Z_1 + Z_2 + Z_3}$, with similar expressions for z_2 and z_3.

The impedance z_1 is thus in series with the detector, which we assume to take no current, so that

$$V_2/V_1 = \frac{z_3 + Z_4}{z_2 + z_3 + Z_4}$$

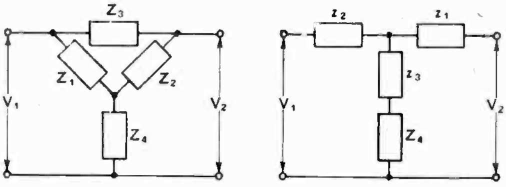
$$= \frac{Z_1Z_2 + Z_4(Z_1 + Z_2 + Z_3)}{Z_3Z_1 + Z_1Z_2 + Z_4(Z_1 + Z_2 + Z_3)}$$

Putting $Z_1 = Z_2 = Z = 1/j\omega C$, $Z_3 = R_x$, and $Z_4 = R$, we have

$$V_2/V_1 = \frac{Z^2 + Z_4(2Z + Z_3)}{Z^2 + ZZ_3 + Z_4(2Z + Z_3)}$$

$$= \frac{\left(RR_x - \frac{1}{\omega^2C^2}\right) - j\frac{2R}{\omega C}}{\left(RR_x - \frac{1}{\omega^2C^2}\right) - j\left(\frac{2R + R_x}{\omega C}\right)}$$

The conditions for a minimum value of $|V_2/V_1|$ can be seen very simply from Fig. 3, which is a graphical representation of the above complex fraction.



(a) (b)

Fig. 2.

$RR_x - \frac{1}{\omega^2C^2}$ is set out horizontally and $\frac{2R + R_x}{\omega C}$ vertically; then $AC = \left(RR_x - \frac{1}{\omega^2C^2}\right) - j\frac{2R}{\omega C}$ is the numerator and $AB = \left(RR_x - \frac{1}{\omega^2C^2}\right) - j\left(\frac{2R + R_x}{\omega C}\right)$ the denominator of the complex fraction, and therefore

$$\frac{AC}{AB} = \left|\frac{V_2}{V_1}\right|.$$

CF parallel to DA meets AB in a fixed point F such that $AF/FB = DC/CB = 2R/R_x$, which is a constant very small fraction. As the capacitance C of the condensers is varied, D moves on a semicircle on AB, which represents to some suitable scale the total impedance $z_2 + z_3 + Z_4$. C moves similarly on a semicircle on FB. It is obvious that the ratio AC/AB gets smaller and smaller as D approaches A and reaches a minimum when $AD = 0$, i.e. when $RR_x = \frac{1}{\omega^2C^2}$. The minimum will be much sharper than indicated in Fig. 3, and approach much nearer to zero, since R_x may be 10,000 times R.

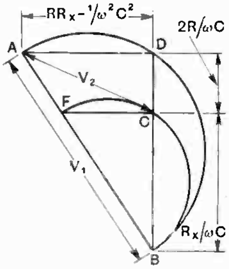


Fig. 3.

The conditions for a minimum value of V_2 may also be seen from Fig. 4 which shows the relations between the currents and voltages in Fig. 1. The current I divides into I_1, which passes through the condenser C_1, and I_2 which passes through R_x and C_2. The voltage V_x across R_x is equal to I_2R_x, and the voltage V_{c2} across C_2 to $I_2/\omega C$. Their resultant is V_{c1} and $I_1 = V_{c1}\omega C$ 90 deg. ahead of V_{c1}. The total current I is the resultant of I_1 and I_2 and the voltage across R is IR. To reduce V_2, the resultant of V_{c2} and IR, to a minimum, it is evident that they should be made approximately equal, or, more accurately, that V_{c2} should equal $IR\frac{OC}{OA}$. Now

$$V_{c2} = \frac{I_2}{\omega C} = \frac{V_x}{\omega CR_x} = \frac{V_{c1}}{\omega CR_x}\cdot\frac{OC}{OB}$$

$$= \frac{I_1}{\omega^2C^2R_x}\cdot\frac{OC}{OB} = \frac{I}{\omega^2C^2R_x}\cdot\frac{OB}{OA}\cdot\frac{OC}{OB}.$$

Hence ω^2C^2 should be made equal to RR_x.

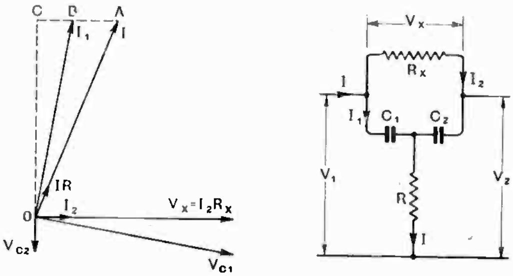


Fig. 4.

In *The Wireless Engineer* for June, 1935, we dealt with the apparent impedance of high resistances at very high frequencies and showed that it fell off rapidly beyond a certain frequency, and could then be represented by a reduced resistance in parallel with a condenser. This phenomenon is not mentioned in the Paper and it is not difficult to see that the method would not be satisfactory at frequencies so high that the phenomenon became important. The effect would be negligibly small in the standard low resistance R; it would be in the high resistance R_x that it might become noticeable. It is stated that "the direct capacitive coupling between input and output is minimised by an electrostatic shield between the stators of the calibrated ganged condensers CC and connected to their common terminal. The direct capacitance between the terminals of the resistor R_x under measurement is likewise effectively reduced by placing the resistor through a perforation in the shield." This shield is shown dotted in Fig. 1, but it is difficult to see how it can reduce the capacitance between terminals 3 and 3′. It is true that 3′ and 2 do not differ very much in potential from the upper end of R to which the shield is connected, but this has the effect of adding the capacitance between terminal 3, together with the rest of the resistor, and the shield to that of the left-hand condenser and thus unbalancing the condensers. It may be that the error so introduced is less than that which would result from the omission of the shield, in fact the author states that consistent results could only be obtained by careful shielding.

G. W. O. H.

Electro-Acoustic Reactions*

With Special Reference to Quartz Crystal Vibrators

By *A. T. Starr, M.A., Ph.D., A.M.I.E.E.*

SUMMARY.—The theory of the quartz vibrator is worked out for the case of plane wave motion, and exact network equivalents are derived for the case of partial and full plating. It is shown that the electro-acoustic branch is composed of a uniform line, the point of entry to which depends upon the amount of plating.

The effects of partial plating are shown to enable a considerable increase of activity to be achieved, to allow a fine adjustment of crystal inductance from a minimum value (for full plate) to at least ten times this value, and to eliminate certain undesired responses.

Experimental verification is given for the plating formulae.

The main uses that result are :—(1) Simple construction of filters with unsymmetrical attenuation curves, such as are required for single sideband equipment; (2) construction of resonators with single response in a wide band; (3) general method of adjusting crystal inductance.

Introduction

ELECTRICAL equivalents of mechanical systems are of common use in applied acoustics, and it is generally assumed that inertia corresponds always to inductance, damping to resistance, and compliance to capacitance: the reason for this assumption is an erroneous application of Maxwell's method of dealing with the energy of an electromagnetic field. It will be shown that there are two (and only two) types of electro-acoustic coupling, which we shall call electromagnetic and electrostatic couplings, and the appropriate electrical equivalents will be derived.

Possible Couplings

Suppose that a mechanical force, F dynes, is caused by a current, I (E.M. units) and a voltage, V (E.S. units), so that

$$F = aI + bV,$$

where a and b are the coupling constants. Let the corresponding velocity, $\dot{x}$ cm/sec., be

$$\dot{x} = cI + dV.$$

If the system is linear, c and d are constants. By the law of the conservation of energy we must equate the electrical and mechanical powers, so that

$$F\dot{x} = acI^2 + bdV^2 + (ad + bc)IV,$$
$$= kIV,$$

if we consider the couplings as independent. It follows at once that

$$ac = bd = 0,$$

and $$ad + bc = k.$$

---

* MS. accepted by the Editor, February, 1940.

The only possibility is either

$$a = d = 0$$

or
$$b = c = 0.$$

The first case is that in which the mechanical force corresponds to voltage (and velocity to current), and we call this the case of electrostatic coupling. In the second case mechanical force corresponds to current (and velocity to voltage), and we call the case electromagnetic coupling. The properties of the two systems and their electrical equivalents are best developed, explained and summarized in the form of the table given below.

By the adoption of the appropriate units, viz., inductance, resistance and reciprocal of capacitance for E.S. coupling, capacitance, conductance and reciprocal of inductance for E.M. coupling, all the constants are the same in any one case. To convert from mechanical to electrical units we must divide by B^2. As an example consider the case of electromagnetic coupling with a rotating system. We have

$$T = BI$$

Energy conservation gives

$$T\dot{\theta} = IE,$$

so that
$$\dot{\theta} = E/B,$$

and
$$C = I/\dot{E} = \frac{T}{B} \div (B\theta)$$

$$= \frac{1}{B^2}\frac{T}{\theta} = \frac{1}{B^2}J.$$

It is obvious that

$$G = \frac{1}{B^2}r$$

and
$$\frac{1}{L} = \frac{1}{B^2}s.$$

To reduce to the practical system of units we must multiply by 9.10^{11} in the first case (hence the daraf, which is the reciprocal of the farad) and by 10^9 in the second case (hence the yrneh, which is the reciprocal of the henry).

Linear Motion.	Rotation.	Electrical System. (E.S. Coupling).	Electrical System. (E.M. Coupling).
Force. F (dyne).	Torque. T (erg.).	Voltage. E. (E.S. unit). 1 E.S. unit = 300 V.	Current. I (E.M. unit). 1 E.M. unit = 10 A.
Power. $P = F\dot{x}$ (erg./sec.)	Power. $P = T\dot{\theta}$ (erg./sec.)	Power. $P = IE$ (erg./sec.) 1 E.S. unit current $= \frac{1}{3.10^9}$ A.	Power. $P = I.E.$ (erg./sec.) 1 E.M. unit voltage = 10^{-8} V.
Velocity. $\dot{x} = \frac{P}{F}$ (cm./sec.)	Angular velocity $\dot{\theta} = \frac{P}{T}$ (sec.$^{-1}$).	Current. $I = P/E$.	Voltage. $E = \frac{P}{I}$.
Mass. $m = F/\ddot{x}$ (gm.)	Moment of inertia. $J = T/\ddot{\theta}$ (gm. cm.^{2}).	Inductance. $L = E/\dot{I}$ E.S. unit inductance = 9.10^{11} H.	Capacitance. $C = I/\dot{E}$ E.M. unit capacitance = 10^9 F.
Damping. $r = F/\dot{x}$ (gm./sec.)	Damping. $r = T/\dot{\theta}$ (erg./sec.)	Resistance. $R = E/I$. E.S. unit resistance = 9.10^{11} Ω.	Conductance. $G = I/E$. E.M. unit conductance = 10^9 mho.
Stiffness. $s = F/x$ (dyne/cm.)	Stiffness. $s = T/\theta$ (erg.)	Reciprocal of capacitance. $\frac{1}{C} = \frac{\dot{E}}{I}$. E.S. unit = 9.10^{11} daraf.	Reciprocal of inductance. $\frac{1}{L} = \frac{\dot{I}}{E}$. E.M. unit = 10^9 yrneh.
Coupling Factor. E for E.S. coupling. I for E.M. coupling.			
$B = F/(E$ or $I)$.	$B = T/(E$ or $I)$.	$\frac{1}{B} = E/(F$ or $T)$.	$\frac{1}{B} = I/(F$ or $T)$.

Combination of Electrical Elements

A shunt arm does not affect the voltage but causes a change of current just before and after its point of insertion. Thus a mechanical element is represented by a shunt electrical arm if it takes up a change of velocity (or displacement) in an electrostatic system or a change of force in an electromagnetic system.

A series electrical arm absorbs a change of voltage, and therefore represents a mechanical element which takes up a change of force in an electrostatic system or a change of velocity in an electromagnetic system.

Simple Case of an Electromagnetic System

Consider a moving coil in a magnetic field H, with moment of inertia J, damping r, and stiffness s. In this case

$$T = (n\ SH)\ I,$$

where n is the number of turns in the coil, and S its area, so that the coupling constant is

$$B = \frac{T}{I} = nSH.$$

The electrical elements are

$$C = \frac{1}{B_2} J = J/n^2S^2H^2,$$

$$G = r/n^2S^2H^2,$$

$$\frac{1}{L} = s/n^2S^2H^2.$$

Each of the elements takes up a part of the torque, which corresponds to current, so that the elements are in parallel.

Finally we must represent the inductance and resistance of the coil as being in series with the electro-acoustic network equivalent, so that the resultant network is that shown in Fig. 1 (a).

A more complicated case can be treated in exactly the same way.

Error of the Usual Representation

The usual representation would be that of Fig. 1 (b), where k is some constant. The probable reason why the error has persisted so long is because the usual representation is the inverse network of the correct method, so that if we consider this alone no great harm is done since the inverse network of a filter is a filter with exactly the same pass band. Where the wrong method gives significant error is in cases of mixed systems, i.e. where we are concerned with an electrical plus an electro-acoustic system. For instance if we include the effect of the inductance and resistance of the coil, the networks of Figs. 1 (a) and (b) give quite different resonant frequencies and decrement factors.

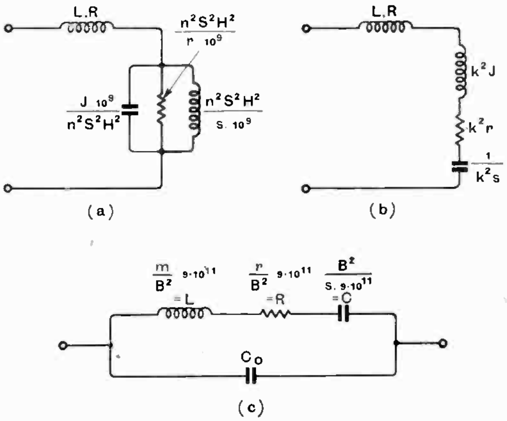


Fig. 1.—*(a) Correct representation of an electromagnetic electro-acoustic system. (b) Incorrect representation. (c) Exact representation of a linear electrostatic electro-acoustic system with one degree of freedom.*

Linear Electrostatic Electro-Acoustic System

If we assume that the system has an effective inertia m, damping r, and stiffness s, the electrical equivalent is clearly that shown in Fig. 1 (c); C_0 is the capacitance of the system when clamped.

Quartz Crystal Vibrator

It has been usual in the literature on quartz resonators to replace the quartz plate or rod by an equivalent system with one degree of freedom and to compute L, R, C for this simplified system. It has moreover been usual to consider that the crystal is fully plated on two parallel faces, or to have one electrode of full plate area above a small air-gap.

We will consider the general case of the network equivalent of a quartz crystal, keeping the infinite degrees of freedom, and finding the effect of a partial plating.

It will be shown that, by plating the crystal partially, a very fine control is obtained on the crystal parameters, so that we can obtain a crystal inductance (as it is called) of any value from a certain minimum upwards. Thus a plate of quartz can furnish an inductance from, say, 10H to 200H by proper plating. A great advantage is obtained for constructing crystal band-pass filters with unsymmetrical attenuation characteristics: for it can be shown that to construct such filters it is necessary to have crystals of widely different values of inductance, in a certain case the values were 10H and 90H. To make a crystal of inductance 90H and 80 kc/s resonant frequency would require a block of quartz 30 mm × 25 mm × 5 mm, which is expensive, and awkward to mount robustly. By partial plating, the quartz plate can be 0.6 mm thick instead of 5 mm thick, and we can make all the crystals of approximately the same size. Moreover, plating adjustment forms the easiest and most efficient method of adjusting crystal inductance without altering the resonant frequency. Considerable economy in filter elements and simplification of filter adjustment result by the use of plating adjustment.

General Character of Network Equivalent

As a quartz plate or bar is a distributed mechanical system, it is reasonable to expect that the equivalent electrical network will be composed of a distributed line, in other words, L, R, C will be replaced by the input impedance of a distributed line.

The effect of partial plating is to decrease the magnitude of the electromechanical coupling, B, and will thus result in an increase of L and R and a decrease of C; the LC product, however, and with it the resonant frequency, will remain constant. As the strain and stress of a bar is not constant throughout its length, different areas will have different capabilities of electro-acoustic or piezo-electric effect. A simple assumption is that the strain and stress are sinusoidally distributed along the length of the bar, and this would result in an effective plating factor which is the sine of the ratio of plating length to crystal length. This assumption is in fact borne out with considerable accuracy by a crystal which vibrates mainly in a plane wave, viz., a — 18.5° cut crystal. Thus we should expect that

$$L_p = L_f \div \sin^2\left(\frac{\pi}{2}\frac{y_0}{y_1}\right),\quad R_p = R_f \div \sin^2\left(\frac{\pi}{2}\frac{y_0}{y_1}\right),$$

$$C_p = C_f \times \sin^2\left(\frac{\pi}{2}\frac{y_0}{y_1}\right),$$

where L_p, R_p, C_p are the values for a crystal of length y_1 plated for a length y_0, and L_f, R_f, C_f are the values for a fully plated crystal.

This simple assumption is qualified by other effects, viz. clamping at the middle of the crystal, air loading at the edges, and coupling with other modes of vibration.

Theory of the Quartz Vibrator

Consider a narrow rod of X-cut or a wider plate of — 18.5° cut; in either case we may assume that the only important motion is parallel to the longest, mechanical, axis, which we call the y-axis. Fig. 2 represents the crystal which has dimensions x_1, y_1, z_1, parallel to the axis. The plating is taken as covering the whole length parallel to the z-axis, but only y_0 of the length parallel to the y-axis; it is shown as shaded in the figure. A voltage V is applied between the plates.

According to our assumption of plane wave motion we need consider only the displacement, v, parallel to the y-axis, and the stress $\widehat{yy}$. The equation of motion for the bar or plate is :—

$$\rho\frac{\partial^2 v}{\partial t^2} = \frac{\partial \widehat{yy}}{\partial y} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where ρ is the density of the quartz, $\widehat{yy}$ the elastic stress along the y-axis. The stress-strain relation is

$$\widehat{yy} = Ge_{yy} = G\frac{\partial v}{\partial y} \quad \ldots \quad \ldots \quad (2)$$

where G = Young's modulus along the y-axis.

There are regions of two different kinds, viz., the region for which the magnitude of y is less than $\frac{1}{2}y_0$ and that for which the magnitude lies between $\frac{1}{2}y_0$ and $\frac{1}{2}y_1$. The system is clearly symmetrical about the mid-point, which we have taken as origin, so that we can concentrate on the regions.

$0 \leqslant y < \frac{1}{2}y_0$, called region I

and $\frac{1}{2}y_0 < y \leqslant \frac{1}{2}y_1$, called region II

In both regions equations (1) and (2) hold, so that the equation for the displacement is

$$\rho\frac{\partial^2 v}{\partial t^2} = \frac{\partial \widehat{yy}}{\partial y} = G\frac{\partial^2 v}{\partial y^2}$$

We assume that the applied voltage V is periodic, with pulsatance ω, so that the equation of motion becomes :—

$$\frac{\partial^2 v}{\partial y^2} + \frac{\omega^2}{G}\rho v = 0$$

It is convenient to write

$$c = \sqrt{\frac{G}{\rho}} \quad \cdots \quad \cdots \quad \cdots \quad (3)$$

c is the velocity of a sound wave along the quartz plate in the y direction.

The equation for v is then

$$\frac{\partial^2 v}{\partial y^2} + \frac{\omega^2}{c^2} v = 0 \quad \cdots \quad \cdots \quad (4)$$

The solutions are

$$v_1 = A \sin\frac{\omega}{c} y + B \cos\frac{\omega}{c} y,$$

$$v_2 = C \sin\frac{\omega}{c} y + D \cos\frac{\omega}{c} y,$$

where the suffixes denote the regions and A, B, C, D are constants determined by boundary conditions.

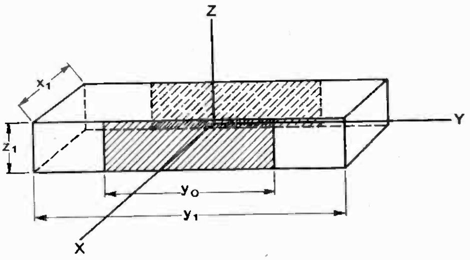


Fig. 2.—*Partially-plated vibrator.*

As the bar is clamped at the origin, $v_1 = 0$ at y_0. This gives at once $B = 0$.

At the edge of the plate there is no stress and thus $\frac{\partial v_2}{\partial y} = 0$ at $y = \frac{1}{2} y_1$. This immediately links C with D in such a way that we may write

$$\left.\begin{aligned} v_2 &= H \cos\frac{\omega}{c}\left(y - \tfrac{1}{2}y_1\right) \\ \text{also} \quad v_1 &= A \sin\left(\frac{\omega}{c} y\right) \end{aligned}\right\} \quad \cdots \quad (5)$$

Continuity demands that $v_1 = v_2$ at $y = \frac{1}{2}y_0$, giving

$$A \sin\frac{\omega}{2c} y_0 = H \cos\frac{\omega}{2c}(y_1 - y_0) \quad \cdots \quad (5a)$$

Finally we have the condition that the stress is discontinuous at the boundary of the two regions, viz. at $y = \frac{1}{2}y_0$, the discontinuity being the magnitude of the piezo-electric force F_y, and is given by :—

$$F_y = \epsilon \frac{V}{x_1} \quad \cdots \quad \cdots \quad \cdots \quad (6)$$

ϵ being the piezo-electric constant. We therefore have :—

$$\frac{G \partial v_1}{\partial y} = \frac{G \partial v_2}{\partial y} + F_y \text{ at } y = \tfrac{1}{2} y_0.$$

Equations (5) then give

$$A \cos\left(\frac{\omega}{2c} y_0\right) = H \sin\frac{\omega}{2c}(y_1 - y_0) + \frac{\epsilon c}{G\omega x_1} V \quad \cdots \quad \cdots \quad (5b)$$

Equations (5a) and (5b) then give :—

$$\left.\begin{aligned} A &= \frac{\epsilon c V}{G\omega x_1} \; \frac{\cos\frac{\omega}{2c}(y_1 - y_0)}{\cos\left(\frac{\omega}{2c} y_1\right)} \\ \text{and } H &= \frac{\epsilon c V}{G\omega x_1} \; \frac{\sin\left(\frac{\omega}{2c} y_0\right)}{\cos\left(\frac{\omega}{2c} y_1\right)} \end{aligned}\right\} \quad \cdots \quad (7)$$

It is instructive to compare the vibration of the partially plated crystal with that of the fully plated. In the latter case there is only one region of vibration, corresponding to region I, and

$$v_f = A_f \sin\left(\frac{\omega}{c} y\right) \quad \cdots \quad \cdots \quad (5f)$$

The boundary condition is then that the discontinuity in stress occurs at the edge so that

$$\frac{G \partial v_f}{\partial y} = F_y \text{ at } y = \tfrac{1}{2} y_1,$$

and consequently

$$A_f = \frac{\epsilon c V}{G\omega x_1} \; \frac{1}{\cos\left(\frac{\omega}{2c} y_1\right)} \quad \cdots \quad \cdots \quad (7f)$$

It is seen that A_f is the value of A given in equation (7) provided y_0 is put equal to y_1, and is just what we should expect. The formulae for the displacements may be re-written as

$$\left.\begin{aligned} v_1 &= \left[A_f \cos\frac{\omega}{2c}(y_1 - y_0)\right] \sin\left(\frac{\omega}{c} y\right) \\ v_2 &= \left[A_f \sin\left(\frac{\omega}{2c} y_0\right)\right] \cos\frac{\omega}{c}\left(y - \tfrac{1}{2} y_1\right) \end{aligned}\right\} \text{partially plated.}$$

$$v_f = A_f \sin\left(\frac{\omega}{c}y\right) \quad \ldots \quad \ldots \text{ fully plated.}$$

A_f being given by equation (7f).

Resonance in both cases occurs when A_f becomes infinite (in practice dissipation causes a finite maximum of A_f), and the condition is :—

$$\cos\left(\frac{\omega}{2c}y_1\right) = 0, \text{ or } \frac{\omega}{2c}y_1 = (n - \tfrac{1}{2})\pi \quad \ldots \quad (8)$$

n being a positive integer (excluding zero). The frequencies of resonance are thus :—

$$f = (n - \tfrac{1}{2})\frac{c}{y_1} \quad \ldots \quad \ldots \quad \ldots \quad (8a)$$

The fundamental frequency is obtained by putting $n = 1$, so that it is

$$f_1 = \frac{c}{2y_1} \quad \ldots \quad \ldots \quad (8b)$$

It follows from equation (7f) that A_f changes sign as the frequency passes through the value f_1. To avoid considering negative signs (as there is no point in bothering about the sign), let us consider the displacement and stresses occurring when the applied frequency is below the fundamental frequency. For a given frequency v_1 is a constant fraction of v_f, whilst v_f increases from zero at $y = 0$ to something less than A_f at the end ; for a frequency near the fundamental and for a half plating v_1 is about 0.7 times v_f. Fig. 3 shows v_f, v_1 and v_2, and the stresses corresponding to them for the case just described. It is therefore erroneous to imagine that the difference between the partially and fully plated cases is merely one of charge collection, since v_1 is not equal to v_f. In fact, when the frequency is well above the fundamental and y_0 is much smaller than y_1 it can easily happen that v_1 has the opposite sign to v_f.

The direct piezo-electric effect states that there is a polarisation produced in region I by the elastic strains of amount

$$P_1 = \epsilon\frac{\partial v_1}{\partial y}$$

This results in a plate charge of

$$Q_1 = z_1\int_{\frac{1}{2}y_0}^{\frac{1}{2}y_0} P_1\,dy = z_1\epsilon\Big[v_1\Big]_{-\frac{1}{2}y_0}^{\frac{1}{2}y_0}$$

$$= 2z_1\epsilon A \sin\left(\frac{\omega}{2c}y_0\right)$$

$$= \frac{2\epsilon^2 z_1 c V}{G\omega x_1}\,\frac{\cos\frac{\omega}{2c}(y_1 - y_0)}{\cos\left(\frac{\omega}{2c}y_1\right)}\sin\left(\frac{\omega}{2c}y_0\right)$$

There is in addition a plate charge due to the electrostatic capacitance of the plates (actually slightly decreased by the piezo-electric action by a very small amount).

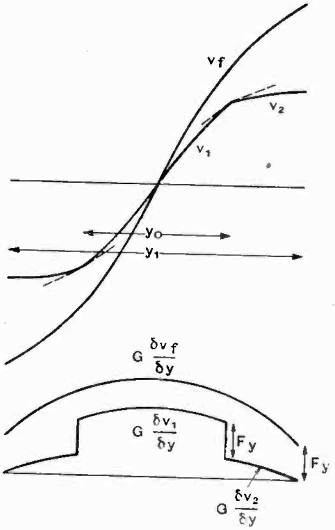


Fig. 3.—*Displacement and stresses of fully- and partially-plated vibrators.*

Denoting the electrostatic capacitance by C_O, where

$$C_O = \frac{k y_0 z_1}{4\pi x_1}\text{ cm,}$$

we have for the total current

$$I = C_O\frac{dV}{dt} + \frac{dQ_1}{dt}$$

$$= j\omega C_O V + j\omega Q_1$$

The resonator admittance is thus :—

$$Y = j\omega C_O + j\omega\frac{Q_I}{V}$$

$$= j\omega C_O + j\omega\frac{2\epsilon^2 z_1 c}{G\omega x_1}\,\frac{\cos\frac{\omega}{2c}(y_1 - y_0)}{\cos\left(\frac{\omega}{2c}y_1\right)}\sin\left(\frac{\omega}{2c}y_0\right)$$

$$= Y_1 + Y_2\text{, say} \quad \ldots \quad \ldots \quad (9)$$

where

$$Y_1 = j\omega C_0 \quad .. \quad .. \quad .. \quad .. \quad (10)$$

and

$$Y_2 = j\omega \frac{2\epsilon^2 z_1 c}{G\omega x_1} \frac{\cos\frac{\omega}{2c}(y_1 - y_0)}{\cos\left(\frac{\omega}{2c}y_1\right)} \sin\left(\frac{\omega}{2c}y_0\right) .. \quad (11)$$

Equivalent Network of the Vibrator

This is shown in Fig. 4, where Y_1 and Y_2 are given by equations (10) and (11). The branch Y_2 is due to the piezo-electric action and is of special interest. It is clear that Y_2 is infinite, i.e. the piezo-electric branch is resonant, when $\cos\left(\frac{\omega}{2c}y_1\right)$ is zero. This gives the condition of equation (8a) and it is important to note that the resonant frequencies are not affected by partial plating.

(*a*) *Complete Plating*

In the case of complete plating Y_2 reduces to

$$(Y_2)_f = j\frac{2\epsilon^2 z_1 c}{Gx_1}\tan\left(\frac{\omega}{2c}y_1\right) \quad .. \quad (11a)$$

At the same time

$$\left.\begin{aligned} (Y_1)_f &= j\omega(C_0)_f \\ \text{where} \quad (C_0)_f &= \frac{k y_1 z_1}{4\pi x_1}\,\text{cm} \end{aligned}\right\} \quad .. \quad .. \quad (10a)$$

It is well known that the admittance of an open-circuited continuously distributed line of inductance L_d and capacitance C_d per cm. and of length l is

$$Y_d = \sqrt{\frac{C_d}{L_d}}\tanh\left(j\omega l\sqrt{L_d C_d}\right)$$

$$= j\sqrt{\frac{C_d}{L_d}}\tan\left(\omega l\sqrt{L_d C_d}\right)$$

It follows that $(Y_2)_f$ is the admittance of a line in which

$$\sqrt{\frac{C_d}{L_d}} = \frac{2\epsilon^2 z_1 c}{Gx_1}$$

and $$l\sqrt{L_d C_d} = \frac{y_1}{2c}$$

These give

$$\left.\begin{aligned} lC_d &= \frac{\epsilon^2 y_1 z_1}{Gx_1} \\ \text{and} \quad lL_d &= \frac{x_1 y_1 G}{4\epsilon^2 z_1 c^2} = \frac{\rho}{4\epsilon^2}\frac{x_1 y_1}{z_1} \end{aligned}\right\} \quad .. \quad (12)$$

The exact equivalent for the fully plated crystal is thus the electrostatic capacitance in parallel with an open-circuited, uniform line of total inductance $\frac{\rho}{4\epsilon^2}\frac{x_1 y_1}{z_1}$ and total capacitance $\frac{\epsilon^2 y_1 z_1}{Gx_1}$. Fig. 5 gives a diagrammatic representation. It is seen that the length of the uniform line is arbitrary; the most aesthetic choice is the length for which the velocity of the electromagnetic wave along the equivalent line is equal to the velocity of the acoustic wave in the vibrator. This means equating $l/\sqrt{L_d C_d}$ and c, so that we get (see Fig. 6)

$$\left.\begin{aligned} l &= \tfrac{1}{2}y_1, \\ C_d &= \frac{2\epsilon^2 z_1}{Gx_1} \\ \text{and} \quad L_d &= \frac{\rho}{2\epsilon^2}\frac{x_1}{z_1} \end{aligned}\right\} \quad .. \quad .. \quad (12a)$$

It is usual (²) to express $(Y_2)_f$ as due to a series inductance L and capacitance C.

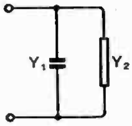


Fig. 4.—*General network equivalent of a piezo-electric vibrator.*

It is possible to do this over a narrow frequency range only, and so it is usual to specify L and C in the neighbouring of a resonant frequency. A diagrammatic plot if $1/(Y_2)_f$ (excluding the factor j), is shown in Fig. 7. We can choose a series circuit (L, C) so as to represent the part $P_1\,Q_1$ *or* $P_2\,Q_2$ *or* $P_3\,Q_3$ of (L_2) near a resonant frequency. Let us choose (L, C) to represent $P_n\,Q_n$ near the n'th resonant frequency, given by :—

$$\omega_n = (n - \tfrac{1}{2})\frac{2\pi c}{y_1}$$

It is necessary that $j\omega L + \frac{1}{j\omega C}$ shall vanish at ω_n. The best approximation is obtained by making the slope of $\left(\omega L - \frac{1}{\omega C}\right)$

equal to the slope of P_nQ_n. We thus get two equations for L and C, viz. :—

$$\omega_n^2 LC = 1$$

and

$$L + \frac{1}{\omega_n^2 C} = -\left[\frac{d}{d\omega}\frac{Gx_1}{2\epsilon^2 z_1 c}\cot\left(\frac{\omega}{2c}y_1\right)\right]_{\omega=\omega_n}$$

$$= \frac{Gx_1 y_1}{4\epsilon^2 c z_1}$$

From these we derive

$$\left.\begin{aligned} L &= \frac{Gx_1y_1}{8\epsilon^2c^2z_1} = \frac{\rho}{8\epsilon^2}\frac{x_1y_1}{z_1} \\ C &= \frac{1}{\omega_n^2 L} = \frac{2\epsilon^2}{(n-\frac{1}{2})^2\pi^2 G}\frac{y_1z_1}{x_1} \end{aligned}\right\} \quad .. \quad (12b)$$

In the neighbourhood of the fundamental frequency

$$\left.\begin{aligned} L &= \frac{\rho}{8\epsilon^2}\frac{x_1y_1}{z_1} \\ C &= \frac{8\epsilon^2}{\pi^2 G}\frac{y_1z_1}{x_1} \end{aligned}\right\} \quad .. \quad .. \quad (12c)$$

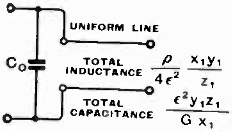


Fig. 5.—*Exact representation of a fully-plated vibrator.*

The value of L of equation (12b) and (12c) is called the inductance of the crystal.

(*b*) *Partial Plating*

The expression for Y_2 for this case is given in equation (11). It is not obvious what network has the admittance Y_2, but, whatever it is, its resonant frequencies must depend on y_1 only, whilst its anti-resonant frequencies depend both on y_1 and y_0.

A possible representation is given by the series (not tandem) combination of an open-circuited and a short-circuited line of equal characteristic impedances but unequal lengths. Fig. 8 shows the arrangement. If the open-circuited line has characteristic impedance Z_1 and total propagation constant θ_1, whilst the short-circuited line has values Z_1 and θ_2, the series combination has impedance

$$Z_I \coth\theta_1 + Z_I \tanh\theta_2 = Z_I \frac{\cosh(\theta_1+\theta_2)}{\sinh\theta_1\cosh\theta_2}$$

so that the admittance is

$$\frac{1}{Z_I}\frac{\sinh\theta_1, \cosh\theta_2}{\cosh(\theta_1+\theta_2)}$$

Comparing this expression with that of equation (11) we see that the representation is possible because in both cases the sum of the θ's in the numerator is equal to the θ of the denominator. We therefore have merely to put

$$\theta_1 = j\omega\frac{y_0}{2c},\ \theta_2 = j\omega\frac{(y_1-y_0)}{2c},\ \text{and } \frac{1}{Z_I} = \frac{2\epsilon^2 z_1 c}{Gx_1}$$

By what has been said for the representation in the case of full plating, it follows that we can choose here distributed inductance and capacitance of exactly the same magnitudes as before, viz. :—

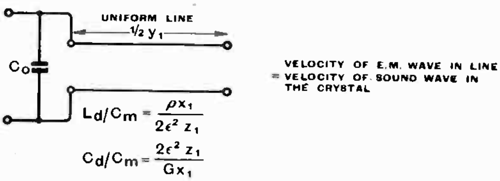


Fig. 6.—*Particular representation of a fully-plated vibrator.*

$$C_d = \frac{2\epsilon^2 z_1}{Gx_1},\ L_d = \frac{\rho}{2\epsilon^2}\frac{x_1}{y_1}$$

The value of $\frac{1}{Z_I} = \sqrt{\frac{C_d}{L_d}}$ then has the correct value, and the propagation constants will be correct if we put l_1 equal to $\frac{1}{2}y_0$ and l_2 equal to $\frac{1}{2}(y_1 - y_0)$. Fig. 8 gives the complete picture. It is seen how this case merges into the previous case of full plating, as plating increases the open-circuited line lengthens and the short-circuited line shortens, until the former becomes of length $\frac{1}{2}y_1$ and the latter is a dead short for the case of full plating. It is easy to see that the resonant frequency of the combination is determined by the length y_1 only, and the simplest way is to redraw Figs. 6 and 8 as Figs. 9 (a) and 9 (b) respectively. We can

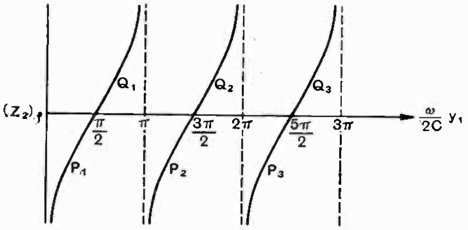


Fig. 7.—*Diagrammatic plot of* $(Z_2)_f$.

imagine that the line is the same, and the effect if partial plating is merely to shift the place of entry into the line. Resonance in both cases when the frequency is such that a phase difference of $(n - \frac{1}{2})\ \pi$ occurs between the left (shorted) end and the right (open) end, and the condition of resonance is at once seen to be that given by equation (8).

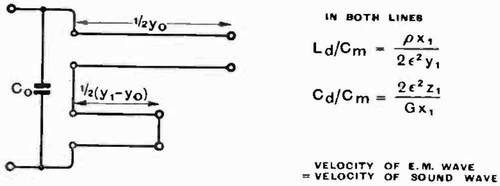


Fig. 8.—*Network equivalent of a partially-plated vibrator. Length plated* y_0, *unplated length* (y_1-y_0).

As before the approximate representation in the neighbourhood of a resonant frequency is obtained by putting

$$\omega_n{}^2 LC = 1$$

and $L + \dfrac{1}{\omega_n{}^2 C}$

$$= -\left[\frac{d}{d\omega}\frac{Gx_1}{2\epsilon^2 z_1 c}\frac{\cos\left(\frac{\omega}{2c}y_1\right)}{\cos\frac{\omega}{2c}(y_1 - y_0)\sin\left(\frac{\omega}{2c}y_0\right)}\right]_{\omega=\omega_n}$$

$$= \frac{Gx_1y_1}{4\epsilon^2c^2z_1}\frac{\sin\left(\overline{n-\frac{1}{2}}\,.\,\pi\right)}{\cos\left(\overline{n-\frac{1}{2}}\,.\,\pi - \frac{\omega_n}{2c}y_0\right)\sin\left(\frac{\omega_n}{2c}y_0\right)}$$

$$= \frac{Gx_1y_1}{4\epsilon^2c^2z_1}\frac{1}{\sin^2\left(\frac{\omega_n}{2c}y_0\right)}$$

$$= \frac{Gx_1y_1}{4\epsilon^2c^2z_1}\ \frac{1}{\sin^2\left(\overline{n-\frac{1}{2}}\,.\,\pi\frac{y_0}{y_1}\right)}$$

remembering that $\frac{\omega_n}{2c}y_1 = (n - \frac{1}{2})\pi$. In the neighbourhood of the fundamental frequency we get

$$L_p = L_f/\sin^2\left(\frac{\pi}{2}\frac{y_0}{y_1}\right),\ C_p = C_f\sin^2\left(\frac{\pi}{2}\frac{y_0}{y_1}\right)\ \ldots\ (13)$$

which is what we expected.

Another way of obtaining this result is to express the denominator of Y_2 in equation (11) by expanding $\cos\frac{\omega}{2c}\left(y_1 - y_0\right)$.

$$Y_2 = j\frac{2\epsilon^2 z_1 c}{Gx_1}\left[\cos\left(\frac{\omega}{2c}y_1\right)\cos\left(\frac{\omega}{2c}y_0\right) + \sin\left(\frac{\omega}{2c}y_1\right)\sin\left(\frac{\omega}{2c}y_0\right)\right]$$

$$\times\frac{\sin\left(\frac{\omega}{2}y_0\right)}{\cos\left(\frac{\omega}{2c}y_1\right)}$$

$$= j\frac{2\epsilon^2 z_1 c}{Gx_1}\left[\sin\left(\frac{\omega}{2c}y_0\right)\cos\left(\frac{\omega}{2c}y_0\right) + \sin^2\left(\frac{\omega}{2c}y_0\right)\tan\left(\frac{\omega}{2c}y_1\right)\right]$$

$$= j\frac{2\epsilon^2 z_1 c}{Gx_1}\left[\tfrac{1}{2}\sin\left(\frac{\omega}{c}y_0\right) + \sin^2\left(\frac{\omega}{2c}y_0\right)\tan\left(\frac{\omega}{2c}y_1\right)\right]$$

$$= (Y_2)_f\left[\tfrac{1}{2}\sin\left(\frac{\omega}{c}y_0\right)\cot\left(\frac{\omega}{2c}y_1\right) + \sin^2\left(\frac{\omega}{2c}y_0\right)\right]$$

Near the fundamental frequency the cotangent vanishes and the sines remain finite.

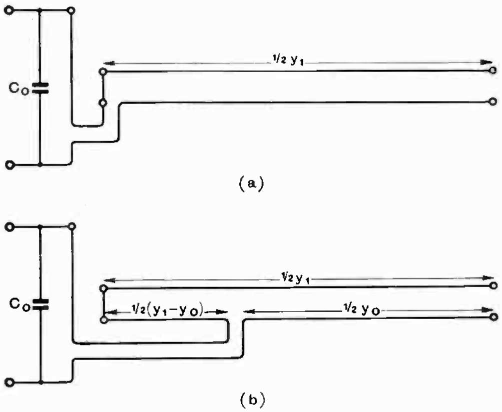


Fig. 9.—*Figures 6 and 8 redrawn. (a) Full plating. (b) Partial plating.*

Thus in this neighbourhood

$$Y_2 = \sin^2\left(\frac{\omega}{2c}y_0\right)(Y_2)_f$$

$$= \sin^2\left(\frac{\pi y_0}{2y_1}\right) \text{ times } (Y_2)_f$$

since $\frac{\omega_1}{2c}y_1 = \frac{\pi}{2}$

This relation gives equations (13).

REFERENCES

(1) "Electric Circuits and Wave Filters," 2nd edition, pp. 93–94. Also S. Butterworth, *Proc. Phys. Soc.*, 1914, Vol. 26, p. 264, and 1915, Vol. 27, p. 410.

(2) "The Piezo-Electric Resonator," by W. G. Cady, *Proc. Inst. Rad. Eng.*, 1922, Vol. 10, No. 38; "The Piezo-Electric Quartz Resonator and its Equivalent Electrical Circuit," by D. W. Dye, *Proc. Phys. Soc.* London, 1926, Vol. 38, No. 399; "The Piezo-Electric Resonator and its Equivalent Network," by K. S. Van Dyke, *Proc. Inst. Rad. Eng.*, 1928, Vol. 16, No. 742; "Quartz Resonators and Oscillators," by P. Vigoureux, pp. 43–48.

(*To be concluded.*)

Books Received

European Science

By H. STAFFORD HATFIELD, Ph.D., F.Inst.P. Pp. 152+XIII. Published for the Orthological Institute by the Basic English Publishing Company, 10, King's Parade, Cambridge. Price 3s. 6d.

This book, which is one of a series, gives an account of European Science in Basic English which employs 850 words only. The three chapters are headed "The New Birth of Learning," "The Unseen Structure of Things"—which includes a number of pages on electric and magnetic forces, and "Living Beings."

Radio Upkeep and Repairs (4th edition)

By ALFRED T. WITTS, A.M.I.E.E. Pp. 215+IX, 131 Figs. Published by Sir Isaac Pitman & Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price 6s.

In order to bring this book, which was originally published in 1933, up to date, three chapters have been deleted, two revised and enlarged and one added. The present 14 chapters are intended to give the amateur sufficient knowledge to track down the majority of faults met with in the operation of a wireless receiver.

N.P.L. Report for 1939

ALTHOUGH the National Physical Laboratory is carrying out much war work, the Annual Report for 1939 by the Department of Scientific and Industrial Research indicates that, in view of the facilities for war research elsewhere, it has been found possible to continue, at least in part, on a peacetime basis to fulfil its main function of assisting industry in solving problems. Many of these problems are, of course, presented by wartime production.

The work of the Radio Department, which mainly comprises a programme of fundamental research under the direction of the Radio Research Board, is described by Dr. R. L. Smith-Rose, the Superintendent of the Department. The investigations of the year under review were mainly concerned with the production and propagation of ultra-short waves (below 10 metres), radio direction finding on frequencies up to 150 Mc/s, and the study of the ionosphere.

The Report, published by H.M. Stationery Office, costs 2s. 6d.

N.P.L. Appointments

DR. E. H. RAYNER, having attained the normal age limit, retired from the post of Superintendent of the Electricity Department at the National Physical Laboratory on 31st March. He has been succeeded by Mr. R. S. J. Spilsbury, formerly Principal Scientific Officer in the Department.

A new Department of Light has been formed at the N.P.L. to comprise the former Optics Division of the Physics Department and the Photometry Division of the Electricity Department. Mr. T. Smith, F.R.S., has been appointed Superintendent of the new department as from 1st April.

The Industry

THE address of the sales and administration offices of Marconi-Ekco Instruments, Ltd., is now Ridgmont Road, St. Albans, Hertfordshire.

A new signal generator, Type TF517A, has been introduced by Marconi-Ekco. It has a range of 150–300 Mc/s and is fitted with a 100 db. attenuator accurate to ± 2 db., ± 2μV. Internal modulation is at 400 c/s, 30 per cent. The standard model has an output transmission line of 80 ohms unterminated, 40 ohms terminated and 8 ohms at a tapping.

Another new instrument is the U.H.F. wavemeter, Type TF643, with a range of 20–300 Mc/s in four bands. A single diode operating from a 1.5 volt cell serves as an indicator in conjunction with a microammeter, and there is also provision for head phones.

Manufacturers who now find difficulty in obtaining supplies of manganin wire, may like to know that a British equivalent is available in "Manganamron" made by The Scott Insulated Wire Co., Ltd., Westmoreland Road, London, N.W.9.

A new price list and schedule of communication and allied instruments including signal generators, beat oscillators, multivibrators and oscilloscopes has been received from Watford Instruments (Paul D. Tyers), 7, Devereux Drive, Watford.

Variable Air Condensers*

Determination of Their Residual Parameters

By R. Faraday Proctor, M.Sc., A.M.I.E.E.

(Communication from the Staff of the Research Laboratories of The General Electric Company, Limited, Wembley, England)

SUMMARY.—This paper describes a method of determining the residual parameters (l_c, r_c and R_c of Fig. 1) of a variable air condenser, using only standard apparatus and two fixed condensers with unknown residual parameters.

For the determination of the residual series parameters l_c and r_c the condenser under test C is used as tuning element in a resonant circuit and the equivalent shunt resistance and capacitance of a fixed auxiliary condenser, measured by shunting it across C, assuming in these measurements that C is a pure reactance. The measurements are repeated at the same frequency with a different value of tuning inductance. From the two different answers thus obtained, the residual parameters l_c and r_c are readily calculated.

The residual shunt parameter R_c of the variable condenser is determined in a similar manner by connecting a fixed auxiliary condenser in series with it and determining two values for the apparent equivalent series resistance and capacitance of this auxiliary condenser.

1. Introduction

At frequencies below its resonant frequency, a variable air condenser can be represented, to a close approximation, by the circuit of Fig. 1, where l_c is the effective series inductance of the condenser, r_c the effective series resistance, and R_c is the equivalent shunt resistance of the dielectric supports of the "live" plates.

While the presence of the residual parameters l_c, r_c and R_c of the condenser can usually be ignored at low frequencies, this is not permissible at high frequencies and corrections must be applied to the measurements to allow for the presence of these parameters.

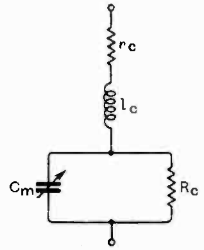


Fig. 1.—*Equivalent circuit of variable air condenser.*

This necessitates a knowledge of the value of l_c, r_c and R_c for the particular condenser.

2. Practical Details Connected with the Determination of the Residual Parameters l_c, r_c, R_c of a Given Condenser by Means of the Formulæ Developed in Section 4.

(a) *Description of Apparatus.*—In the case of an isolated condenser, or one which can be easily removed from the apparatus, the measurement of its residual parameters can be readily carried out by means of the circuit shown in Fig. 2. The resonant circuit L, C is mutually coupled to the H.F. generator. To ensure that there is no electrostatic coupling between the generator and the tuned circuit, an electrostatic screen S is placed between these two portions of the apparatus. The current flowing through the coupling coil is measured by means of a thermal milliammeter i_0. The coupling between the generator and the tuned circuit should be kept sufficiently loose, so that the current flowing through the coupling coil is practically unaffected by any changes made in the impedance of the tuned circuit. The resistance r consists of one of a series of fixed H.F. resistances which dip into small mercury cups. These resistances all have approximately the same inductance. They are constructed of composite lengths of copper and eureka wire of such a gauge that their increase in resistance with frequency due to "skin effect" is negligible, or of a sufficiently low order to enable their H.F. resistance to be accurately estimated. E is a self-biased anode-bend valve voltmeter.

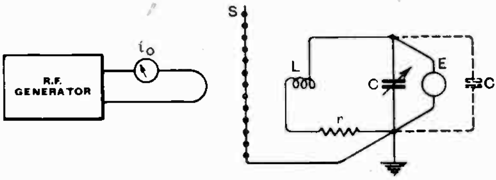


Fig. 2.—*Test circuit for determining the series inductance and the series resistance of a variable condenser.*

---

* MS. accepted by the Editor, February, 1940.

The fixed condenser C_a should be provided with fixing lugs as shown in Fig. 3 so that it may be readily connected directly across the variable condenser C, under test, and take up exactly the same position on reconnection in circuit after each removal.

The importance of this latter point will be apparent from the following: During a measurement of the series inductance of a variable condenser, it was decided to fix small terminals on to the terminals of the variable condenser to enable the fixed condenser C_a to be more readily added and removed without disturbing the configuration of the resonant circuit. These additional terminals had the effect of displacing C_a by approximately 10 millimetres, relatively to the terminal face of the variable condenser, resulting in a change in the effective series inductance of C_a, referred to the terminals of the variable condenser, from 0.0124 μH to 0.029 μH.

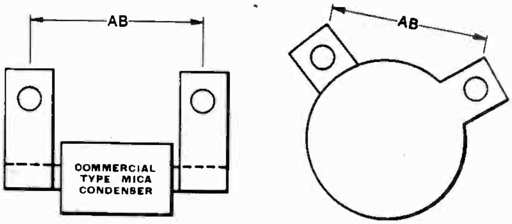


Fig. 3.—*Two examples of suitable constructions for the fixed condenser C_a. The distance AB should be chosen to suit the terminals of the condenser under test.*

A knowledge of the constants of the condenser C_a is not required, since these are eliminated by the method of measurement and do not appear in the final formulae, nor is it necessary that C_a should have a low series inductance. The only requirement of C_a, apart from its approximate magnitude, is that its electrical constants should remain constant throughout the measurements, at any one frequency.

Owing to the loss in accuracy with decrease in frequency, it is advisable to use a fairly high test frequency when determining the values of l_c and r_c. Care should, however, be taken to verify that the test frequency is not so high that the quantities $\omega^4 l_c^2 C_{m1} C_{m2}$ etc., which are neglected in deriving equations 15, 20 and 25, are no longer negligible compared with the remaining terms of the parent equations.

(b) *Determination of l_c.*—The effective series inductance l_c of the variable condenser is determined as follows:

The oscillator is set at some convenient test frequency f and the variable condenser C adjusted until the circuit resonates. Let the "read" (low frequency) value of the capacitance of the variable condenser in this condition be C_{m1}. The fixed condenser C_a is then shunted across the variable condenser and the circuit retuned to resonance. Let the new value of the "read" capacitance be C_{m2}.

Keeping the test frequency constant, the inductance coil L is now changed and the above two measurements repeated. Let the new values of the "read" capacitance be C_{m3} and C_{m4}.

The series inductance l_c of the condenser is then calculated from equation 15 of section 4 (a) viz.

$$l_c = \frac{(C_{m1} - C_{m2}) - (C_{m3} - C_{m4})}{2\omega^2(C_{m1}C_{m4} - C_{m2}C_{m3})} \quad .. \quad (15)$$

(c) *Determination of r_c.*—The measurement of the effective series resistance of the variable condenser is carried out as follows:

With the input current i_0 constant and the resistance $r = r_0$, the circuit is tuned to resonance, and the "read" capacitance of the variable condenser corresponding to this condition noted, as is also the reading of the valve voltmeter. Let these be C_{m1} and E_1 respectively.

The fixed condenser C_a is then shunted across the variable condenser and the circuit re-tuned to resonance. Let the new values of "read" capacitance and voltage be C_{m2} and E_2.

Then it can readily be shown that the apparent shunt resistance R_{m1} of the condenser C_a, assuming the variable condenser to be a pure reactance, is given by

$$R_{m1} = K \cdot \frac{E_2}{E_1 - E_2}$$

The constant K is calculated from the following equation

$$K = \frac{1}{\omega^2 C_1^2 R_1}$$

where R_1 is the total effective series resistance of the resonant circuit determined by means of adding a known series resistance, as described in section 4 (d), and C_1 is the total and 6

$$C_a \doteq C_{x1} - C_{x2} = \frac{C_{m1}}{1 - \omega^2 l_c C_{m1}} - \frac{C_{m2}}{1 - \omega^2 l_c C_{m2}} \quad \ldots \quad \ldots \quad (11)$$

Similarly, for the case of the second value of inductance coil,

$$C_a \doteq C_{x3} - C_{x4} = \frac{C_{m3}}{1 - \omega^2 l_c C_{m3}} - \frac{C_{m4}}{1 - \omega^2 l_c C_{m4}} \quad \ldots \quad \ldots \quad (12)$$

$$C_{m1} - C_{m2} = C_a(1 - \omega^2 l_c C_{m1})(1 - \omega^2 l_c C_{m2}) \quad \ldots \quad \ldots \quad (13)$$

$$C_{m3} - C_{m4} = C_a(1 - \omega^2 l_c C_{m3})(1 - \omega^2 l_c C_{m4}) \quad \ldots \quad \ldots \quad (14)$$

$$(C_{m1} - C_{m2})(1 - \omega^2 l_c C_{m3})(1 - \omega^2 l_c C_{m4}) = (C_{m3} - C_{m4})(1 - \omega^2 l_c C_{m1})(1 - \omega^2 l_c C_{m2})$$

which on multiplying out and neglecting

$$\omega^4 l_c^2 C_{m1} C_{m2}(C_{m3} - C_{m4})$$

and $\omega^4 l_c^2 C_{m3} C_{m4}(C_{m1} - C_{m2})$,

which are small compared with the remaining terms, reduces to

$$l_c = \frac{(C_{m1} - C_{m2}) - (C_{m3} - C_{m4})}{2\omega^2(C_{m1} C_{m4} - C_{m2} C_{m3})} \quad \ldots \quad (15)$$

(b) *Derivation of equation 20 used in section 2 (c) for the determination of r_c.*—Referring to section 2 (c) let R_{x1} be the equivalent shunt resistance, and let C_{x1} be the equivalent shunt capacitance of the variable condenser when adjusted to resonate with the first value of inductance coil, corresponding to a " read " capacitance of C_{m1}, and let R_{x2} and C_{x2} be the values when C_a is shunted across the variable condenser. Then from equation 9

$$\frac{1}{R_{x1}} = \frac{1}{R_c}(1 + \omega^2 l_c C_{x1})^2 + \omega^2 C^2_{x1} r_c \quad \ldots \quad (16)$$

$$\frac{1}{R_{x2}} + \frac{1}{R_a} = \frac{1}{R_c}(1 + \omega^2 l_c C_{x2})^2 + \omega^2 C^2_{x2} r_c + \frac{1}{R_a} \quad \ldots \quad \ldots \quad (17)$$

where R_a is the equivalent shunt resistance of the added condenser C_a. Subtracting equation 16 from equation 17 gives the apparent shunt resistance of C_a as measured, assuming the variable condenser to be a pure reactance, namely R_{m1}.

$$\frac{1}{R_{m1}} = \frac{1}{R_c}\left[(1 + \omega^2 l_c C_{x2})^2 - (1 + \omega^2 l_c C_{x1})^2\right] + \omega^2 r_c(C^2_{x2} - C^2_{x1}) + \frac{1}{R_a}$$

$$\frac{1}{R_{m1}} \doteq \frac{1}{R_c}\left[1 + 2\omega^2 l_c C_{x2} - (1 + 2\omega^2 l_c C_{x1})\right] + \omega^2 r_c(C^2_{x2} - C^2_{x1}) + \frac{1}{R_a}$$

$$\frac{1}{R_{m1}} \doteq \omega^2(C_{x2} - C_{x1})\left[\frac{2l_c}{R_c} + r_c(C_{x2} + C_{x1})\right] + \frac{1}{R_a} \quad \ldots \quad \ldots \quad (18)$$

Similarly with the second value of inductance coil

$$\frac{1}{R_{m2}} \doteq \omega^2(C_{x4} - C_{x3})\left[\frac{2l_c}{R_c} + r_c(C_{x4} + C_{x3})\right] + \frac{1}{R_a} \quad \ldots \quad \ldots \quad (19)$$

Subtracting equation 19 from equation 18, noting that $C_{x4} - C_{x3} = C_{x2} - C_{x1}$ gives after rearrangement

$$r_c = \frac{\dfrac{1}{R_{m1}} - \dfrac{1}{R_{m2}}}{\omega^2[C^2_{x2} - C^2_{x1} - (C^2_{x4} - C^2_{x3})]} \quad \ldots \quad (20)$$

(c) *Derivation of equation 25 used in section 2(d) for the determination of R_c.*—Referring to section 2 (d) let r_{x1} be the equivalent series resistance of the variable condenser when adjusted to resonate with the first value of inductance coil, and let the equivalent shunt capacitance of the condenser be C_{x1}, corresponding to a " read " capacitance of C_{m1}. Further let the corresponding values be r_{x2}, C_{x2} and C_{m2} when the condenser C_a has been inserted in series. Then from equation 10

$$r_{x1} = \frac{(1 + \omega^2 l_c C_{x1})^2}{\omega^2 C^2_{x1} R_c} + r_c \quad \ldots \quad (21)$$

$$r_{x2} + r_a = \frac{(1 + \omega^2 l_c C_{x2})^2}{\omega^2 C^2_{x2} R_c} + r_c + r_a \quad \ldots \quad (22)$$

where r_a is the equivalent series resistance of the added condenser C_a.

Subtracting equation 21 from equation 22 gives the apparent series resistance of the condenser C_a namely r_{m1}

$$r_{m1} = \frac{(1 + \omega^2 l_c C_{x2})^2}{\omega^2 C^2_{x2} R_c} - \frac{(1 + \omega^2 l_c C_{x1})^2}{\omega^2 C^2_{x1} R_c} + r_a$$

$$r_{m1} \doteq \frac{1}{\omega^2 R_c}\left[\frac{1}{C^2_{x2}} - \frac{1}{C^2_{x1}}\right] + \frac{2l_c}{R_c}\left[\frac{1}{C_{x2}} - \frac{1}{C_{x1}}\right] + r_a \quad \ldots \quad \ldots \quad (23)$$

Similarly

$$r_{m2} \doteqdot \frac{1}{\omega^2 R_c}\left[\frac{1}{C^2_{x4}} - \frac{1}{C^2_{x3}}\right] + \frac{2l_c}{R_c}\left[\frac{1}{C_{x4}} - \frac{1}{C_{x3}}\right] + r_a \quad \ldots \quad \ldots \quad (24)$$

Subtracting equation 23 from equation 24 and rearranging gives

$$\frac{1}{R_c} = \frac{\omega^2(r_{m1} - r_{m2})}{\frac{1}{C^2_{x2}} - \frac{1}{C^2_{x1}} - \left(\frac{1}{C^2_{x4}} - \frac{1}{C^2_{x3}}\right)} \quad \ldots \quad (25)$$

(d) *Determination of the series resistance of the resonant circuit.*—The series resistance of the resonant circuit is determined as follows.

With the lowest resistance r_0 added to the circuit, the circuit is tuned to resonance, and the voltage recorded on the valve voltmeter noted. Let this be E_1.

A resistance r_1 is next inserted, and the new value of the resonant volts noted. Let this be E_a.

Then it can be readily shown that the series resistance of the resonant circuit (with the minimum resistance unit r_0 in circuit) is given by

$$R_1 \doteqdot \frac{(r_1 - r_0)E_a}{E_1 - E_a} \quad \ldots \quad \ldots \quad (26)$$

Correspondence

Velocity-Modulated Beams

To the Editor, The Wireless Engineer

SIR,—The greater part of the letters from Mr. C. Strachey and Mr. D. M. Tombs, published in the May issue, are already answered by my letter preceding theirs in the same issue. I have to tender my sincere apologies for drawing a somewhat hasty conclusion. When my article, which is already accepted, is published, it will become clear how I came to draw this conclusion, also it will be shown how the correct formula was derived.

Meanwhile I would like to offer some comments and explanations.

Mr. Strachey expands his formula (2) into a power series with a factor $2u_0/m$. This seems to me to be an error, and it should perhaps read: $2u_0/\omega m$. Only then is my approximate formula obtained with the first term of the expansion.

I note with interest that Mr. Strachey is also under the impression that Mr. Tombs aimed at a value of optimum drift-tube length given by the maximum density at a plane.

I was, of course, under the same impression, as it seemed to me then—and still does seem—that a graphical method using large finite intervals can only be an inferior substitute when compared with a method employing infinitesimally small intervals. With the latter method it is comparatively simple to find the optimum drift-tube length even in cases where the greatest energy *between two planes* is desired. But starting from a formula derived by a method using finite intervals (in Mr. Tombs' case, 30°) it is impossible to predict the position of optimum energy between two planes, say, 10° apart, as shown in fact by Mr. Tombs' wrong prediction for a limiting value at $0.5\left(\frac{2\pi}{\omega}\right)\cdot\frac{u_0}{m}$. Mr. Tombs' results may be satisfactory for the arbitrarily chosen value of 30°, but their general usefulness is necessarily restricted.

Referring to Fig. A in Mr. Tombs' letter, I note that his guess at my assumption has not quite succeeded. The curve which represents my first equation cuts the $\frac{u}{u_0} = 1$ line at the 180° point and only that curve crosses the $\frac{u}{u_0} = 1$ line vertically. The curve which Mr. Tombs describes as giving a vertical non-re-entrant line would perhaps be better described as a curve which has a vertical tangent at the point of inflexion. (At X.)

Regarding Fig. B, I have inserted the values for $\left(\frac{\omega}{2\pi}\cdot\frac{1}{u_0}\right)S'$ derived from the correct formula (using the correction factor c), and I find that they coincide exactly with the curve (c) of that figure. This is rather surprising, considering that this curve (c) has been found with a graphical method using 15° intervals. Unfortunately the curves are not drawn farther than $m = 0.2$; unfortunately, because it is between $m = 0$ and $m = 0.2$ that my approximate formula comes very near to the correct formula.

I would like to mention that I had an opportunity of putting that approximate formula to a practical test before publishing it. In an article: "Experimental proof of phase-focusing" by L. Mayer in *Zeitschrift fur technische Physik*, Vol. 20, No. 2, 1939, p. 38, the following operating conditions are mentioned:

$V_b = 330$ volts
$\hat{v} = 52$ volts
$(m = 0.158)$
$\omega = 2\pi \times 1.19 \times 10^8$
$S' = 18$ cms.

Inserting these values in the approximate formula

$$S' = \frac{1}{\pi}\left(\frac{2\pi}{\omega}\right)\frac{U_0}{m}, \text{ (where } U_0 = 5.9 \times 10^7\, V_b\text{)}$$

I found 18.2 cms. for S'!

RUDOLF KOMPFNER.

London, S.E.24.

[A copy of the above letter was sent by the writer to Mr. Strachey, from whom we have received the following note for publication.—ED.]

"Mr. Kompfner is, of course, right when he points out that the expansion of the formula (2) external tuning capacitance, namely the read capacitance C_{m1}, corrected for its inductance l_c plus the input capacitance of the valve voltmeter, etc.

$$C_1 = \frac{C_{m1}}{1 - \omega^2 l_c C_{m1}} + C_v$$

A repeat test using a different value of inductance coil gives

$$R_{m2},\ C_{m3} \text{ and } C_{m4}$$

The value of r_c is then calculated from equations 4 and 20, namely

$$r_c = \frac{\dfrac{1}{R_{m1}} - \dfrac{1}{R_{m2}}}{\omega^2[C^2_{x2} - C^2_{x1} - (C^2_{x4} - C^2_{x3})]} \quad .. \quad (20)$$

$$C_x = \frac{C_m}{1 - \omega^2 l_c C_m} \quad .. \quad .. \quad (4)$$

(d) *Determination of R_c.*—The test conditions required by equation 25 of section 4 (c) cannot be realised very readily in practice, owing to the presence of stray earth capacitances, but are approached fairly closely by the circuit of Fig. 4 if the earth capacitances of r and C_a are kept small. In Fig. 4 the valve voltmeter has been placed across the inductance coil, in lieu of across the variable condenser, so that C_a may be inserted into the circuit directly in series with the latter.

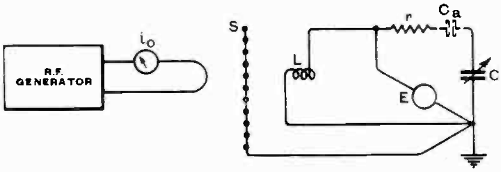


Fig. 4.—*Test circuit for determining the equivalent shunt resistance R_c of a variable condenser.*

The actual determination consists of the four following operations.

(i) The series resistance of the resonant circuit is first determined as described in section 4 (d), and a note made of the "read" capacitance of the variable condenser C. Let these be R_1 and C_{m1}.

(ii) The fixed condenser C_a is inserted in series with C, and a redetermination of the circuit resistance carried out. Let this new resistance be R_2 and let C_{m2} be the new value of the read capacitance.

Two further similar determinations (iii) and (iv) are then carried out using a different value of inductance coil. Let the results of these latter tests be R_3, C_{m3} and R_4, C_{m4} respectively.

$$r_{m1} = R_2 - R_1$$

and $$r_{m2} = R_4 - R_3$$

The value of R_c is then calculated from equations 4 and 25 namely

$$\frac{1}{R_c} = \frac{\omega^2(r_{m1} - r_{m2})}{\dfrac{1}{C^2_{x2}} - \dfrac{1}{C^2_{x1}} - \left(\dfrac{1}{C^2_{x4}} - \dfrac{1}{C^2_{x3}}\right)} \quad .. \quad (25)$$

$$C_x = \frac{C_m}{1 - \omega^2 l_c C_m} \quad .. \quad .. \quad .. \quad (4)$$

3. Alternative Test Procedure

Equations 15, 20 and 25, enable the evaluation of l_c, r_c and R_c to be carried out with the minimum number of readings.

An alternative method of determining l_c, r_c and R_c giving rather greater accuracy and supplying, at the same time, a check on the independence of the values of l_c, r_c and R_c on the setting of the variable condenser, is briefly as follows. This method, however, involves the taking of a greater number of readings than required in the method described in section 2, and is generally not worth while.

Multiplying out equation 13 and neglecting the term $\omega^4 l_c^2 C_{m1} C_{m2}$ which is small compared with the remaining terms, gives

$$C_{m1} - C_{m2} = C_a - \omega^2 l_c C_a (C_{m1} + C_{m2})$$

Tests are carried out as described in section 2, with a series of different inductance coils, and the values of $C_{m1} - C_{m2}$ and $C_{m1} + C_{m2}$ noted.

Plotting $C_{m1} - C_{m2}$ against $C_{m1} + C_{m2}$ will give a straight line, if l_c is independent of the setting of the condenser. The intercept of this line with the y axis gives the value of C_a and the slope of the line $\alpha = \omega^2 l_c C_a$

whence $$l_c = \frac{\alpha}{\omega^2 C_a}$$

Rearranging equation 18 gives

$$\frac{1}{R_{m1}} \doteqdot \omega^2 (C_{x2} - C_{x1}) \frac{2l_c}{R_c} + \frac{1}{R_a} + \omega^2 r_c (C_{x2} - C_{x1})(C_{x2} + C_{x1})$$

Proceeding as before and plotting the value of $1/R_{m1}$ against $C_{x2} + C_{x1}$ will give a straight line having a slope

$$\alpha = \omega^2 r_c (C_{x2} - C_{x1})$$

whence $$r_c = \frac{\alpha}{\omega^2 (C_{x2} - C_{x1})}$$

Similarly, rearranging equation 23 gives

$$r_{m1} \doteqdot \frac{1}{\omega^2 R_c}\left(\frac{1}{C_{x2}} - \frac{1}{C_{x1}}\right)\left(\frac{1}{C_{x2}} + \frac{1}{C_{x1}}\right) + \frac{2l_c}{R_c}\left(\frac{1}{C_{x2}} - \frac{1}{C_{x1}}\right) + r_a$$

Proceeding again as in the two previous cases and plotting r_{m1} against $1/C_{x2} + 1/C_{x1}$ will give a straight line having a slope

$$\alpha = \frac{1}{\omega^2 R_c}\left(\frac{1}{C_{x2}} - \frac{1}{C_{x1}}\right)$$

from which $$R_c = \frac{\dfrac{1}{C_{x2}} - \dfrac{1}{C_{x1}}}{\omega^2 \alpha}$$

An example of this latter method of determining l_c, r_c and R_c will be found in an article by R. F. Field and D. B. Sinclair in the *Proceedings of the Institution of Radio Engineers*, 1936, Vol. 24, p. 255.

Fig. 5.—$C'_m \doteqdot C_m$; $r_d \doteqdot \frac{1}{\omega^2 C^2_m R_c}$

4. Theory of Method

The equivalent circuit of a variable condenser, Fig. 1, can be replaced by Fig. 5, where

$$C'_m \doteqdot C_m \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

$$r_d \doteqdot \frac{1}{\omega^2 C^2_m R_c} \quad \ldots \quad \ldots \quad (2)$$

Fig. 5 can in turn be replaced by Fig. 6, where

$$r_x = r_c + r_d \quad \ldots \quad \ldots \quad (3)$$

$$C_x = \frac{C'_m}{1 - \omega^2 l_c C'_m} \doteqdot \frac{C_m}{1 - \omega^2 l_c C_m} \quad \ldots \quad (4)$$

A further transformation yields Fig. 7 in which

$$R_x \doteqdot \frac{1}{\omega^2 C^2_x r_x} \quad \ldots \quad \ldots \quad (5)$$

$$C'_x \doteqdot C_x \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

From equation 5

$$\frac{1}{R_x} = \omega^2 C^2_x r_x = \omega^2 C^2_x (r_c + r_d)$$

Substituting for r_d from equation 2 gives

$$\frac{1}{R_x} = \omega^2 C^2_x \left(r_c + \frac{1}{\omega^2 C^2_m R_c}\right)$$

$$\frac{1}{R_x} = \frac{\omega^4 C^2_x C^2_m R_c r_c + \omega^2 C^2_x}{\omega^2 C^2_m R_c} \quad \ldots \quad (7)$$

Rearranging equation 4 gives

$$C_m = \frac{C_x}{1 + \omega^2 l_c C_x} \quad \ldots \quad \ldots \quad (8)$$

Fig. 6.—$r_x = r_c + r_d$;

$C_x = \frac{C'_m}{1 - \omega^2 l_c C'_m} \doteqdot \frac{C_m}{1 - \omega^2 l_c C_m}$

Substituting equation 8 in equation 7 gives

$$\frac{1}{R_x} = \frac{\dfrac{\omega^4 C^4_x R_c r_c}{(1 + \omega^2 l_c C_x)^2} + \omega^2 C^2_x}{\dfrac{\omega^2 C^2_x R_c}{(1 + \omega^2 l_c C_x)^2}}$$

which reduces to

$$\frac{1}{R_x} = \frac{1}{R_c}(1 + \omega^2 l_c C_x)^2 + \omega^2 C^2_x r_c \quad \ldots \quad (9)$$

Expressing r_x in terms of R_c, l_c and r_c by means of equations 5 and 9 gives

$$r_x = \frac{(1 + \omega^2 l_c C_x)^2}{\omega^2 C^2_x R_c} + r_c \quad \ldots \quad (10)$$

Equations 4, 9 and 10 form the basis of the method of determining the values of the parameters l_c, r_c and R_c for any given variable condenser.

(a) *Derivation of equation* 15 *used in section* 2(b) *for the determination of* l_c.—Referring to section 2 (b) let C_{m1} be the "read" capacitance of the variable condenser for the tuned circuit alone with the first value of inductance coil, and C_{m2} the corresponding value when the fixed condenser C_a has been added in shunt. Then from equations 4

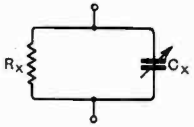


Fig. 7.—$R_x \doteqdot \frac{1}{\omega^2 C^2_x r_x}$;

$C'_x \doteqdot C_x$

in my letter (which is incidentally identical with his own formula revised by his 'correcting factor') should read

$$S' = \frac{2u_0}{m\omega}\left\{1 - \frac{9}{8}m^2 + \frac{243}{128}m^4 + \ldots\right\}$$

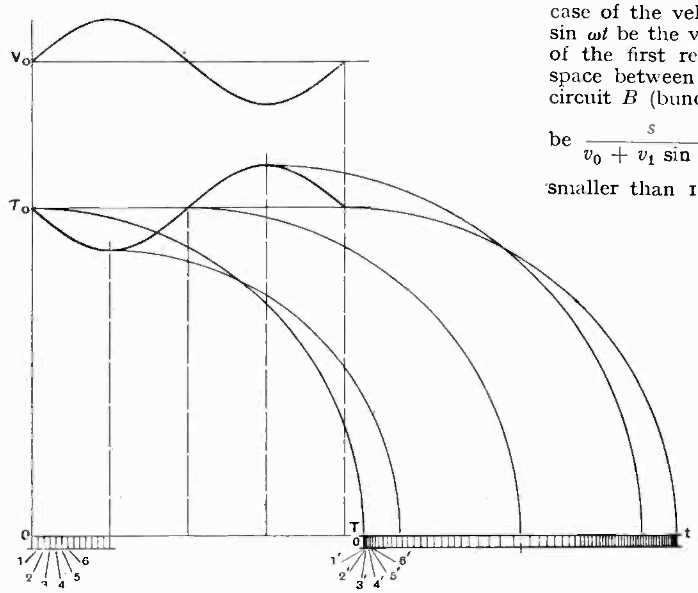
and not

$$S' = \frac{2u_0}{m}\left\{1 - \frac{9}{8}m^2 + \frac{243}{128}m^4 + \ldots\right\}$$

"I am grateful to Mr. Kompfner for pointing out this slip."—C.S.

To the Editor, The Wireless Engineer.

SIR,—In his paper on Velocity-Modulated Beams, published in the February issue of *The Wireless Engineer*, Mr. Martineau Tombs writes that, so far as he is aware, "the principle of velocity modulating a beam of charged particles so that at a distance down the beam the more rapidly moving particles may have caught up to the more slowly moving ones," was first mentioned by Heil in 1935.



It may be of interest to your readers to refer them to the description I gave of the operation of the positive grid type of micro-ray-tube which was used on the Calais-Dover radio link on a 17 cm. wavelength in 1931. This description appeared for instance in the July 1933 issue of *Electrical Communication*.

Briefly speaking, the explanation was the following: electrons leaving the cathode at time t will take a transit time τ to reach the plane of the grid; in the absence of oscillations on the grid and neglecting initial velocity distribution, the transit time τ will remain constant and equal to τ_0. In case, however, the grid is oscillating, the transit time will fluctuate around τ_0 and will have a fundamental component at an angular frequency ω equal to the angular frequency of the grid oscillation. This results in electrons starting at $t + dt$ catching up eventually to electrons which started at t; and the density of the electron beam at the grid plane will fluctuate with a "ω" component. Those electrons which go through the meshes of the grid are driven back later on owing to the retardating field in the grid-plate space. Optimum operation is obtained when the resulting total fluctuation of electron density at the grid is in due phase relation with the grid voltage oscillation.

A corresponding graphical method may be utilised in this case.

Let $V_0 + V_1 \sin \omega t$ be the voltage fluctuation on the grid; the resulting transit time is shown on the figure in a particular instance as $\tau_0 - \tau_1 \sin \omega t$. Electrons leaving at instants 1, 2, 3, 4 . . . will then reach the grid at instants 1', 2', 3' . . . and the density of points 1', 2', 3' will give an idea of the electronic density at the grid plane in the case considered.

This method may be easily transferred to the case of the velocity-modulated beam; let $v_0 + v_1 \sin \omega t$ be the velocity fluctuation due to the action of the first resonant circuit A_1, then if s is the space between circuit A and the second resonant circuit B (bunching space) the time of transit will be $\dfrac{s}{v_0 + v_1 \sin \omega t}$ and in case $\dfrac{v_1}{v_0}$ remains much smaller than 1, this may be written

$$\tau = \frac{s}{v_0}\left(1 - \frac{v_1}{v_0}\sin \omega t\right)$$

The resulting electronic density at circuit B is shown by the linear density of points 1', 2', 3' . . . .

This method can be extended to different kinds of numerical cases and problems and is not limited to the restriction that electrons should not overtake other electrons which left the cathode at a previous instant.

As an instance of the utilisation of the graphical method outlined above, let us find the condition for which electrons will exactly catch up to the previous ones at distance s. As shown on the figure, the maximum of electronic density occurs for electrons starting at $\omega t = 0, 2\pi \ldots$; in order that electron 2, starting very soon after electron 1, may catch up to 1, we must have:

$$\left(\frac{d\tau}{dt}\right)_{t=0} = -1,$$

that is to say

$$\omega \frac{s}{v_0} \cdot \frac{v_1}{v_0} = 1$$

This is the same condition, of course, as that given by Webster in his kinematic analysis of the velocity-modulated tube (*Journal of Applied Physics*, Vol. 10, July, 1939).

Antony, Seine, France. **A. G. CLAVIER.**

Abstracts and References

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

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

PROPAGATION OF WAVES

2128. A DEMONSTRATION OF GUIDED WAVES [Step-by-Step Description of Experiments demonstrating Nature & Properties].—Southworth & others. (*Bell Lab. Record*, March 1940, Vol. 18, No. 7, pp. 194–198.)

2129. THE LAWS OF THE RADIATION OF ELECTROMAGNETIC WAVES IN HOLLOW ULTRA-SHORT-WAVE GUIDES OF RECTANGULAR CROSS-SECTION.—H. Buchholz. (*E.T.Z.*, 8th Feb. 1940, Vol. 61, No. 6, pp. 136–137: summary of article in *Jahrb. AEG-Forschung* 1939.)

The rectangular section is taken for this mathematical analysis because it allows the radiation processes to be investigated for a dipole perpendicular to the tube axis as well as for one parallel to the axis. "Dipoles parallel to the axis produce transverse magnetic or electric fields according to whether a magnetic or an electric dipole is taken as the exciting source; dipoles perpendicular to the axis and parallel to the sides of the section produce longitudinal-section waves of magnetic and electric types for electric and magnetic exciting sources respectively." The investigation of current distribution is made on the same assumptions as are commonly made for wireless aerials: the basic condition of uniform distribution of inductance and capacitance is fulfilled in such wave-guides. For other work by the same writer *see* 412 & 2629 of 1939 and 1301/1302 of April.

2130. ON THE PERMEABILITY OF IRON AND NICKEL FOR HERTZIAN OSCILLATIONS [Wavelengths down to about 16 cm]: EXTENSION OF A PREVIOUS PAPER.—K. F. Lindman. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 21, 1940, pp. 27–30.)

For the previous paper *see* 3026 of 1939. Author's summary:—"By a comparison of the writer's experimental results with some formulae for two parallel wires derived by Laville [in 1924] from Mie's theory, it is shown that these formulae, and also the formula theoretically derived by Sommerfeld for single wires, assuming as they do waves which are undamped in time, hold only approximately for the writer's measurements carried out with waves on wires which were damped in time; and that the observed, but contrary to theory, equality of wavelengths and propagation velocities along very thin single wires and along two similar parallel wires was probably due to deviations of the experimental conditions from the theoretical presuppositions.

"Although the permeability curves, for the iron and nickel wires employed, derived from the writer's measurements by using the Laville formulae differ from the corresponding curves obtained from the Sommerfeld formula, they show, in the same way as these, a steep fall of permeability at decreasing wavelengths if the normal wave is shorter than about 50 cm." A footnote mentions that the Laville formulae are not, it seems, quite correct theoretically: Placinteanu has communicated to the writer an improvement on them, which the latter has found to yield results almost the same as the Laville formulae but agreeing still better with some of his own measurements. *Cf.* 2449.

2131. FREE SPACE PROPAGATION MEASUREMENTS AT 75 MEGACYCLES [in Study of Radiation Characteristics of Aircraft Aerials].—G. L. Haller. (*Journ. Franklin Inst.*, Feb. 1940, Vol. 229, No. 2, pp. 165–180.)

The theory of the errors in propagation measurements due to ground reflection is first given, with curves of reflection coefficient and reflection phase shift as functions of the angle of incidence, and the calculated error due to reflection in the horizontal and vertical fields. A wooden "radiation test tower" was built on which the model aircraft was mounted. The wiring diagrams of the test transmitter and the field-strength meter are given; the propagation curves obtained are shown in Fig. 11. "The recorded values for both horizontal and vertical polarisation taken on the tower follow very closely the theoretical free space curve." Measurement of a transmitter configuration (Fig. 12) including transmission with both vertical and horizontal components gave polar diagrams on the tower which agreed well with calculation (Fig. 13).

2132. A High-Frequency Broadcast-Station Field-Coverage Survey [W8XNU (Cincinnati) on about 26 Mc/s: Car Measuring Equipment: Differences on Hill Slopes facing & away from Transmitter: Effect of Aeroplanes: etc.].—G. F. Leydorf & others. (*Proc. Inst. Rad. Eng.*, Feb. 1940, Vol. 28, No. 2, p. 94.) Summary only, of paper & Discussion.

2133. Research Work on Propagation of Waves [including Ultra-Short] by German P.O.—(*See* 2494, below.)

2134. Diffraction of Radio Ranges by Hills [Scattering of Long Electromagnetic Waves by Hemispherical Obstacles on Conducting Plane applied to Course-Splitting of Radio Range Beacons by Hilly Country].—W. R. Haseltine. (*Phys. Review*, 1st Feb. 1940, Series 2, Vol. 57, No. 3, p. 253: abstract only.)

2135. Propagation of Radio Waves over a Spherical Earth: Experimental Data and Empirical Formulae.—D. Pierucci. (*Boll. tecnico dell' Istituto Militare Superiore delle Trasmissioni* [*Boll. I.M.S.T*], No. 1/2, Year 18, 1939, pp. 33–45.)

2136. Ionic Recombination in Gases [Cause of Apparent Variation with Ionisation Intensity: Equilibrium Ion Density and Electrical Conductivity in the Lower Atmosphere: Rate of Recombination in Argon & Helium, and the Great Influence of Impurities: etc.].—J. Sayers. (*Abstracts of Cambridge Dissertations*, 1938/1939, pub. 1940, p. 154.) Printed at the University Press, Cambridge. *See* also 883 of 1939; *also* Appleton & Sayers, 3432 of 1939.

2137. The Ionisation Loss of Energy [of a Fast Charged Particle] in Gases and in Condensed Materials [Theory based on Classical Electrodynamics: Loss larger in Rarefied Substance than in Condensed One: Application to Cosmic Radiation Problems].—E. Fermi. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, pp. 485–493.)

2138. Wave Form, Energy, and Reflection by the Ionosphere [between 53 and 82 km] of Atmospherics.—Laby & others. (*See* 2184.)

2139. Ozone "Clouds" [Hour-to-Hour Fluctuations of Ozone Density measured at Arosa with Dobson Photoelectric Spectrophotometer].—F. W. P. Götz. (*Helvetica Phys. Acta*, Fasc. 1, Vol. 13, 1940, pp. 3–5: in German.)

2140. Researches on the Physical Theory of Meteor Phenomena: III [including Section on Composition of Upper Atmosphere].—E. Öpik. (*Acta et Commentationes Universitatis Tartuensis* (*Dorpatensis*), Section A, Vol. 33, 1939, pp. 1–69: in English.)

2141. On the Absorption of Short Waves in the Ionosphere [Confirmation of Absorbing D Layer].—A. Shchukin. (*Journ. of Tech. Phys.* [in Russian], No. 15, Vol. 9, 1939, pp. 1393–1400.)

It is pointed out that in addition to the electron density N in the ionosphere the other important factor affecting the absorption of electromagnetic waves is the number of collisions ν of free charges with neutral particles. In the present paper a theoretical analysis is given of the absorption of the waves, in which the effect of ν is taken into account. An equation (eqn. 6b, bottom of p. 1395), expressing in a general form the law of absorption, is derived, and using experimental data a simplified equation (eqn. 8: $D = 2h_e\sqrt{(m\omega^2/4\pi N_c e^2) - 1} \cong 2h_e\omega\sqrt{m/4\pi N_c e^2}$) is obtained, from which the absorption coefficient for the total length of the wave path can be determined.

This analysis confirms the existence of an absorbing D layer below the E layer.

2142. The Association of Meteorological Changes with Variations of Ionisation in the F_2 Region of the Ionosphere.—J. Bannon, A. J. Higgs, D. F. Martyn, & G. H. Munro. (*Proc. Roy. Soc.*, Series A, 21st Feb. 1940, Vol. 174, No. 958, pp. 298–309.)

"A study . . . of the day-to-day variations in the noon values of the maximum electron density in the F_2 region of the ionosphere, at two observing stations near Sydney and Canberra . . . Large day-to-day fluctuations . . . are associated with meteorological changes observed at the ground." Higher values of F_2 ionisation are found to be associated with freedom from "frontal" conditions. "The theoretical difficulties in the way of an explanation of the association here found . . . are discussed . . . current views concerning the seasonal variation of F_2 ionisation in various regions of the earth may require revision. The current view regards the F_2 region ionisation as normally influenced solely by the intensity of solar radiation, thus depending in magnitude solely on latitude. The results here presented suggest that local climatological factors may exert a profound influence on the magnitude, and on the seasonal and diurnal variations, of F_2 ionisation."

2143. On the Existence of a Biannual Component in the F_2-Layer Ionisation [Fluctuation Effects (as Distinct from Secular Effect) analysed into Seasonal & Biannual Effects, proportional to Sunspot Number, and Annual Effect (tentatively suggested as due to Extra-Terrestrial Radiation from Galaxy, and thus as related to Jansky Noise): Biannual Effect suggested as associated with Distribution of Sunspots on Surface].—T. L. Eckersley. (*Terr. Mag. & Atmos. Elec.*, March 1940, Vol. 45, No. 1, pp. 25–36.)

2144. MEASUREMENTS OF F_2-REGION IONISATION OVER NEW ZEALAND [Diurnal Curves show No Marked Morning & Afternoon Maxima in Critical Frequency: Occasional Marked Difference between Critical Frequencies at Christchurch & Wellington, although Magnetic Activity affects Both Stations similarly: etc.].—F. W. G. White, C. J. Banwell, & G. A. Peddie. (*Terr. Mag. & Atmos. Elec.*, March 1940, Vol. 45, No. 1, pp. 37–43.) For a preliminary communication *see* 2651 of 1939.

2145. RELATION BETWEEN ACTUAL AND VIRTUAL IONOSPHERIC HEIGHT.—H. G. Booker & S. L. Seaton. (*Phys. Review*, 15th Jan. 1940, Series 2, Vol. 57, No. 2, pp. 87–94.)

"Translation of virtual height of the ionosphere into actual height is achieved by fitting a parabolic maximum of electron density to observations of variation of virtual height with wave frequency. Methods for measuring the thickness of a region and the height of maximum electron density are described and applied. The simplest measure of the actual height of maximum electron density is the virtual height at five-sixths of the penetration frequency. This measure is found to be remarkably reliable for F region at night. During the daytime it is often necessary to correct F_1 observations for presence of E region, and F_2 observations for presence of F_1 region. A simple technique of correction is described and applied. The disadvantages of minimum virtual height for quantitative study of diurnal variation of ionospheric height are emphasised."

2146. THE RECEPTION OF RADIO ECHOES FROM DISTANT IONOSPHERIC IRREGULARITIES [and Variations in Curvature of F Layer: Wave Motion in Upper Atmosphere].—J. A. Pierce & H. R. Mimno. (*Phys. Review*, 15th Jan. 1940, Series 2, Vol. 57, No. 2, pp. 95–105.)

"Studies of numerous reflection patterns strongly indicate that the delayed echoes are returned from regions where there is marked curvature of the F layer. A region of this sort normally occurs at the edge of the sunlit zone and can turn back a ray which may have travelled many thousands of kilometres around the dark side of the earth. Small night-time variations in the curvature of the F layer are of very common occurrence and are believed to explain several phenomena, including much long-period, long-distance fading. These variations are frequently of cyclic character and may tentatively be attributed to wave motion in the upper atmosphere."

2147. STUDIES OF THE IONOSPHERE AT CALCUTTA [1936/37: Observed Ionisation Variations in Region "E_2" in General Agreement with Chapman's Theory, but with Deviations in Summer, probably due to Frequent Thunderstorms: No Discontinuity found in (P',f) Curves to support "Sporadic E" Hypothesis: Abnormal "E_1" Ionisation and Thunderstorms: Ionisation of "E_2" Region (150–170 km, usually detected by Day but occasionally at Night): F-Region Ionisation (Triple Splitting? etc.)].—J. N. Bhar. (*Indian Journ. of Phys.*, Aug. 1939, Vol. 13, Part 4, pp. 253–276.) Regarding triple splitting, *cf.* for example Kessenikh, 3880 of 1939.

2148. RESEARCHES ON THE IONOSPHERE AT SHANGHAI [with 115 m Pulses: Equipment: Results, particularly the Rapid Echo-Intensity Variations, and Their Explanation as a Result of Turbulence].—P. Lejay. (*L'Onde Élec.*, Jan./Feb. 1940, Vol. 19, No. 217/218, pp. 8–38.)

For previous work *see* 1801 of 1939. The wavelength used in the present observations was chosen for important reasons of local interference; it was too long for F echoes by day, and it was generally near the E critical frequency in the evening and at sunrise, which introduced complications in the measurement of equivalent heights. Reflection factors for the E region were sometimes around 0.8, on days when no multiple echoes were found; for the F region, on occasion, it can have been very little short of unity. "It is at Shanghai a fact of everyday observation: successive echoes are hardly ever of an intensity decreasing regularly from one echo to the next": very often a fifth or seventh echo is as high in intensity as the first, or even higher.

Regarding the rapid fluctuations in the intensity of the echoes, these were of large amplitude, representing field variations from 1 to 10. About once in three times these variations had a clearly periodic character; the period, of the order of from some seconds to a minute, was sometimes constant and sometimes slowly varying. "The phenomenon is too frequent to be attributed to mere chance. Its simplest explanation would be to suppose that the fields of electrons pass in the neighbourhood of the zenith with quite a high velocity and are disturbed by a turbulence analogous to that which forms the cirrus of quasi-periodic character in the upper troposphere. It might alternatively be supposed that there existed an absorption during the passage, due to a cause which itself varied periodically." A footnote suggests a comparison of such a turbulence with that postulated by Combier to explain the deformations in the luminous trail of a large meteor (bolide) "the sinuosities of which were accentuated for at least ten minutes." The footnote continues: "We have already been led to believe that at a lower altitude, in the ozone layer, movements of considerable masses of air must exist; and without having as yet any direct proofs, everything seems to confirm that the high layers of the atmosphere are subject to disturbances which, naturally, would involve movements much more rapid than those which we observe in the troposphere."

An alternative explanation, on the lines of a rotation of the plane of polarisation at reflection, was dismissed after some experiments. But although the latter disproved the rotation of polarisation as a cause of the rapid variations of echo-intensities, they by no means disproved the existence of such rotations; in fact, in one isolated case a definitely positive result was obtained. An appendix deals with the analysis of the radiation from a two-loop aerial designed specially for vertical radiation. This is an improved form of the single-loop arrangement actually employed, which was analysed earlier (pp. 11–18.)

2149. The Reflection of Very Long Wireless Waves from the Ionosphere [Experimental & Theoretical Work].—M. V. Wilkes. (*Abstracts of Cambridge Dissertations*, 1938/1939, pub. 1940, pp. 156–157.) Printed at the University Press, Cambridge. *See* also 3884 of 1939 and back references.

2150. The Ionosphere at Watheroo, July/Sept. 1939, *and* The Ionosphere at Huancayo, July/Sept. 1939. — Parkinson & Prior: Wells. (*Terr. Mag. & Atmos. Elec.*, March 1940, Vol. 45, No. 1, pp. 45–47: pp. 49–52.)

2151. The Bearing of Recent Ionospheric Studies on Commercial Short-Wave Communication [Overhead Expenses would be Reduced, & Dellinger Effect Overcome, by Increase (1.5 or 2 Times) of Present Frequencies for Daylight Paths, except in Summer].—K. Ohno. (*Jap. Journ. of Engineering, Abstracts*, Vol. 18, 1939, p. 87.)

2152. Pulsations in an Ionised High Zone of 650–800 km during the Appearance of Giant Pulsations in the Geo-magnetic Records.—L. Harang: Leithäuser. (*Funktech. Monatshefte*, Jan. 1940, No. 1, p. 13.)

A review of Harang's paper in *Terr. Mag. & Atmos. Elec.* for March 1939, in which the writer's results during the abnormal magnetic pulsations of Dec. 1938 are described. Using an 11 Mc/s frequency and a transmitter sending out 50 kw pulses, he obtained echoes from heights between 700 and 2500 km during the last days of December, and moreover found "the remarkably interesting fact" that during the abnormal magnetic pulsations the heights between 650 and 800 km showed pulsations of just the same period (116 seconds); so that this type also of magnetic disturbance owes its origin to processes in the ionosphere.

Leithäuser points out the resemblance of these pulsations to the relaxation oscillations in a gaseous-discharge-lamp circuit containing a condenser. "If the electrons arriving from the sun are concentrated by magnetic deflection towards the polar regions and are there able to produce a space charge, the discharge of this (to the accompaniment of weak auroral displays) might give rise to a completely similar pulsating process . . . This would also explain the great regularity of the period."

2153. Magnetic Storms and Disturbed Days at Alibag, 1938, *and* Magnetic Notes for January, 1940.—M. R. Rangaswami. (*Current Science*, Bangalore, Feb. 1940, Vol. 9, No. 2, pp. 90–91: p. 91.)

2154. On the Variation of Magnetic Character-Numbers at Dombaas Observatory [including Comparison with Sunspot Numbers: Parallelism obtained by Two-Years' Displacement of Scale of Years].—K. F. Wasserfall. (*Terr. Mag. & Atmos. Elec.*, March 1940, Vol. 45, No. 1, pp. 1–4.) "No opinion is ventured regarding physical justification of this displacement."

2155. Theory of Terrestrial Magnetism.—D. R. Inglis & E. Teller: Elsasser. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, p. 568: abstract only.) Discussion and extension of work dealt with in 2254 & 2659 of 1939.

2156. Principal Magnetic Storms.—(*Terr. Mag. & Atmos. Elec.*, March 1940, Vol. 45, No. 1, pp. 44, 48, 107–111.)

2157. Agincourt Magnetic Data 1899–1937 and the Sunspot Cycle [*D*, *H*, & *V* can all be expressed as Linear Functions of Wolfer Sunspot Number].—W. E. W. Jackson. (*Sci. Abstracts*, Sec. A, 25th March 1940, Vol. 43, No. 507, p. 183.)

2158. Sunspots, Bright Eruptions, and Magnetic Storms [including Relation of H and K and H_a to "Bright Patches," of "3" & "2" Bright Eruptions to Magnetic Storms, and of Bright Eruptions to Sudden Fade-Outs: Solar Flares of Ultra-Violet Light may have Common Point of Origin with Corpuscular Streams].—H. W. Newton. (*Sci. Abstracts*, Sec. A, 25th March 1940, Vol. 43, No. 507, p. 183.) *Cf.* Lisman, 1755 of May. For a previous letter *see* 449 of 1937.

2159. Auroras and Sunspots [Study of 55-Year Record at Blue Hill Observatory: Aurora Frequency shows Marked Double Annual Period: Maximum Number of Spots in Central Area occurs One Day before Aurora: Effect of Size & Latitude of Spots: etc.].—H. H. Clayton. (*Terr. Mag. & Atmos. Elec.*, March 1940, Vol. 45, No. 1, pp. 13–17.)

2160. On Some Recently Detected Important Variations within the Auroral Spectrum [Occurrence of H-Lines must be due to Showers of Hydrogen or to a "Hydrogen-Radiation" occasionally coming from Sun: etc.].—L. Vegard. (*Terr. Mag. & Atmos. Elec.*, March 1940, Vol. 45, No. 1, pp. 5–12.)

"The radiation producing the atmospheric changes [formation of ozone and atomic oxygen & nitrogen?] . . . cannot be only the ultra-violet part of the temperature radiation, but mainly the radiation of the X-ray type, the existence of which has been assumed to account for the distribution of matter and ions in the auroral region."

2161. Variation of the Lower Boundary of the Aurora Borealis at the Transition from the Dark to the Sun-Lit Atmosphere [and Observations on the Behaviour of Ionospheric Layers during Auroras].—L. Harang: Leithäuser. (*Funktech. Monatshefte*, Jan. 1940, No. 1, pp. 13–14.)

A review of Harang's paper in *Gerlands Beiträge*, No. 2, Vol. 54, 1939. The table shows that when the earth's shadow fell at 100 km height, the auroral height was about 107 km, which increased to 120 km as the shadow fell to 50 km. The writer attributes this result to thermal expansion of the atmosphere under the influence of the solar radiation. Leithäuser points out, however, that from the Tromsö investigations reported by Fränz (851 of

1937) it can be deduced that an ionising effect may be added to the thermal effect.

Harang's observations also confirmed the frequent occurrence, noted by other workers, of a strongly reflecting layer at 125 km when an aurora is illuminated by the sun; its critical frequency is high, for example 7.6 Mc/s. On days free from aurora an F layer occurs at 240–300 km with a smaller critical frequency, around 6 Mc/s.

2162. Auroras, Radio Field-Strengths, and Solar Activity [1917/1939 Blue Hill Auroral Records compared with Zürich Sunspot Numbers: Lag between Major Solar Activities & Major Auroral Effects (consistent with Grotian's "Low-Velocity Particles"): Radio Transmission on a Broadcast Frequency: Magnetic Character-Figures and Auroral Dates].—H. T. Stetson. (*Terr. Mag. & Atmos. Elec.*, March 1940, Vol. 45, No. 1, pp. 77–86.)

"While Fig. 5 indicates that changes in atmospheric ionisation attending sunspot activity is on the average followed a day later by peak performances in auroral displays, another day elapses before the ionisation of the E layer is so affected as to produce minimum field strengths over the transmission path from Chicago to Boston. Since, if there is a direct solar effect, one might well expect E-layer disturbances would follow changes in the ionisation of the higher F region, observational data of transmission in the F region might be hoped to yield an intermediate lag." Transoceanic records, investigated for such a result, indicate a half-day lag. For Grotian's paper *see* 26 of January.

2163. Night-Sky Light and Nocturnal E-Layer Ionisation [Simultaneous Investigation shows "Practically No Correlation": Possible Reasons (Nocturnal E Ionisation may consist of Patches or Clouds: Sporadic Variations in Ion-Density with Periods below 3 Minutes would cause Many Coincidences to be Missed, owing to Time Constant of Photocell Circuit: etc.)].—N. E. Bradbury & W. T. Sumerlin. (*Terr. Mag. & Atmos. Elec.*, March 1940, Vol. 45, No. 1, pp. 19–24.) For previous work see 2656 of 1939: for a summary of the present paper see *Phys. Review*, 1st Feb. 1940, Vol. 57, No. 3, pp. 249–250.

2164. Levels of Emission of Night-Sky Spectra [Different Mechanisms responsible for Radiation of Auroral Green Line High in Atmosphere and Nitrogen Lines as Low as Ozonosphere].—J. Kaplan. (*Phys. Review*, 1st Feb. 1940, Series 2, Vol. 57, No. 3, p. 249: abstract only.)

2165. Origin of the Yellow Line in Twilight and the Night Sky Luminescence [is the D_1D_2 Doublet of Sodium].—E. Tönsberg & L. Vegard. (*Nature*, 13th April 1940, Vol. 145, pp. 588–589.)

2166. The Absorption of the Yellow Twilight Ray by Sodium Vapour.—A. Kastler. (*Comptes Rendus*, 8th April 1940, Vol. 210, No. 15, pp. 530–532.)

2167. Green Corona Line 5303 A.U. [Convincing Evidence of Direct Connection between Regions of Intense Line-Emission and Terrestrial Magnetic Disturbances: etc.].—M. Waldmeier. (*Sci. Abstracts*, Sec. A, 25th March 1940, Vol. 43, No. 507, p. 184.)

2168. Spectrum of the Night Sky and Zodiacal Light.—C. Hoffmeister. (*Sci. Abstracts*, Sec. A, 25th March 1940, Vol. 43, No. 507, p. 184.)

2169. Predictions of Normal Radio Critical Frequencies related to Solar Eclipses in 1940 [Annular of 7th April and Total of 1st October].—N. Smith. (*Journ. of Res. of Nat. Bur. of Stds.*, Feb. 1940, Vol. 24, No. 2, pp. 225–228.)

2170. Law of Solar Rotation [New Formulation: Conclusion that Sunspots & Spectroscopically Observed Solar Surface rotate Identically, Faculae & Flocculi move about 1% More Rapidly, Prominences Still More Rapidly].—R. E. de Lury. (*Sci. Abstracts*, Sec. A, 25th March 1940, Vol. 43, No. 507, pp. 183–184.)

2171. Provisional Sunspot-Numbers for October to December, 1939 [Zürich Observatory].—W. Brunner. (*Terr. Mag. & Atmos. Elec.*, March 1940, Vol. 45, No. 1, p. 18.)

2172. A Big Sunspot [March 20th–April 1st: Accompanying Chromospheric Eruption, Magnetic Storm, Aurora].—(*Nature*, 30th March 1940, Vol. 145, p. 509.)

2173. On the Curve of Energy of the Solar Spectrum [Jungfraujoch Observations].—D. Chalonge & G. Déjardin. (*Journ. de Phys. et le Radium*, March 1940, Series 8, Vol. 1, No. 3, pp. 28–30 S.)

2174. The Composition of the Sun [Opportunity afforded by Annular Eclipse of measuring Infra-Red Radiation from Limb].—O. Struve. (*Science*, 15th March 1940, Vol. 91, Supp. p. 10.)

2175. Light incident on Particles falling in Magnetic Field produces Motion along Lines of Force: Formation of Solar Corona, *and* Light under Certain Conditions exerts Attractive Force on Matter.—Ehrenhaft. (*Science*, 1st March 1940, Vol. 91, Supp. p. 10.) From American Physical Society papers.

2176. Radiation from a Point Charge revolving in a Circular Orbit [Work related to "Rotating Electromagnetic Waves"].—Poritsky. (*See* 2473.)

2177. On Inhomogeneous Plane Waves [with Amplitude, in an Arbitrary Direction in the Plane, varying Exponentially: produced at Refraction on Passage from a Transparent to an Absorbing Medium].—T. Westerdijk. (*Ann. der Physik*, Dec. 1939, Series 5, Vol. 36, No. 8, pp. 696–736.)

From the laboratories of the Batavian Petroleum Company. Sections (1) and (2): Inhomogeneous waves, leading to conclusions regarding propagation in a transparent medium: (i) phase velocity is no longer exclusively dependent on the properties of the medium but depends also on the degree of inhomogeneity b^2 of the wave itself, becoming continually smaller as b increases, and finally approaching zero ($c' = c/\sqrt{\epsilon\mu + b^2c^2/p^2}$); (ii) both the electric and the magnetic vibrations are elliptic, the magnetic vector remaining always in a plane through the Z axis, the plane of the electric vector making an angle V with this plane; $V = \pi/2$ when $b = 0$, and $= \gamma$ when $b = \infty$; (iii) the electric and magnetic vectors lie in the wave plane only at definite instants, and only at these instants does the Poynting vector coincide with the wave normal; the wave plane can therefore only be defined as a phase plane; (iv) no inhomogeneous plane wave can be propagated as a straight ray unless the inhomogeneity b^2 is constant, so that the amplitude A satisfies the differential equation on p. 700; (v) the relation between the Poynting vector and the "ray" of geometrical optics is not so simple as with homogeneous waves: *see* section (5); (vi) all quantities, except the phase velocity (with its derived refractive index) and wavelength, are dependent on the angle γ (*see* Fig. 1) between the gradient and the electric vector in the wave plane; (vii) the real inhomogeneous wave (with elliptic electric and magnetic vibrations) is the real component of the projection of a homogeneous wave (with linear vibration) propagating in an imaginary direction determined by the inhomogeneity.

Section (3): Complex waves (inhomogeneous waves in an absorbing medium): the treatment developed and employed in (2) for a transparent medium, involving a transformation to homogeneous waves with the help of an axis rotation (made up of three partial rotations) through an imaginary angle, is here extended to give the equations for inhomogeneous waves in an absorbing medium; the imaginary angle is now a complex one. Unlike the usual treatment of propagation in an absorbing medium, where the electric force is assumed to be either perpendicular or parallel to the gradient, the orientation of the vibration directions with respect to the gradients is here quite arbitrary: thus equations 20a and 20b, giving the electric and magnetic vibrations (and derived without any use of the Maxwell equations for absorbing media), can be made to give the two special cases by putting $\gamma = 0$ and $\gamma = \pi/2$. The treatment is prefaced, on p. 709, by the proof that the waves which are formed by refraction in an absorbing medium are actually of the type discussed, with constant inhomogeneity $q''^2 \tan^2\phi$ determined by the angle of refraction and the medium (Fig. 3).

Sections (4): The Poynting vector, and (5): the relation between the Poynting vector and the ray: with homogeneous waves in a transparent medium the direction of the Poynting vector gives simultaneously the direction of the energy flow, and the integral (26a) gives the mean energy through a given point. With absorbed inhomogeneous waves, however, the vector describes a cone; if the above relations still held good, this would involve the ray also describing this cone, which is an untenable supposition. "It must be remembered that all these complications enter in principle even with the smallest amount of absorption, so that this result would be most unsatisfactory. The difficulty arises even with an absorbed *homogeneous* wave, though it is not so conspicuous." The Poynting vector is therefore analysed into two components, a constant vector remaining unchanged in direction and magnitude (and therefore corresponding to the "ray") and a periodically varying component in a plane which only coincides with the plane of the constant component under special conditions. The planes of the electric, magnetic, and periodic-Poynting vectors intersect in three directions (Fig. 9), and the "ray" (constant component) has the same direction as the line of intersection of the electric and magnetic vectors. This line makes an angle (eqn. 28) with the wave-normal which only becomes zero when one of the quantities k (absorption), b, or $\cos\gamma$ is zero. The intensity of the ray is still given by the mean time-integral of the Poynting vector, but this integration must now be carried out vectorially (eqn. 28a).

Sections (6) and (7) deal with the energy balance and the optical magnitudes n and k, and lead to section (8), on the complex refraction law applying to refraction into an absorbing medium: beginning with a discussion of the result already mentioned in (3), that "the direction of the normal given by the complex refractive index (or the complex refraction law) also lies in the plane of incidence—a fact which hitherto has always been ignored." This complex law is applied to the phenomenon of the disappearance of the critical angle with absorption: in Fig. 13 a zero absorption in the second medium ($k_0 = 0$) gives the Snell's law line with its discontinuity at the critical angle, at A. Absorption (theoretically the slightest absorption) rounds off the discontinuity and causes the disappearance of the critical angle (there is no *total* reflection at an absorbing medium); the curve gets lower and lower as k_0 increases. The intensity of the reflected and refracted light is calculated for the case of the electric vibration perpendicular to the plane of incidence, and Fig. 14 gives the curves (from eqn. 38) for the light intensity reflected from an absorbing medium as a function of the angle of incidence, for five values of k_0 between 0 and 31.6×10^{-4}. "Even the smallest absorption causes the disappearance of the discontinuity, so that in the reflected light also the disappearance of the critical angle is visible." It was the difficulties thus arising in refractometer measurements of the refractive index of liquids that gave rise to this investigation of inhomogeneous waves.

The final section (9) considers the complex refraction in transparent liquids, for total reflection. From section (2) it was seen that an inhomogeneous wave in a transparent medium can be regarded as a homogeneous wave whose normal makes an imaginary angle with the real ray direction. Conversely, from eqn. 39 it may be concluded that the refracted ray emerging at total reflection is produced by an inhomogeneous wave running along in the second medium at the surface of demarcation; the inhomogeneity b is the greater, the greater the angle of incidence, and its value (and the inhomogeneous wavelength λ) can be calculated from the angle between the real inhomogeneous and the complex homogeneous ray-directions, through the formulae on pp. 699 & 705, which yield eqns. 43a & b. The latter equations show that at the critical angle the inhomogeneity is zero: as the angle increases, so does b, while the ray direction remains unchanged. Simultaneously λ becomes steadily smaller, till at $i = \pi/2$ it reaches the value λ_1 (wavelength in first medium). It is now also possible to calculate the amplitude of the refracted ray, and this is done for the case where the electric vibration is perpendicular to the plane of incidence. Finally the Poynting vector and the energy flow for this condition of two transparent media is discussed, and an explanation given of the *apparent* breaking of the energy law by the fact that for all angles of incidence greater than the critical angle there is "total" reflection (reflected amplitude = incident amplitude), in spite of the fact that an energy flow occurs in the second medium.

2178. AN ESTIMATE OF THE ABSORPTION OF AIR IN THE EXTREME ULTRA-VIOLET [380–1600 A.U.].—E. G. Schneider. (*Journ. Opt. Soc. Am.*, March 1940, Vol. 30, No. 3, pp. 128–132.)

2179. COMPUTATION OF TRANSMISSION FACTORS OF ULTRA-VIOLET RADIATION THROUGH WATER, *and* SUBMARINE ILLUMINATION IN PHOTOMETRIC UNITS.—Benford: Utterback & Wilson. (*Journ. Opt. Soc. Am.*, March 1940, Vol. 30, No. 3, pp. 133–135: pp. 136–139.)

2180. FURTHER INVESTIGATION OF THE VELOCITY OF PROPAGATION OF LIGHT *in Vacuo* IN A TRANSVERSE MAGNETIC FIELD [using Michelson Interferometer Method: Effect less than 1 Part in 5×10^8 in Field of 20 000 Oersteds].—C. J. Banwell & C. C. Farr. (*Proc. Roy. Soc.*, Series A, 28th March 1940, Vol. 175, No. 960, pp. 1–25.) For previous work *see* 1932 Abstracts, p. 576.

2181. A QUADRATIC DOPPLER EFFECT [shown by New Formula and confirmed Experimentally].—G. Otting. (*Physik. Zeitschr.*, 15th Nov. 1939, Vol. 40, pp. 681–687.)

2182. NOTE ON THE PHOTOMETRY OF LARGE SOURCES: RÔLE OF THE DIFFUSION OF THE LIGHT BY THE SUSPENDED CORPUSCLES IN THE ATMOSPHERE [Defence of Writer's Statement that a Projected Beam is extinguished More Rapidly than the Light from an Omnidirectional Source].—Marsat. (*Bull. de la Soc. franç. des Élec.*, Jan. 1940, Series 5, Vol. 10, No. 109, pp. 53–63.)

2183. LINEAR EXTENSION OF REFLECTED IMAGE PRODUCED BY A SURFACE TRAVERSED BY WAVES [Sheet of Disturbed Water].—F. C. Auluck. (*Indian Journ. of Phys.*, Nov. 1939, Vol. 13, Part 5, pp. 321–329.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

2184. WAVE FORM, ENERGY, AND REFLECTION BY THE IONOSPHERE, OF ATMOSPHERICS.—T. H. Laby, J. J. McNeill, F. G. Nicholls, & A. F. B. Nickson. (*Proc. Roy. Soc.*, Series A, 1st Feb. 1940, Vol. 174, No. 957, pp. 145–163.)

From the authors' summary:—The atmospherics are received on a vertical aerial which is connected through an aperiodic amplifier to a cathode-ray tube. The spot on the screen of the tube is photographed on a film fixed to the external surface of a cylindrical drum which rotates at a uniform peripheral speed. Many hundreds of wave forms have been recorded from atmospheric sources 70–1500 km distant, and incidental to the observations we have made, evidence has been obtained of the reflection of atmospherics at an ionised layer. Such records show the intervals of time elapsing between the arrival of the first pulse along the ground and the various reflected pulses. From the simple theory and methods of reduction given in the paper, it is possible to determine the height of the reflecting ionised layer and the distance of the flash. . . The height of the layer is found to be between 53 and 82 km. . . . The observations are consistent with the sky wave and the ground wave having the same velocity to 0.7%. Oscillograms of typical atmospheric wave forms are shown, together with a possible interpretation of many of them. The assumption is made that the electrical discharge which radiates an atmospheric is a damped oscillation with a period determined by the instantaneous resistance, inductance, and capacity. The relation between the distance of an atmospheric source and its field strength is found to be linear, and figures are given for the peak power and the total energy radiated as found from representative examples.

2185. DIRECTION-FINDING OF SOURCES OF ATMOSPHERICS, AND SOUTH AFRICAN METEOROLOGY [Results with Cathode-Ray Direction-Finders].—Schonland & Hodges. (*Sci. Abstracts*, Sec. A, 25th March 1940, Vol. 43, No. 507, p. 190.)

2186. AUTOMATIC CATHODE-RAY OSCILLOGRAPHS FOR THE RECORDING OF LIGHTNING CURRENTS.—J. W. Flowers. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, p. 560: abstract only.)

2187. GEOGRAPHICAL DISTRIBUTION OF POINTS STRUCK BY LIGHTNING IN THE AVEYRON DEPARTMENT.—C. Dauzère. (*Comptes Rendus*, 18th March 1940, Vol. 210, No. 12, pp. 442–444.) For similar work on other Departments *see* 934 of March.

2188. THE LOCAL VARIATION OF ATMOSPHERIC POTENTIAL-GRADIENT MEASURED AT TAIHOKU, FORMOSA, JAPAN, *and* COMMENT ON THIS PAPER [questioning Ogasahara's Data on which he bases his Hypothesis of Formation of Alternate Strata of Space Charge and Displacement of One Stratum by Another through Circulation & Subsidence].—K. Ogasahara: O. W. Torreson. (*Terr. Mag. & Atmos. Elec.*, March 1940, Vol. 45, No. 1, pp. 53–68: pp. 69–70.)

2189. Report on Work in Terrestrial Magnetism and Electricity in U.S.S.R. during 1936/1939 [Abstract of Full Report to International Union of Geodesy & Geophysics].—Lazarev & others. (*Terr. Mag. & Atmos. Elec.*, March 1940, Vol. 45, No. 1, pp. 71–76.)

2190. Phenomena in a Cloud Chamber operated without a Sweep Field [and the Possibility of obtaining Information on Diffusion and Recombination of Electrons & Ions, etc.].—A. Ruark & E. Pardue. (*Review of Scient. Instr.*, March 1940, Vol. 11, No. 3, pp. 108–109.)

2191. Ionic Recombination in Gases [Cause of Apparent Variation with Ionisation Intensity: etc.].—Sayers. (*See* 2136.)

2192. The Ionisation Loss of Energy [of a Fast Charged Particle: Application to Cosmic Radiation Problems].—Fermi. (*See* 2137.)

2193. Solar Influences on Cosmic-Ray Intensity at High Elevations.—S. A. Korff. (*Sci. Abstracts*, Sec. A, 25th March 1940, Vol. 43, No. 507, p. 200.)

PROPERTIES OF CIRCUITS

2194. A Generalised Coupling Theorem for Ultra-High-Frequency Circuits [Parallel Lines].—R. King. (*Proc. Inst. Rad. Eng.*, Feb. 1940, Vol. 28, No. 2, pp. 84–87.)

Further development of the work dealt with in 515 of February, to cover the "inverted" or "sine" symmetry of the *E* and *A* fields encountered later when designing the variable oscillator (for u.h.f. measurements) dealt with in 723 of February.

2195. Radiation from a Point Charge revolving in a Circular Orbit [and the Natural Frequency of Electrical Oscillations of a Thin Ring].—Poritsky. (*See* 2473.)

2196. Condenser and Coil Values for the Construction of Filters for All Frequencies from 100 to 10 000 c/s.—J. Schmidt. (*Funktech. Monatshefte*, Jan. 1940, No. 1, pp. 14–15.)

2197. Tone-Frequency Control- and Filter-Quartzes.—Rohde. (*See* 2360.)

2198. Duality of the Lagrangean Equations of Motion in the Fundamental Equations of Networks.—S. Okada. (*Jap. Journ. of Engineering, Abstracts*, Vol. 18, 1939, pp. 89–90.)

2199. On the Theory of [Mechanical] Auto-Oscillations produced by Forces effective by Virtue of Their Position only.—Strelkov. (*See* 2489.)

2200. Frequency Characteristic of Regeneration in a Regenerative Detector, and an Improved Regeneration System.—S. Kanazawa. (*Journ. Inst. Elec. Comm. Eng. Japan*, No. 180, 1938, pp. 154–166: in Japanese only.)

2201. Valve Circuit Conventions.—D. A. Bell: G. W. O. H. (*Wireless Engineer*, April 1940, Vol. 17, No. 199, p. 165.) Discussion on the editorial referred to in 2096 of May.

2202. Valve and Circuit Noises: Designing RF and Frequency-Changer Stages for High Signal/Noise Ratio.—(*Wireless World*, May 1940, Vol. 46, No. 7, pp. 262–265.)

2203. Concerning Thermionic Regulation of D.C. Generators [Theory leading to Quantitative Assessment of Importance of Possible Sources of Instability in Amplifier or Generator].—W. E. Danforth. (*Journ. of Franklin Inst.*, March 1940, Vol. 229, No. 3, pp. 384–386.) Theoretical treatment of thermionic regulator described in 1217 of 1938, condensed from paper dealt with in 4194 of 1939.

2204. A High-Gain Linear Amplifier employing Degeneration [for A.C. Signals or Pulses: Time Constant kept down to 0.001 to improve Counting Resolution].—A. A. Petrauskas & L. C. Van Atta. (*Review of Scient. Instr.*, March 1940, Vol. 11, No. 3, pp. 103–104.) *Cf.* Waddel, 65 of January. An over-all voltage gain of 250 000 is obtained; 0.707 of the maximum is given (in a 2-stage unit) at 250 c/s and 10 kc/s.

2205. D.C. Amplifier [with Successive Stages directly coupled without Use of Batteries].—W. M. Brubaker. (*Phys. Review*, 1st Feb. 1940, Series 2, Vol. 57, No. 3, p. 248: abstract only.)

2206. Table for Determining the Frequency Characteristics of Resistance Amplifiers.—J. G. Lang. (*Funktech. Monatshefte*, Feb. 1940, No. 2, p. 30.)

2207. The Importance of Nyquist Diagrams in the Study of Negative-Feedback Amplifiers and Their Stability, of Filters, etc.—Levy. (In paper dealt with in 2323, below.)

2208. Correction to Equation in "A New Hard-Valve Relaxation Oscillator."—D. H. Black. (*Elec. Communication*, Jan. 1940, Vol. 18, No. 3, p. 252.) *See* 4580 of 1939.

2209. On the Synchronisation of a Thyratron [Saw-Tooth] Oscillator.—Gulyaev. (*See* 2402.)

2210. Gas Discharge Tubes in Quench Circuits.—G. Windred. (*Electronics and Television & Short-Wave World* [formerly *Television*], March 1940, Vol. 13, No. 145, pp. 134 and 136–138.)

2211. The Calculation of the Hum Voltage in Mains Rectifier Circuits [with Simple Approximate Formula].—W. Rentsch. (*Funktech. Monatshefte*, Feb. 1940, No. 2, p. 29.)

2212. The Inductor with Air-Gapped Magnetic Circuit.—G. W. O. H: Glazier. (*Wireless Engineer*, April 1940, Vol. 17, No. 199, pp. 145–146.) Editorial prompted by Glazier's paper (354 of January).

2213. The Application of Fourier Analysis to the Problem of Frequency Multiplication [by Iron-Cored Couplings].—M. Pongratz. (*Hochf:tech. u. Elek:akus.*, Jan. 1940, Vol. 55, No. 1, pp. 19–24.)

In his 1926 theoretical investigation of the iron-cored frequency transformer, Guillemin assumed a primary current approximately sinusoidal thanks to a suitable air-cored inductance in the primary circuit. Kramar's use of a strongly distorted primary current gave a much higher efficiency, as was shown later by Gutzmann (1932 Abstracts, p. 294). Since, however, the object of the present work is to show that the Fourier analysis method can be applied conveniently to such frequency-transforming circuits (in place of the methods hitherto used, which assumed a sudden permeability jump in the iron, yielding voltage pulses in the secondary circuit) the writer limits himself to the simplest case, that taken by Guillemin. The possibility of applying Fourier analysis was mentioned in the latter's paper, "but was not pursued further": but *cf.* Guillemin & Rumsey, 1929 Abstracts, p. 447.

2214. D.C. Excited Iron-Cored Variable Reactance Coil and Current Transformer for Direct Current [including the Use of a Third (Short-Circuited) Winding].—H. Ohasi & S. Wada. (*Jap. Journ. of Engineering, Abstracts*, Vol. 18, 1939, pp. 97–98.)

2215. A Simple Circle Diagram for the Doubly Excited Magnetic Circuit [*e.g.* a Loaded Transformer].—F. Unger. (*E.T.Z.*, 1st Feb. 1940, Vol. 61, No. 5, pp. 101–103.)

2216. The Wattless Circuit-Factor and Its Circle-Diagrams of Transformers with Secondary Condensers.—S. Ozawa. (*Jap. Journ. of Engineering, Abstracts*, Vol. 18, 1939, pp. 95–96.)

TRANSMISSION

2217. Some Electronic and Electrical Measurements at Very High Radio Frequencies [Experiments with Plane-Electrode Triode with Variable Grid/Plate Distance: Importance of Ratio of Inter-Electrode Distances: Method of Absolute Measurement of Impedances at 300 Mc/s: etc.].—R. A. Chipman. (*Abstracts of Cambridge Dissertations*, 1938/1939, pub. 1940, pp. 146–147.) Printed at the University Press, Cambridge. For previous papers *see* 496 of 1936, 2905 of 1938, and 1618 of 1939.

2218. Velocity-Modulated Electron Beams in Crossed Deflecting Fields.—B. Kockel & L. Mayer. (*Jahrb. der AEG-Forschung*, No. 2, Vol. 6, 1939, pp. 72–77.)

The new plan of issuing this *Jahrbuch* three times yearly was referred to in 3841 of 1939. The present paper is the first of a series (*see* below) introduced by general remarks on "electron motion in h.f. fields (transit-time phenomena)," pp. 69–71.

The writers give a theoretical and experimental treatment of the electron motion through an accelerating field and two subsequent crossed deflecting fields, particularly the case of a steady magnetic deflecting field combined with accelerating and electrostatic deflecting fields both having the same frequency. If the transit time is comparable with the a.c. period, while the transit-time differences are not so comparable, then the effect is to produce an apparent phase displacement, constant in time, between the two alternating voltages.

If, however, the transit-time differences also are comparable with the period, effects of catching-up and passing occur among the electrons, giving rise to "velocity modulation" and producing quite different figures on the screen of the cathode-ray tube, since now the phase difference no longer remains constant. A discussion of the figures thus obtained, from the standpoint of first- and second-order "phase focusing" (*cf.* for example Brüche & Recknagel, 2325 of 1938) leads to the theoretical conclusion that with a sinusoidal accelerating field phase focusing of the second order is the more probable. For a long summary see *Hochf:tech. u. Elek:akus.*, Feb. 1940, pp. 53–54.

2219. The Electron Lens with Transit-Time Phenomena, *and* On the Achromatism of Electron Lenses.—A. Recknagel: A. Nesslinger. (*Jahrb. der AEG-Forschung*, No. 2, Vol. 6, 1939, pp. 78–82: pp. 83–85.)

Recknagel calculates the "optical" properties of electrostatic lenses supplied with alternating voltages of such frequency that the period is comparable with the transit time of the electrons; this involves the determination of the motion of the electrons close to the axis, for all starting phases. The use of a "phase screen" is essential for the formation of an image, since the optical properties depend on the starting phase. The refracting power increases linearly with the lens voltage, whereas in the static case it increases as the square. Divergent as well as convergent lenses can be obtained with refracting powers well above those produced under otherwise similar conditions in the static case.

Nesslinger deals with the possibility of obtaining achromatic images with such an arrangement fed with h.f. voltage; that is, with the question whether the same refracting power can be exerted on electrons of different speeds by reason of their different transit times. He finds that at maximum refracting power the lens is chromatically corrected and that the influence of the finite aperture of the "phase screen" is approximately eliminated. The secondary spectrum is smallest when the screen lies immediately in front of the lens.

2220. Velocity Changes of the Electrons in the Deflecting Condenser at Ultra-High Frequencies [Experimental Confirmation of the Theoretical Conclusions regarding Energy Give-and-Take in Cathode Ray].—H. Döring. (*Jahrb. der AEG-Forschung*, No. 2, Vol. 6, 1939, pp. 91–94.)

For a long summary see *Hochf:tech. u. Elek:akus.*, Feb. 1940, pp. 56–57. The energy changes theoretically predicted by Recknagel *see* 2257 of 1938: *also* 1406 of 1939), which can be related directly to the deflection angle, are shown experimentally. The figures are given which occur, for various path-times, if the u.h.f. field produces a horizontal deflection and a combined electric and magnetic field (according to Wien's method of compensated rays) produces a vertical deflection proportional to the energy change.

2221. Model Tests on the Electron-Motion in Alternating Fields [and the Give-and-Take of Energy].—E. Brüche & H. Döring. (*Jahrb. der AEG-Forschung*, No. 2, Vol. 6, 1939, pp. 95–103.)

The field was represented by a V-shaped glass tube pivoted at the base of the "V" and swung backwards and forwards. A ball representing the electron was set going at various phases and amplitudes; the phenomena of energy-interchange, beat effects, etc., were shown. The results lead to a discussion of the damping and regenerating effects as related to cathode and anode "sorting-out" processes (*cf.* also Kockel & Mrowka, 1403 of 1939), in the generation of u.h.f oscillations.

2222. New Transit-Time Devices [Velocity-Modulated "Drift Tubes" for Micro-Waves: Survey].—H. E. Hollmann. (*Funktech. Monatshefte*, Jan. 1940, No. 1, pp. 1–7.)

"Drift tubes" (to use the American designation) are not ultradynamic negative resistances but amplifiers with separate control and output electrodes; they require an external regenerative coupling if they are to generate oscillations. The essential principle was given in the present writer's 1936 patent application, and is discussed with the help of Fig. 1. Haeff's power amplifier is then treated, and section 2 deals with the Hahn & Metcalf drift tube, utilising the "phase focusing" of Brüche & Recknagel (similar to Möller's "phase sorting" in his treatment of the retarding-field oscillator) and resembling in its modulation method the 1935 generator of Arsenjewa-Heil; the electron motion is discussed with the help of Fig. 8. The final section deals with the Varian & Varian "Klystron," including the monitoring of its action by observation, on a fluorescent screen, of the behaviour of the spot representing the spectrally analysed beam: *cf.* the writer's "inversion spectrograph," 274 & 448 of 1939, and 2386, below (Thoma).

2223. Measurement of the Frequency Excursion [Frequenzhub] in Frequency Modulation [Comparison of Three Methods].—H. Bosse. (*Hochf:tech. u. Elek:akus.*, Dec. 1939, Vol. 54, No. 6, pp. 194–198.)

The various methods of measuring the phase excursion ϕ (= $\Delta F/f$, where F is the unmodulated carrier frequency and f the sinusoidal note frequency with which this is modulated: ΔF is the frequency excursion, the maximum departure from the basic frequency) suitable for the determination of unwanted frequency modulation occurring with amplitude modulation, are applicable only for values of ϕ up to about π. In deliberate frequency modulation, however, much higher values of ϕ occur, and those methods are no longer applicable. Of the three applicable methods here described, the first is based on the conversion, by means of a frequency-dependent resistance, of the frequency-modulated oscillation into an amplitude-modulated one, from whose amplitude fluctuations the original frequency excursion is deduced. The great objection is that the measurements are only accurate for the particular value of input voltage used for calibrating the apparatus, since the steepness of slope of the "convertor" characteristic (a series oscillatory circuit is used for the conversion) varies with the input current I; another consequence of this is that errors will also be produced if any unwanted amplitude modulation is present, unless steps are taken to prevent this from reaching the measuring equipment by the use of some amplitude-limiting device.

The second method avoids these defects by so designing the series oscillatory circuit that its resonance frequency F_r can be adjusted to any value in the range covered by the variations of the carrier frequency F_0; that is, from F_1 to F_2 in Fig. 3. This figure shows that when F_r lies anywhere actually inside this range, the voltage U in the negative modulation period sinks *twice* to the value U_r. It is therefore only necessary to determine the arrival at, or departure from, this voltage U_r as the resonance frequency F_r is varied; and this can be done by a cathode-ray tube or, more accurately, by the valve indicator-circuit shown in Fig. 4. Here valve 1 is connected as a rectifier whose l.f. fluctuations of anode current provide, through a resistance R, the grid voltage for valve 2. The grid bias U_{g2} is so adjusted with regard to the peak of the l.f. fluctuation that the whole circuit provides a current I_0 which changes as shown in Fig. 5 with the resonance frequency F_r of the series oscillatory circuit. The appearance of maximum values in this curve is therefore an indication of the arrival at F_1 and F_2, so that from the calibrated scale of the series circuit the frequency departure of the modulation can be obtained as $\frac{1}{2}(F_2 - F_1)$. Practical precautions are discussed at the beginning of p. 196. The average accuracy is within about ± 500 c/s.

Both the above methods demand fairly elaborate apparatus, including a wide-band amplifier. Method 3 has the advantage of requiring only a simple tuned amplifier; it also gives a higher accuracy, at the expense of a limitation of the frequency which can be used for modulation (the other methods allow the use of any desired frequency) since the possible error in the value obtained for the frequency excursion is equal to $\pm f/2$. In principle it is entirely different from the other two methods; an exploring-note technique is employed to determine the frequency-spacing b_m (eqn. 7) between the two sideband-frequencies having maximum amplitudes. The curve of the sideband amplitudes is given by the Bessel function yielding the curve of Fig. 6, and the frequency excursion can be obtained by adding $b_m/2$ and a correction factor c, values of which, calculated for a modulation frequency of 50 c/s, are shown in the curve of Fig. 7. The h.f. exploring frequency need not have an accurately constant amplitude, since only the *positions* of the required sideband-frequencies are needed. Simultaneous amplitude modulation (unless the modulation factor is very large—above 0.8) does not affect the method. Method 2 also is unaffected, and moreover will give correct results even if the frequency-modulated wave is not sinusoidal. This applies to method 3 also, provided that the frequency curve is not too unsymmetrical. "The methods are applicable, by the addition of a frequency-changing stage, to short waves."

2224. A SPECIAL METHOD FOR INCREASING THE EFFICIENCY OF RADIO-COMMUNICATION [by Simultaneous Amplitude and Frequency Modulation].—Tetelbaum. (*See* 2460.)

2225. APPLICATION OF COMPOSITE [Frequency-and-Amplitude] MODULATION TO PROBLEMS OF SIDE-BAND WIDTH CONTRACTION.—Hayasi & Yamagiwa. (*See* 2459.)

2226. ON THE PROPERTIES AND THE DESIGN CALCULATIONS OF AN OSCILLATOR FREE FROM GRID CURRENT AND WITH FREQUENCY ADJUSTMENT [over a Narrow Range of ± 5 c/s about a 1000 c/s Frequency].—W. Zaiser. (*Hochf:tech. u. Elek:akus.*, Jan. 1940, Vol. 55, No. 1, pp. 9–19.)

The recent plan of separating the generating stage from the output stage enables the former to be designed with only limited attention to power relations, with the advantage that improvements in other properties can be introduced. The writer considers three important lines of improvement: (1) the separation of the amplitude stabilisation from its usual dependence on the grid current of the oscillator valve, and the consequent possibility of obtaining an oscillator free from grid current; (2) magnification of sharpness of resonance; and (3) frequency adjustment by phase rotation in the feedback path.

As regards (1), the usual method of stabilisation by grid current results in a distorted anode current. With a separate oscillator stage the amplitude of the anode current is of secondary importance; a large amplitude is not worth paying for by a high harmonic content. There are three chief ways in which the stabilisation can be obtained without grid current: (a) "level control," as in C. H. Walter's German patent No. 108 402 of 1933, where part of the anode a.c. voltage is rectified to give a biasing voltage which controls the amplification factor of the oscillator valve; (b) amplitude-dependent voltage-dividers, arranged so as to vary the feedback factor in accordance with the anode a.c. voltage; and (c) amplitude-dependent bridge circuits. The first of these is selected for the purposes of the paper.

As regards (2), magnification of the sharpness of resonance enables the ratio of Φ (phase rotation in external circuit) to ϕ (resulting phase rotation in the frequency-determining components) to be made large, where otherwise it would not exceed unity (with unity only attainable by marked under-matching). "An oscillator with resonance-sharpness magnification as shown in Fig. 4b, compared with one without as shown in Fig. 4a, will therefore show a far smaller deviation from its resonance frequency for a given phase rotation Φ in the external circuit . . . and if temperature and ageing effects in the oscillatory circuit are compensated, a very high absolute constancy of frequency will be obtained": *cf.* Meacham, 263 of 1939.

As regards (3), the usual way of adjusting the frequency over a small range—by variation of the oscillatory-circuit capacitance—is impossible when the frequency-controlling element is a mechanical one such as a tuning fork, because of the loose coupling between the mechanical and electrical parts of the arrangement; and a mechanical adjustment of frequency is undesirable because of the deterioration of frequency stability. It is here that the method of phase rotation in the feedback path becomes useful, and the oscillator here described is given, by this method, an adjustment of ± 5 c/s about its standard frequency of 1000 c/s, with a frequency constant to within 10^{-4} over the whole of this range. The effect of such a phase rotation on the constancy of amplitude and of frequency is examined closely, and is found to be harmless provided the range of the feedback phase angle is kept down to about ± 45°. This limitation does, however, prevent the employment of the resonance-sharpness magnification system of (2), since this would reduce the frequency-adjustment range below the required 5%.

2227. FREQUENCY CONTROL BY THERMIONIC VALVES [Survey of Modern Methods, including Automatic Tuning Correction].—F. Weitzenmiller. (*Funktech. Monatshefte*, Feb. 1940, No. 2, pp. 17–23.)

2228. THE MONITORING OF BROADCASTING TRANSMITTERS [illustrated by Description of Equipment at the Sottens Station: Complete Test in 4 Minutes].—(*Bull. Assoc. suisse des Élec.*, No. 4, Vol. 31, 1940, pp. 101–104: in French.)

2229. THE APPLICATION OF FOURIER ANALYSIS TO THE PROBLEM OF FREQUENCY MULTIPLICATION [by Iron-Cored Couplings].—Pongratz. (*See* 2213.)

2230. RAFT RADIO: AUTOMATIC SOS TRANSMITTER. —(*Wireless World*, May 1940, Vol. 46, No. 7, p. 241.) Produced by a Danish firm.

RECEPTION

2231. ON THE DETECTION OF FREQUENCY-MODULATED OSCILLATIONS.—V. N. Milstein. (*Journ. of Tech. Phys.* [in Russian], No. 13, Vol. 9, 1939, pp. 1199–1212.)

The limitations of the method suggested by Chaffee (2997 of 1935) for calculating the low-frequency detection products are pointed out and a new method based on the results obtained by Carson & Fry (464 of 1938) is proposed. A formula (14a) with complex coefficients is derived for determining the amplitude variation obtained as a result of frequency detection. The phase characteristic of the detector is taken into account in this formula and no restrictions are imposed on the frequency modulation, but it is assumed that the frequency and phase characteristics of the detector can be expressed by polynomials of the third power. A more general formula (29) is then derived for polynomials of any power. In an appendix the application of formula (14a) to the case of the Armstrong frequency-modulation detector (Fig. 1) is discussed (2550 of 1936).

2232. Remotely Controlled Radio Receiving Systems.—Mossman & others. (*See* 2471.)

2233. Frequency Control by Thermionic Valves [Survey of Modern Methods, including Automatic Tuning Correction].—F. Weitzenmiller. (*Funktech. Monatshefte*, Feb. 1940, No. 2, pp. 17–23.)

2234. Valve and Circuit Noises: Designing RF and Frequency-Changer Stages for High Signal/Noise Ratio. — (*Wireless World*, May 1940, Vol. 46, No. 7, pp. 262–265.)

2235. The Shape of the Characteristic Curve of the Rotating Condenser and Its Influence on the Synchronism [Ganging in Receivers: Linear-Wavelength ("Kidney") Plates: Logarithmic (Exponential) and Linear-Frequency Plates: Tracking in Superheterodynes].—H. Pitsch. (*Funktech. Monatshefte*, Jan. 1940, No. 1, pp. 8–12.) With a number of patent references.

2236. Report of Swiss Committee on Impracticability of Complete Suppression of Interference by Treatment of Sources: Recommendation of Communal Aerial Systems.—(*Bull. de l'Assoc. suisse des Élec.*, No. 24, Vol. 30, 1939, p. 750: in French.)

2237. Communal Distribution and the Local Transmitter [and the Development of a Suitable Filter Circuit].—(*Electronics and Television & Short-Wave World* [formerly *Television*], March 1940, Vol. 13, No. 145, pp. 138–139 and 142.)

2238. "'Pro Radio' Jahrbuch 1938" [Year's Work of This Association in the Suppression of Interference: Book Review].—(*Bull. de l'Assoc. suisse des Élec.*, No. 24, Vol. 30, 1939, p. 759: in German.)

2239. Valves at Low Voltages [60–40 V]: Operating Conditions for a Headphone Portable.—W. T. Cocking. (*Wireless World*, May 1940, Vol. 46, No. 7, pp. 239–241.)

2240. "All-Dry" Valves: Obtaining Good Performance with Low-Wattage [0.07 W] Filaments [Some Osram Types: Practical Problems connected with Their Use].—(*Wireless World*, May 1940, Vol. 46, No. 7, pp. 236–238.)

2241. H.M.V. Battery Receiver Model 1404 [with Special Loudspeaker: Total Anode Current only 5 mA], *and* H.M.V. DC/AC Model 1351.—(*Wireless World*, May 1940, Vol. 46, No. 7, p. 248.)

2242. Test Report: Murphy A90 [designed for War-Time Production: "Highest Possible Performance, particularly on Short Waves, with Economy in Materials & Labour"]. (*Wireless World*, May 1940, Vol. 46, No. 7, pp. 246–248.)

AERIALS AND AERIAL SYSTEMS

2243. The Laws of the Radiation of Electromagnetic Waves in Hollow Ultra-Short-Wave Guides of Rectangular Cross-Section.—Buchholz. (*See* 2129.)

2244. A Generalised Coupling Theorem for Ultra-High-Frequency Circuits [Parallel Lines].—King. (*See* 2194.)

2245. Free Space Propagation Measurements at 75 Megacycles [in Study of Radiation Characteristics of Aircraft Aerials].—Haller. (*See* 2131.)

2246. A New Directive Aerial System [for Short and Ultra-Short Waves: Particularly Rigid Form, and Easy Matching to Feeder].—H. Pigge. (*Hochf:tech. u. Elek:akus.*, Dec. 1939, Vol. 54, No. 6, pp. 190–194.)

Author's summary:—"On the basis of the current and voltage distribution occurring on dipoles of resonant length, a special mode of feeding the individual radiators and their combination to form directing and reflecting dipoles leads to a new type of beam system which possesses certain advantages, particularly as regards feeder matching and mechanical construction. After an explanation of the directive action and the feeding of such a dipole combination, the polar diagram, radiation resistance, and feeder matching are calculated from theory for an experimental model, and investigated experimentally; good agreement between calculated and measured values is found."

The system is covered by a patent application of 8.10.1937. The fundamental principle is explained as follows. If at the extreme end of a feeder E (Fig. 1), which is symmetrical with respect to earth, a dipole of length λ is arranged, and at a distance $\lambda/4$ from it (*i.e.* $\lambda/4$ along the feeder, measured backwards from the end) another similar dipole, then because of the 90° phase difference between equivalent points of the two dipoles the first will act as a "director" or radiator L and the second as an active reflector R; so that, since the two radiation compounds mutually add in the direction of the feeder end and cancel in the backwards direction, a one-sided radiation of energy takes place in the direction of the "director" dipole, *i.e.* to the left. Since a current node is always formed at the end of a dipole, and since each half of the "director" dipole L has a length $\lambda/2$, there must be (if the presence of the "reflector" R is neglected for the moment) a current node at each of the two points a, a where these halves spring from the end of the feeder, and current antinodes at the points a', a', at $\lambda/4$ distance back along the feeder E. In order that the addition of the reflector dipole R at these points may not upset this distribution, each half of this dipole must be made $3\lambda/4$, so that owing to the current nodes at its ends a'', a'' there will also be current antinodes at a', a' (270° phase difference) coinciding with those on the feeder. The resulting current and potential distribution has the following effect: the free ends b, b of the "director" dipole L and the free ends a'', a'' of the "reflector" dipole R are *at equal potentials* (except for slight differences due to changes in the radiation resistances resulting from the additional radiation-coupling and from differences in characteristic impedance) so that the points b and a'' can be directly connected by bending the outer $\lambda/4$ sections of dipole R over at right angles, thus forming the double-rectangle figure (with its advantageous rigidity) shown in heavy lines in Fig. 1. These two bent-over ends carry currents in opposed phase, as shown by the arrows, so that their radiation components cancel out and do not affect the radiation diagram of the pure dipole combination; moreover, the relations between the four transverse wires aa' and bb' are such that the system need not be symmetrical with regard to earth—that is, one half of the system could be used by itself without affecting the radiation diagram.

The fact that the four transverse conductors, taken in pairs, can be regarded as symmetrical transmission lines leads to the possibility of using them as transformers for the matching of the radiation resistances to the feeder (*cf.* Walmsley, 1933 Abstracts, p. 101: *also* Hollmann's *Physik u. Technik der Ultrakurzen Wellen*). This is easily accomplished by a suitable choice of the characteristic impedances of the dipoles and the transverse conductors. The experimental model (Fig. 4) was made of an array of two such systems (spaced $\lambda/2$) to give better concentration in the equatorial plane. The measured polar diagrams (Fig. 6) were slightly better in sharpness of beam than the calculated (Fig. 5) but showed small backward lobes, no doubt owing to imperfect phase and amplitude conditions.

2247. An "S.I.C.E." Cable for High Frequencies [Coaxial Cable with Braided Outer Conductor and Roller-Shaped Distance-Pieces: Curve of Attenuation for 4–20 m Waves].—Soc. Italiana Conduttori Elettrici. (*L'Elettrotecnica*, 25th Jan. 1940, Vol. 27, No. 2, p. 45.)

2248. Special Aerials for Vertical Radiation for Ionospheric Research.—Lejay. (*See* end of 2148, above.)

2249. The Gain and the [Rüdenberg] "Absorption Surfaces" of Large Directive Arrays.—K. Fränz. (*Hochf:tech. u. Elek:akus.*, Dec. 1939, Vol. 54, No. 6, pp. 198–204.)

Rüdenberg in 1908 defined the gain of an array by its "absorption surface" when considered as a receiving aerial, instead of by the ratio of the power received from it to that received from a single dipole radiating the same power. Since the absorption surface of an elementary dipole, independent of its length, is $F_a = 3\lambda^2/8\pi$, the absorption surface of a directive array is connected with the gain g by the equation $F_a = g\lambda^2.3/8\pi$. "The object of the present work is to bring into the simplest possible form the laws controlling this gain, and also to prove them rigidly. The results have a particularly simple form for aerials which are long in terms of the wavelength . . . The calculation of the gain falls into two parts; first, the field-strength diagram is calculated from the current distribution in the aerial, and then the gain is obtained from this by the integral equation 2 . . . The elements of the array are assumed to be excited by equal currents, not necessarily in the same phase."

Section II discusses the particularly simple boundary equations 3a & 3b for the large arrays: 3a applies to "line" arrays (elements polarised perpendicularly to the main dimension of the array) and 3b to "column" arrays (elements polarised in that dimension). These formulae are represented in Fig. 1, the full lines referring to 3a and the dotted line to 3b. For spacings in the neighbourhood of λ the gain of the "line" array sinks very rapidly (in the radiation diagram this is evidenced by the sudden appearance of side lobes). Fig. 2 shows the very marked effect which may be produced by a small spacing change when d is near $n\lambda$: it is assumed that the array is 20λ wide and contains either 20 dipoles (full curve) or 21 (dotted curve). The small change in spacing brought about by the addition of one element produces an enormous effect on the field-strength diagram in the direction perpendicular to the main radiation, while leaving the diagram undisturbed in the direction of that radiation. The gain of a "column" array also varies with its dipole-spacing h_1, but smoothly; when $h_1 = n\lambda$ the subsidiary lobes must form in the direction of the dipole axes, in which direction the individual dipoles do not radiate. Thus at the point $h_1 = n\lambda$ the gain curve of Fig. 1 has only a single point of inflexion.

Section III deals similarly with arrays of medium size ("finite" aerials): the corresponding equations 6 & 7 (*see* also Southworth, 1931 Abstracts, p. 211) are not convenient, and 6 is better replaced by the series in negative powers of N whose first terms are given in 8, which for the most generally employed spacing of $\lambda/2$ becomes simplified to 8a. Section IV discusses the previous results of other workers. Section V gives the mathematical derivation of the equations already discussed and considers the doubling of the gain of a plane array by means of a reflector, the reduced action of a second reflector, and finally the possibility of obtaining an arbitrarily large gain (and absorption surface) with an array of arbitrarily small geometrical surface, by an array of elementary dipoles with a common axis, fed in pairs in opposed phase. If each dipole has the field-strength diagram $\cos \epsilon$, the first pair will (for an infinitely small d) have the diagram $\sin \epsilon \cos \epsilon$, and N pairs the diagram $\sin^N \epsilon \cos \epsilon$, while for large values of N the gain tends towards $4N/3e$, where e is the basis of natural logarithms.

2250. The "Bound" Energy of a Radiating Wire.—V. N. Kessenikh. (*Journ. of Tech. Phys.* [in Russian], No. 17, Vol. 9, 1939, pp. 1557–1563.)

An infinitely long wire and the surrounding space up to a radius R are considered. An e.m.f. $E_0 e^{j\omega t}$ is applied along the wire. The "bound" (or "reserve") energy of this system is defined as follows:—if the e.m.f. is removed, then the average "bound" energy $\overline{U}_j$ is equal to the difference between the average total energy of the system and the average energy radiated through the surface of cylinder R during the time required for the disturbance of the field caused by the removal of the e.m.f.

to reach this surface. It is shown that $\overline{U}_j$ can be determined from a general formula (2). For previous work *see* 1934 Abstracts, pp. 30–31.

2251. All-Wave Aerials: Which is the Best Type for Present-Day Listening?—F. R. W. Strafford. (*Wireless World*, May 1940, Vol. 46, No. 7, pp. 266–269.)

2252. Large Frame Aerial provided for Small Portable Receiver by Wires woven into Shoulder Strap.—(*Wireless World*, May 1940, Vol. 46, No. 7, p. 240.)

2253. Dangerous Catch Phrases [applied to Screened Aerials].—M. G. Scroggie: Green. (*Wireless World*, May 1940, Vol. 46, No. 7, p. 257.) Reply to Green's protest (1863 of May).

VALVES AND THERMIONICS

2254. New Transit-Time Devices [Velocity-Modulated "Drift Tubes" for Micro-Waves: Survey].—Hollmann. (*See* 2222.)

2255. Input Conductance: Measurement in High-Slope H.F. Amplifier Valves [at 37 Mc/s: Electrode-Lead Effects are Predominant Factor: Input Conductance can be reduced to Desired Value by Use of Multiple Cathode Leads: etc.].—F. Preisach & I. Zakarias. (*Wireless Engineer*, April 1940, Vol. 17, No. 199, pp. 147–157.)

2256. The Augetron and Its Applications: *also* The Photo-Augetron and Its Applications [including Television, Film Gramophones, & Optical Telephony]: *and* The Behaviour of the Augetron at High [Radio] Frequencies.—Vacuum Science Products. (*Electronics and Television & Short-Wave World* [formerly *Television*], Jan. 1940, Vol. 13, No. 143, pp. 17–19: Feb., No. 144, pp. 75–76 and 78: March, No. 145, pp. 131–132.)

2257. On the Mode of Action of the Electron Multiplier [of "Pendulum" (Go-and-Return) Type: Theoretical Investigation of a Single Plane Cathode with Electrons brought back by D. C. Field and Superposed H. F. Field].—R. Orthuber & A. Recknagel. (*Jahrb. der AEG-Forschung*, No. 2, Vol. 6, 1939, pp. 86–90: summary in *Hochf:tech. u. Elek:akus.*, Feb. 1940, pp. 51–52.)

For previous work, on the Farnsworth (two-plate) multiplier, *see* 2266 of 1936. Neglecting any effect of the anode field and assuming homogeneous fields, it is found that for optimum conditions the ratio of the d.c. voltage to the alternating voltage should be 0.26, the phase region taking part in the multiplying action being then 35°, instead of 65° as in the two-plate type of multiplier.

2258. Field-Enhanced Secondary Electron Emission.—H. Nelson. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, p. 560: abstract only.) Additional data supporting the hypothesis dealt with in 3171 of 1939.

2259. On Secondary Electron Emission.—N. L. Yasnopol'ski & G. A. Tyagunov. (*Journ. of Tech. Phys.* [in Russian], No. 17, Vol. 9, 1939, pp. 1573–1582.)

It is stated that no satisfactory theory of secondary electron emission has yet been evolved, mainly because no exact information is available on the movement of electrons in the emitters and on the transference of electron energy. In this paper a mathematical discussion is presented, although it is not claimed that it gives more than a qualitative picture of the processes taking place in the emitter. A formula (2) is quoted, determining the impulse transmitted by a primary electron to the emitter electron, and a function (10) is derived determining the distribution of energy in electrons emitted from a metallic surface. A similar function (12) is also derived for the case of a non-metallic surface. The coefficient of secondary emission δ depends on the number of ionisations N caused by a primary electron and the probability of emission q/Q, where q is the number of electrons which may leave the surface as a result of each ionisation by each primary electron, and Q the total number of secondary electrons produced per unit length. Methods are indicated for estimating these factors, and a formula (25) is derived for determining δ.

2260. The Emission from Composite Cathodes under Simultaneous Electron Bombardment and Illumination [Dember and Shmakov Effects].—P. Borzyak. (*Journ. of Tech. Phys.* [in Russian], No. 15, Vol. 9, 1939, pp. 1380–1392.)

The Dember effect (*i.e.* the total secondary electron current from an aluminium surface caused by simultaneous electron bombardment and illumination exceeds the sum of the two currents observed separately) and the Shmakov effect (4152 of 1936: *i.e.* the "negative" action of illumination, under certain conditions, on oxide-caesium cathodes) are discussed, and a report is presented on an experimental investigation undertaken to verify the existence of these two effects in the case of oxide-caesium cathodes. The main conclusions reached are as follows: (a) the Dember effect does not hold good for this type of cathode, *i.e.* the two currents are additive, and (b) the Shmakov effect could not be detected although the same type of cathode was used as in Shmakov's experiments.

2261. On the Nature of Particles emitted from NaCl when irradiated with Electrons.—M. M. Vudynski. (*Journ. of Tech. Phys.* [in Russian], No. 15, Vol. 9, 1939, pp. 1377–1379.)

It has been suggested that the comparatively high coefficient of secondary emission from NaCl is due to the dissociation of negative ions of Cl under electron bombardment. Experiments described in this paper have shown that the particles liberated from NaCl by electron bombardment are mainly electrons and not ions.

2262. On the Velocity Distribution of Secondary Electrons emitted from NaCl.—M. M. Vudynski. (*Journ. of Tech. Phys.* [in Russian], No. 17, Vol. 9, 1939, pp. 1583–1588.)

Report on an experimental investigation; the apparatus used is described and a number of experimental curves are shown. The main conclusions reached are as follows :—(1) The curves showing the velocity distribution of secondary electrons for NaCl do not differ greatly from those of pure metal and composite surfaces ; (2) the position of the maximum of a curve is not greatly affected by the velocity of the primary electrons ; and (3) the number of high-velocity electrons increases somewhat with an increase in the velocity of primary electrons.

2263. On the Secondary Electron Emission from Mercury.—Yu. M. Kushnir, V. I. Milyutin, & V. P. Goncharov. (*Journ. of Tech. Phys.* [in Russian], No. 17, Vol. 9, 1939, pp. 1589–1591.)

The secondary electron emission from mercury was measured at temperatures of −196° C, −80° C, and + 5° C, and was found to be effectively independent of temperature (Fig. 3).

2264. Thermionic Emission, Migration, and Evaporation of Barium on Tungsten [Experiments confirming and extending Earlier Results on Migration : New Information on Activation of Different Tungsten Crystals as Function of Amount of Barium Deposited].—J. A. Becker & G. E. Moore. (*Phil. Mag.*, Feb. 1940, Series 7, Vol. 29, No. 193, pp. 129–139.) *See* 1933 Abstracts, p. 330 ; and *cf.* Benjamin & Jenkins, 551 of 1939.

2265. The Adsorption of Oxygen in Tungsten [Investigation by Method depending on Extreme Sensitivity of Accommodation Coefficient of Neon with Tungsten Surface to Presence of Absorbed Films].—J. L. Morrison. (*Abstracts of Cambridge Dissertations*, 1938/1939, pub. 1940, pp. 132–133.) Printed at the University Press, Cambridge. For a *Proc. Roy. Soc.* paper *see* 3338 of 1939.

2266. The Thermionic Constants of Tungsten as a Function of Crystallographic Direction [Measurements on Long Single Crystals of Tungsten].—M. H. Nichols. (*Phys. Review*, 15th Feb. 1940, Series 2, Vol. 57, No. 4, pp. 297–306.)

2267. The Contact Difference of Potential between Barium and Zinc. The External Work Function of Zinc [Measurement by Retarding Potential Method with Variable Anode : Work Function measured under Optimum Vacuum Conditions is Characteristic of Clean Zinc].—P. A. Anderson. (*Phys. Review*, 15th Jan. 1940, Series 2, Vol. 57, No. 2, pp. 122–127.)

2268. Positive Ion Emission from Nickel [Ions with Relative Masses 58 & 60 : No Emission observed from Iron and Cobalt].—G. A. Jarvis. (*Phys. Review*, 15th Feb. 1940, Series 2, Vol. 57, No. 4, p. 335.)

2269. Campbell's Theorem and Its Application to the Theory of the Shot Effect [Good Results for Temperature-Limited Condition : Space-Charge Conditions & the Control Effect of Electrons which have passed the Barrier : Internal Ordering in Space Charge apparently Non-Linear in Effects of Individual Electrons, can only be treated Roughly].—E. N. Rowland. (*Abstracts of Cambridge Dissertations*, 1938/39, pub. 1940, pp. 111–112.) Printed at the University Press, Cambridge. For previous papers *see* 3958 of 1938 (*also* Campbell, 1477 of 1939).

2270. Testing Amplifier Output Valves by means of the Cathode-Ray Tube [for Comparison of Distortions, etc., in Different Valves : Necessity for Reference to I_a/V_a Diagram and Load-Line : Apparatus and Auxiliary Arrangements for Simultaneous Appearance of Two Diagrams on Screen, with Axes & Calibration Lines : Unusual Arrangement of D.C. Push-Pull Amplifier : Example of Use of Equipment].—A. J. H. van der Ven. (*Philips Tech. Review*, March 1940, Vol. 5, No. 3, pp. 61–68.)

2271. Valve Symbols as used in *Wireless World* Circuit Diagrams [including Cathode-Ray Tube, Barretter, & Tuning Indicator Symbols].—(*Wireless World*, May 1940, Vol. 46, No. 7, p. 250.)

2272. A High-Power Transmitting Triode for Short Waves [Water-Cooled Triode Type E.2006 : Data for Long, Medium, & Short Waves down to 12.4 m].—R. Warnecke & R. Bonne. (*L'Onde Élec.*, Jan./Feb. 1940, Vol. 19, No. 217/218, pp. 39–47.)

2273. Recent Changes in Radio-Tube-Manufacturing Technique [particularly from Introduction of Loktal Types].—R. M. Wise. (*Proc. Inst. Rad. Eng.*, Feb. 1940, Vol. 28, No. 2, p. 94 : short summary only.)

2274. Improved Repeater Tubes [Mica-Disc Support at Top of Electrode Structure : Insulation improved Ten Times (Use of Fluffy Insulating Layer to increase Conducting Path across Mica, etc.) : Life increased Several Times].—G. E. Moore. (*Bell Lab. Record*, March 1940, Vol. 18, No. 7, pp. 219–222.)

2275. Standardisation of R.C.A. Valves [with Preferential List : Example for British Manufacturers].—(*Electronics and Television & Short-Wave World* [formerly *Television*], March 1940, Vol. 13, No. 145, p. 113.)

2276. "All-Dry" Valves [Some Osram Types].—(*See* 2240.)

2277. "The Wireless World" Valve Data, 1940 [with Key to Base Connections].—(*Wireless World*, May 1940, Vol. 46, No. 7, pp. 249–255 and Advert. pp. 11–31.)

DIRECTIONAL WIRELESS

2278. Diffraction of Radio Ranges by Hills.—Haseltine. (*See* 2134.)

2279. DIRECTION-FINDING OF SOURCES OF ATMOSPHERICS, AND SOUTH AFRICAN METEOROLOGY [Results with Cathode-Ray Direction-Finders].—Schonland & Hodges. (*Sci. Abstracts*, Sec. A, 25th March 1940, Vol. 43, No. 507, p. 190.)

2280. CATHODE-RAY DIRECTION-FINDERS.—J. T. Henderson. (*Proc. Inst. Rad. Eng.*, Feb. 1940, Vol. 28, No. 2, p. 94: short summary only.)

2281. TELEVISION RANGE-FINDERS [Size of Spot on Screen made to Vary with Strength of Signal, indicating Distance].—A. N. Goldsmith. (*Electronics and Television & Short-Wave World* [formerly *Television*], Nov. 1939, Vol. 12, No. 141, p. 625: paragraph only.)

2282. A DISTANCE METER [based on Optical Effect observed when passing Two Fences, one behind the other: Applicable also to Velocity Measurement].—Lau. (*Zeitschr. f. Instrumentenkunde*, Sept. 1939, Vol. 59, No. 9, pp. 369–372.)

ACOUSTICS AND AUDIO-FREQUENCIES

2283. ON THE DESIGN OF A UNIDIRECTIONAL MICROPHONE.—V. K. Jofe. (*Journ. of Tech. Phys.* [in Russian], No. 13, Vol. 9, 1939, pp. 1213–1217.)

A mathematical analysis of the operation of the condenser-type of unidirectional microphone proposed by Braunmühl & Weber (1039 of 1936). Equations 3 and 4 are derived for the velocity of the "front" diaphragm of the microphone when the source of sound is (a) in front, and (b) at the rear of the microphone. By equating (4) to zero conditions are established, depending on the dimensions of the microphone and the upper frequency limit, which are necessary for obtaining a unidirectional effect. Using the results obtained, equations 21 and 24 are derived determining the velocity of the front diaphragm when the sound falls on it (a) normally, and (b) obliquely.

In order to obtain a uniform frequency characteristic either the velocity or the displacement of the diaphragm must be made independent of frequency. For each of the above cases the nature of the impedances of the diaphragms and of the mechanical system mounted between them is determined.

2284. ON THE FORCED RADIAL VIBRATION OF A HOLLOW SPHERE.—M. Matudaira & T. Hayasaka. (*Jap. Journ. of Engineering, Abstracts*, Vol. 18, 1939, p. 82.) For Matudaira's spherical velocity microphone *see* 4501 of 1939.

2285. ON THE THERMAL DAMPING IN THE AIR SPACES OF MICROPHONES [DVL Investigations].—H. Pfriem. (*Akust. Zeitschr.*, March 1940, Vol. 5, No. 2, pp. 103–111.)

"A comparison with the total damping of condenser microphones, as calculated from the practical measurements of Ernsthausen [3760 of 1937] shows that the thermal damping determined above represents only a fraction of the total damping."

2286. ON TRANSVERSE VIBRATIONS OF CURVED MEMBRANES [General Theory].—C. E. Weatherburn. (*Phil. Mag.*, Dec. 1939, Series 7, Vol. 28, No. 191, pp. 632–634.)

2287. UNITARY THEORY OF THE PROPER VALUES OF MEMBRANES AND OF PLATES WITH FIXED EDGES.—A. Weinstein. (*Comptes Rendus*, 29th Jan. 1940, Vol. 210, No. 5, pp. 161–163.)

2288. THE TRANSPORT OF SOUND FILM IN APPARATUS FOR RECORDING AND REPRODUCTION [Difficulties due to Film Shrinkage, and Methods of Overcoming Them: More Rigorous Demands of Philips-Miller System: etc.].—J. J. C. Hardenberg. (*Philips Tech. Review*, March 1940, Vol. 5, No. 3, pp. 74–81.)

2289. CONSTRUCTION OF APPARATUS FOR RECORDING SOUND ON STEEL WIRE.—R. L. Mansi. (*Electronics and Television & Short-Wave World* [formerly *Television*], Jan., Feb., & March 1940, Vol. 13, Nos. 143, 144, & 145.)

2290. GETTING THE BEST FROM RECORDS: PART IV—THE RECORD HAS THE LAST WORD.—Voigt. (*Wireless World*, May 1940, Vol. 46, No. 7, pp. 242–245.) Conclusion of the series dealt with in 1904 of May.

2291. DYNAMICS OF THE PIANOFORTE STRING AND THE HAMMER: PART III—GENERAL THEORY.—M. Ghosh. (*Indian Journ. of Phys.*, Aug. 1939, Vol. 13, Part 4, pp. 277–291.) For previous parts *see* 1527 & 3989 of 1939.

2292. THEORY AND PRACTICE OF THE EXCITATION OF PIANO STRINGS: II, *and* MEASUREMENTS OF THE SOUND VOLUME OF THE PIANOFORTE.—Jakovlev: Belov & Ugolnikov. (*Journ. of Tech. Phys.* [in Russian], No. 13, Vol. 9, 1939, pp. 1218–1226: No. 15, Vol. 9, pp. 1401–1412.)

2293. AN ELECTRODYNAMIC DETECTOR OF MECHANICAL VIBRATIONS, AND ITS APPLICATIONS [to Study of Machine Vibrations, Key-Board Musical Instruments (also for Distant Reproduction), etc.].—G. Giulietti. (*L'Elettrotecnica*, 25th Sept. 1939, Vol. 26, No. 18, pp. 631–632.)

2294. THE MUSICAL SCALE OF THE HIGHLAND BAGPIPE.—G. E. Allan. (*Phil. Mag.*, Feb. 1940, Series 7, Vol. 29, No. 193, pp. 154–161.)

2295. HIGH-SPEED MOTION PICTURES OF THE HUMAN VOCAL CHORDS.—D. W. Farnsworth. (*Bell Lab. Record*, March 1940, Vol. 18, No. 7, pp. 203–208.)

2296. SECRECY BY INVERSION OF SYLLABLES.—Marro. (*See* 2468.)

2297. REVERBERATION TIME AND ATTENUATION COEFFICIENT AT GRAZING INCIDENCE [and the Production of "Flutter" Echoes].—L. Cremer. (*Akust. Zeitschr.*, March 1940, Vol. 5, No. 2, pp. 57–76.) Filling in the gaps in previous work (2384 of 1938).

2298. On the Sound Absorption of Resonators [starting from Measurements of the Absorption/Frequency Characteristics of Various Types of Celotex in Tube Form].—V. L. Jordan. (*Akust. Zeitschr.*, March 1940, Vol. 5, No. 2, pp. 77–87.)

2299. The Acoustic Wind Method applied to the Plotting of Resonance Curves of a Helmholtz Resonator.—E. Kucher & K. Teodorchik. (*Journ. of Tech. Phys.* [in Russian], No. 15, Vol. 9, 1939, p. 1413.)

2300. Stroboscopic Measuring Instrument for Frequencies and Revolutions.—Sturm. (*See* 2497.)

2301. The Musical Pitch of Orchestras [Measurements on Frequency of Reference Note of an Orchestra].—G. B. Madella. (*Nature*, 9th March 1940, Vol. 145, pp. 396–397.) Notes on the paper dealt with in 1456 of April.

2302. A 1000 c/s Oscillator free from Grid Current and with a 5 c/s Frequency Adjustment by Phase Rotation in the Feedback Path.—Zaiser. (*See* 2226.)

2303. Tone-Frequency Control- and Filter-Quartzes.—Rohde. (*See* 2360.)

2304. Torsional Vibrations of Crystalline Cylinder [Theoretical Interaction of Torsional and Flexural Frequencies].—W. F. Brown. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, pp. 558–559: abstract only.)

2305. Magnetostriction Oscillators [Experimental Investigation].—Stenning. (*See* 2364.)

2306. The Radiation of the Acoustic Air-Jet Generator derived from Direct Observation of the Amplitude of the Aerial Vibrations in the Oscillator.—J. Hartmann & F. Lazarus. (*Phil. Mag.*, Feb. 1940, Series 7, Vol. 29, No. 193, pp. 140–147.) For this generator *see* 1931 Abstracts, p. 329 (*also* 2835 of 1939).

2307. Effects of Intense Sound on Molten Metals: Part II [Experiments on Wood's Metal, Frequencies 50 c/s to 284 kc/s].—G. Schmid & A. Roll. (*Sci. Abstracts*, Sec. A, 25th March 1940, Vol. 43, No. 507, pp. 222–223.)

2308. Absorption of Supersonic Waves in Water and in Aqueous Suspensions [measured at Frequencies between 990 & 2500 kc/s: Results compared with Theory].—G. K. Hartmann & A. B. Focke. (*Phys. Review*, 1st Feb. 1940, Series 2, Vol. 57, No. 3, pp. 221–225.)

2309. The Dispersion of Supersonic Waves in Cylindrical Rods of Polycrystalline Silver, Nickel, and Magnesium [Test of Theory of Giebe & Blechschmidt: Agreement only for Low-Frequency Dispersion].—S. K. Shear & A. B. Focke. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, pp. 532–537.) *See* 1934 Abstracts, p. 99, r-h column.

2310. On a Method of Determining the Elastic Constants of Isotropic Solid Bodies with the Help of Supersonic Waves.—R. Bär. (*Helvetica Phys. Acta*, Fasc. 1, Vol. 13, 1940, pp. 61–76: in German.)

2311. The Resonance [Piston-Oscillator] Method for Measuring the Ratio of the Specific Heats of a Gas, C_p/C_v: Part II.—A. L. Clark & L. Katz. (*Canadian Journ. of Res.*, March 1940, Vol. 18, No. 3, Sec. A, pp. 39–63.) *Cf.* Parodi, 1486 of April. Part I was in the February issue.

2312. On the "Rotation Sound" of Propellers.—E. Nepomnaschij. (*Journ. of Tech. Phys.* [in Russian], No. 13, Vol. 9, 1939, pp. 1227–1241.)

2313. Investigations on the Transmission of Sound in Water-Filled Tubes.—E. Ganitta. (*Akust. Zeitschr.*, March 1940, Vol. 5, No. 2, pp. 87–102.)

PHOTOTELEGRAPHY AND TELEVISION

2314. Improved Television Definition: 625-Line Scanning and Larger Pictures, *and* A New Method of Television Transmission [Papers on the DuMont System: Prevention of Receiver Obsolescence: Reduction of Sideband Width: etc.].—DuMont. (*Electronics and Television & Short-Wave World* [formerly *Television*], Feb. 1940, Vol. 13, No. 144, p. 55: March 1940, No. 145, pp. 103–104 and 106.)

2315. Advance in Television [Philco Demonstrations: 605-Line Screens: Built-In Vertical Loop Aerials, necessitating Vertically Polarised Transmission, but reducing Diathermy Interference—a "Major Problem"].—R. D. Potter. (*Science*, 23rd Feb. 1940, Vol. 91, Supp. pp. 8–9.)

2316. Television in Italy: Safar Television Equipment.—A. Castellani. (*Electronics and Television & Short-Wave World* [formerly *Television*], Feb. 1940, Vol. 13, No. 144, pp. 63–65.) Based on the paper in Italian referred to in 1497 of April.

2317. Progress and Actual Development of Television in Germany.—A. Gehrts. (*L'Elettrotecnica*, 25th Dec. 1939, Vol. 26, No. 24, pp. 742–753.) With 25 literature & (Italian) patent references.

2318. The 16th Great German Broadcasting and Television Exhibition.—F. Fuchs. (*Hochf:tech. u. Elek:akus.*, Jan. 1940, Vol. 55, No. 1, pp. 1–9.)

2319. The Berlin Wire-Television Network, 1939/1940.—K. Lipfert. (*Funktech. Monatshefte*, Feb. 1940, No. 2, Supp. pp. 1–3.)

2320. Big-Name Talent may "Freeze" Television Advance.—(*Sci. News Letter*, 16th March 1940, Vol. 37, No. 11, p. 165.) "Analogous situation held up phonograph improvements for many years: FCC urges caution in buying sets now."

2321. Television Range-Finders [Size of Spot on Screen made to Vary with Strength of Signal].—Goldsmith. (*See* 2281.)

2322. An "S.I.C.E." Coaxial Cable for High Frequencies.—Soc. Italiana Conduttori Elettrici. (*See* 2247.)

2323. Methods and Apparatus for measuring Phase Distortion [Part I—Theory: Part II—Methods of Measurement, including New L.M.T. Phasemeter (100 c/s to 5 Mc/s) and Nyquist Recorder for Automatic Tracing of Nyquist Diagrams (20–4000 kc/s)].—M. Levy. (*Elec. Communication*, Jan. 1940, Vol. 18, No. 3, pp. 206–228.) A summary was referred to in 257 of January.

2324. Facsimile Telegraphy: Some New Commercial Applications ["Teledeltos" Recording Paper makes Automatic Operation practicable, leading to Western Electric "Automatic Telegraph Transmitter," "Facsimile Transmitter-Recorder," & "Duplicator 3-A"].—J. H. Hackenberg. (*Elec. Communication*, Jan. 1940, Vol. 18, No. 3, pp. 240–251.)

2325. On the Improvement of the Brilliancy of Optical Apparatus [by Use of Thin Layers applied to Glass Surfaces].—A. Smakula. (*Zeitschr. f. Instrumentenkunde*, Feb. 1940, Vol. 60, No. 2, pp. 33–36.) *See*, for example, 3407 of 1939.

2326. Optical and Magnetic Properties of a Magnetite Suspension [Action of Suspension of Magnetite Powder in Oil as Light Shutter according to Direction of Magnetic Field: Theory giving Equation for Amount of Transmitted Light in Terms of Magnetic Field Strength: Magnetisation Curve of Dense Suspension].—C. W. Heaps. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, pp. 528–531.)

2327. Electrical Birefringence [Survey of Knowledge on Kerr Effect in Gases & Vapours, Liquids, Solids, Solutions, & Suspensions].—A. de Stefano. (*Nuovo Cimento*, Dec. 1939, Vol. 16, No. 10, pp. 497–512.)

2328. The Skiatron: a New Scophony Development for Large-Screen Projected Pictures [based on Electron Opacity Effects: Use of Microcrystalline Layers of Alkali Halides: Possibilities of Colour Television: Other Applications].—A. H. Rosenthal: Scophony. (*Electronics and Television & Short-Wave World* [formerly *Television*], Feb. & March 1940, Vol. 13, Nos. 144 & 145, pp. 52–55 & 117–119.)

2329. Maintaining Spot Focus in Cathode-Ray Tubes [Introduction of Very Fine-Mesh Grid about 0.1 mm from Cathode, producing Flat Field: Black-to-White Range as small as 3–5 Volts].—E.M.I. Laboratories. (*Electronics and Television & Short-Wave World* [formerly *Television*], March 1940, Vol. 13, No. 145, p. 100.)

2330. Fluorescent Screen replaced by Totally Reflecting Prism carrying Particles of Carbon or Mica which move under Action of Cathode Ray.—(*Electronics and Television & Short-Wave World* [formerly *Television*], March 1940, Vol. 13, No. 145, p. 116.)

2331. A New Scanning Oscillator [avoiding Difficulties due to Miller Effect: Valve rendered Non-Conductive during Return Period].—Gramophone Company. (*Electronics and Television & Short-Wave World* [formerly *Television*], Dec. 1939, Vol. 12, No. 142, pp. 690 and 692.)

2332. Correction to Equation in "A New Hard-Valve Relaxation Oscillator."—D. H. Black. (*Elec. Communication*, Jan. 1940, Vol. 18, No. 3, p. 252.) *See* 4580 of 1939.

2333. Cathode-Ray View-Finder for the Emitron [Usual Optical Finder Not Always Satisfactory: Use of a Monitor-Tube Equipment].—E.M.I. Laboratories. (*Electronics and Television & Short-Wave World* [formerly *Television*], March 1940, Vol. 13, No. 145, p. 108.)

2334. Image-Scanning Pick-Up Tubes [Transparent Photocathode of Original Farnsworth Tube replaced by Opaque: Consequent Modifications of Design: Necessity for Multi-Ring Anode to keep down Eddy Currents due to High Scanning Frequency Fields: the Combined Electron Multiplier (with 45° Secondary-Emission Plate and Weiss Multi-Gauze System: Advantages): Superiority over Storage-Type Pick-Ups in Transmission of D.C. Component, etc.].—W. Hartmann. (*Funktech. Monatshefte*, Feb. 1940, No. 2, Supp. pp. 3–5.) From the Fernseh laboratories.

2335. The Diavisor—a New Type of Transmitting Tube [Television Pick-Up Tube, using Volume instead of Surface Effects: Alkali-Halide Screen acted on by "Exciting" and "Quenching" Radiations].—Scophony Laboratories. (*Electronics and Television & Short-Wave World* [formerly *Television*], Dec. 1939, Vol. 12, No. 142, pp. 686–689.) A correction on p. 19 of the issue for Jan. 1940 states that the name "Diavisor" will not be used: no name has yet been decided on.

2336. A New Pick-Up Tube for Television [using "Secondary-Electron Controlling Method" instead of Storage Method: Use of Metallic Net with Thin Insulating Film on One Side].—J. Osawa. (*Jap. Journ. of Engineering, Abstracts*, Vol. 18, 1939, p. 70.) An illumination of 5×10^{-3} lumen/cm^2 on the photoelectric surface gave a signal output of about 7 mv.

2337. Optical Properties of Evaporated Silver Films [show Two Distinct Physical States, One Continuous to Opaque Film, One Continuous to Thinnest Film].—J. Strong & B. Dibble. (*Phys. Review*, 1st Feb. 1940, Series 2, Vol. 57, No. 3, p. 247: abstract only.)

2338. The Emission from Composite Cathodes under Simultaneous Electron Bombardment and Illumination.—Borzyak. (*See* 2260.)

2339. Papers on the "Photo-Augetron"—Vacuum Science Products. (*See* 2256.)

2340. Some Applications of Multi-Stage Photo-cells with Secondary Emission to the Measurement of Light of Low Intensity.—Rodionov: Kubetski. (*See* 2495.)

2341. On the Mode of Action of the Electron Multiplier [Theoretical Investigation of a Single Plane Cathode with Electrons brought back by D.C. Field and Superposed H.F. Field].—Orthuber & Recknagel. (*See* 2257.)

2342. Conductivity Measurements on Potassium Halides [over Wide Ranges of Temperature and Electrical Stress: Exponential Conductivity/Temperature Relation].—C. G. Brennecke. (*Journ. of Applied Phys.*, March 1940, Vol. 11, No. 3, pp. 202–207.)

2343. Metallic Reflection and the Surface Photoelectric Effect [particularly the Alkali Metals].—R. E. B. Makinson. (*Abstracts of Cambridge Dissertations*, 1938/1939, pub. 1940, pp. 109–110.) "Extensions and generalisations" of work in a previous paper (628 of 1938). The *Abstracts* are printed at the University Press, Cambridge.

2344. Sensitisation of Photoelectric Surfaces by Electric Discharges in Water Vapour and Atomic Hydrogen.—Tykociner, Kunz, & Garner. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, p. 565: abstract only.)

2345. The Effect of Deuterium and of Electric Discharges in Deuterium Oxide on the Sensitisation of Photoelectric Cells.—J. T. Tykociner & L. R. Bloom. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, p. 571: abstract only.)

2346. On the Quantum Output of Antimony-Caesium Cathodes.—S. Yu. Luk'yanov. (*Journ. of Tech. Phys.* [in Russian], No. 13, Vol. 9, 1939, pp. 1175–1179.)

It is pointed out that in the papers published during recent years on antimony-caesium cathodes no information is given on the absolute value of the spectral sensitivity of these cathodes. Consequently in the present paper this value k (electrons per quantum of incident energy) is calculated from comparatively simple measurements of the spectral and integral sensitivity. It appears that for this type of cathode k is considerably higher than for any other photoactive surface, namely about 1.3 electrons per quantum.

It is stated that antimony-caesium photocells have already been used at the Principal Observatory of the U.S.S.R. for photoelectric registration of stars, and that as a result of these experiments it is expected that the field of observations will be extended by at least two orders of stellar magnitude.

2347. Photoelectric Modifications of Mercuric Oxide at Its Contact with an Electrode [leading to the "Contact-Resistance" Photo-cell (with Advantages for Qualitative Uses with White or Ultra-Violet Light) and "Mercuric-Oxide Photoelectric Couple" (without Auxiliary Voltage) for measuring Low Light Intensities (10^{-6} or 10^{-8} Lumen) with Electrometer].—G. Déchêne. (*Journ. de Phys. et le Radium*, March 1940, Series 8, Vol. 1, No. 3, pp. 112–120.) For a *Comptes Rendus* Note *see* 1613 of 1939.

2348. The Photoeffect and Its Use in Photo-cells [Survey].—H. Verleger. (*Zeitschr. f. Instrumentenkunde*, Oct. 1939, Vol. 59, No. 10, pp. 396–415.)

2349. Changes in the Internal Resistance of Selenium Barrier-Layer Cells caused by Exposure to Light [Experimental Curves indicate that Changes occur in Barrier Layer Itself].—A. E. Sandström. (*Phil. Mag.*, Dec. 1939, Series 7, Vol. 28, No. 191, pp. 642–648.) For previous work *see* 223 of 1939.

MEASUREMENTS AND STANDARDS

2350. On the Inductor-Type Voltmeter, and Modes of Electrical Oscillation of Wire Circuit for Ultra-Short Waves [Design of Special Voltmeter, & Determination of Length of Inductor, for Investigation of Potential Distribution on Single-Wire, Parallel-Wire, and Plate-&-Cylinder Systems: of Sudden Changes in Electrical Behaviour due to Minute Changes in Exciting Wavelength: and of U.H.F. Resistance of Parallel-Wire System: etc.].—H. Iwakata. (*Jap. Journ. of Engineering, Abstracts*, Vol. 18, 1939, p. 96.)

2351. A Generalised Coupling Theorem for Ultra-High-Frequency Circuits [Parallel Lines].—King. (*See* 2194.)

2352. Some Electronic and Electrical Measurements at Very High Radio Frequencies [Method of Absolute Measurement of Impedances at 300 Mc/s: etc.].—Chipman. (*See* 2217.)

2353. GENERATOR FOR RADIO TESTING [Frequencies 7.5 to 320 Mc/s].—General Radio. (*Journ. of Applied Phys.*, March 1940, Vol. 11, No. 3, p. 186.)

2354. MEASUREMENT OF THE FREQUENCY EXCURSION IN FREQUENCY MODULATION.—Bosse. (*See* 2223.)

2355. THE DIELECTRIC CONSTANT OF WATER VAPOUR AT A FREQUENCY OF 42 MEGACYCLES [measured with Heterodyne Beat Apparatus: Verification of Clausius-Masotti Relation: Dielectric Constant determined at Three Different Temperatures and 760 mm Hg].—A. C. Tregidga. (*Phys. Review*, 15th Feb. 1940, Series 2, Vol. 57, No. 4, pp. 294–297.)

2356. AN EXPERIMENTAL CONDENSER FOR DETERMINATION OF DIELECTRIC CONSTANTS OF LIQUIDS [Total Error less than 0.01%].—D. T. Williams & C. S. Copeland. (*Review of Scient. Instr.*, March 1940, Vol. 11, No. 3, pp. 105–107.)

2357. A 1000 C/S OSCILLATOR FREE FROM GRID CURRENT AND WITH A 5 C/S FREQUENCY ADJUSTMENT BY PHASE ROTATION IN THE FEEDBACK.—Zaiser. (*See* 2226.)

2358. A METHOD OF MEASURING AND RECORDING THE FREQUENCY ERROR OF A.C. POWER SUPPLIES.—F. O. Morrell & G. R. Oman. (*Electrician*, 8th March 1940, Vol. 124, pp. 183–184.) Summary of an I.E.E. paper.

2359. THE THREE-CRYSTAL METHOD OF QUARTZ RESONATOR MEASUREMENT [Measurement of Crystal Impedance at Frequencies near Resonance-Curve Peak with Radio-Frequency Bridge].—K. S. Van Dyke & A. M. Thorndike. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, p. 560: abstract only.)

2360. TONE-FREQUENCY CONTROL- AND FILTER-QUARTZES.—L. Rohde. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 21, 1940, pp. 30–34.)

The application of quartz bars excited at audio-frequencies has hitherto been limited to their use as resonators in frequency measurements. The development of special electrodes and holders, here described, allows these bars to be used simply and successfully in many circuits. Bars cut to give flexional vibrations in the Z direction (Figs. 1 & 2) are found to be best as regards their properties, size, saving of material (this point is stressed later on) and ease of preparation. Vibrating to their fundamental, they give vibration nodes at K_1 and K_2; the electrode arrangement for such excitation is seen in Fig. 3. For excitation at harmonic frequencies other electrode arrangements are preferable. Fig. 4 shows photographs of rods for fundamentals from 1 to 30 kc/s (the author's summary gives 20 kc/s as the useful limit): their lengths range from 130 to 15 mm.

Such flexional vibrators have a natural damping of the order of 0.00003, but the holder usually doubles or trebles this. Since the surfaces radiating energy to the air are comparatively small it is desirable to put the bars in a vacuum only if the additional damping due to the holder is as small as the natural damping of the bar. The whole success of these oscillators has depended on the development of special sintered-on electrodes (of silver) and special methods of holding the bars (*cf.* previous paper on longitudinal vibrators, 2456 of 1939). The arrangement of these electrodes on the surfaces of the bar is seen in Fig. 6, on the lines of Fig. 3 but connected (Fig. 5) so as to form a "3-pole" filter (suggested symbol Fig. 7) in which "by a special separating coating it is attained that no electrical coupling between pole 1 and pole 2 occurs through the dielectric of the quartz itself." The flexional oscillator presents special difficulties in fixing, on account of the absence of external nodal points and the presence of small vibrations in directions other than the Z direction; the fixing must therefore be elastic to keep down the damping, and Fig. 8 shows the method adopted, with four springs (also acting as leads) soldered to the silvering of the bar as close as possible to the nodes. Guard threads are stretched across the container to prevent over-bending of these springs in case of excessive shock.

The property of phase-rotation enables these "3-pole" oscillators to be used extremely simply as oscillation generators, and Fig. 11 shows such an arrangement with ohmic resistances only (*cf.* previous paper, *loc. cit.*); the circuit must be such as to limit the possible voltage to the bar, to protect it from vibrating too vigorously. The frequency constancy of such a circuit, containing as it does no frequency-controlling element except the quartz, is very high (Fig. 11); for ordinary working conditions the frequency variation is of the order of 10^{-6}. The influence of the valve grid capacity on the frequency is utilised by adding a small trimmer condenser by which a precision adjustment of the quartz frequency can be made. The temperature-coefficient of frequency is of the order of -8 to -16×10^{-6} per degree, and cannot be reduced by "special cuts," etc: some form of thermostatic control is necessary for high accuracy (p. 33, r-h column). Finally, the use is described of these filters to bring out, separately and free from interference, three frequencies from a line carrying cross-talk, broadcast, and other unwanted frequencies. Since the natural damping of the filter is extremely low, interfering frequencies only about 10^{-4} from the desired frequency are practically eliminated. These quartzes are also specially suitable for the generation of carrier-current frequencies. They are very economical as regards the consumption of quartz; a 4 kc/s bar weighs only 1.4 gm, compared to 5 gm for an ordinary 60 kc/s crystal.

2361. TORSIONAL VIBRATIONS OF CRYSTALLINE CYLINDER [Theoretical Interaction of Torsional and Flexural Frequencies].—W. F. Brown. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, pp. 558–559: abstract only.)

2362. THE "TELEPHONE CLOCK" [Quartz-Controlled Clock in Broadway Windows of A.T. & T. Headquarters].—W. A. Marrison. (*Bell Lab. Record*, March 1940, Vol. 18, No. 7, pp. 209–213.)

2363. Materials with Special Temperature Coefficient of the Modulus of Elasticity [particularly the Development of the Iron-Nickel-Chromium Alloys WT 10 (specially Valuable for Tuning Forks & Magnetostriction Oscillators: T.C. of Frequency below 5×10^{-6}) and WT 8, for Constant Springs].—Fahlenbrach & Meyer. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 21, 1940, pp. 40–44.)

2364. Magnetostriction Oscillators [Experimental Investigation: Simultaneous Action of Three Types of Feedback: Reason for Extreme Sensitivity to External Fields (Reversal of Orientation in Earth's Field can be made to increase Amplitude Many Times): Temperature-Variation of Frequency: Effect of Knife Edges (Position & Pressure): etc.].—D. C. Stenning. (*Wireless Engineer*, April 1940, Vol. 17, No. 199, pp. 158–160.)

2365. A New Method of Measuring the Magnetic Permeability of Iron and Permalloy in Very Weak Magnetic Fields.—L. N. Loshakov. (*Journ. of Tech. Phys.* [in Russian], No. 17, Vol. 9, 1939, pp. 1540–1547.)

The method proposed by the author is similar to that used by Deubner for measuring the resistance of electrolytes (1930 Abstracts, p. 580) and is based on determining the active resistance of a sample connected to the oscillating circuit of a valve oscillator, by observing the self-excitation limit of the latter. The theory of the method is discussed and the apparatus used described (Fig. 2). Measurements of iron and permalloy permeability were carried out in very weak magnetic fields (as low as 0.001 örsted) of frequencies between 7.5 and 23 Mc/s. The results of these measurements are reported and discussed. It is stated that the error in determining permeability by this method does not exceed 10%.

2366. Moment-Free Field Coil for Magnetometer Measurements [Compensation Coil with Reversed Field Direction on Same Side of Magnetometer Needle as Coil containing Specimen and Very Close to It].—W. Steinhaus & A. Kussmann. (*Physik. Zeitschr.*, 15th Feb. 1940, Vol. 41, No. 3/4, pp. 53–55.)

2367. A Note on the Carey-Foster Method of Measuring a Mutual Inductance in Terms of a Capacity [Graphical Analysis of Observations leads to New Results].—E. Tyler. (*Phil. Mag.*, Feb. 1940, Series 7, Vol. 29, No. 193, pp. 162–168.)

2368. Bridged-T Measurement of High Resistances at Radio Frequencies [in Terms of the Most Accurate R.F. Standards obtainable, Air-Dielectric Condensers & Resistors up to 100 Ohms: Resistances from 0.01 to 10 Megohms].—P. M. Honnell. (*Proc. Inst. Rad. Eng.*, Feb. 1940, Vol. 28, No. 2, pp. 88–90.) Results were compared with those given by the susceptance-variation method (Sinclair, 1619 & 4072 of 1939) at frequencies up to 3.3 Mc/s.

2369. A Square-Wave Impulse Generator [for testing Wide-Band Amplifiers, particularly for Television: Fundamentals from 10 to 5000 c/s].—General Radio. (*Electronics and Television & Short-Wave World* [formerly *Television*], March 1940, Vol. 13, No. 145, pp. 105–106.)

2370. Methods and Apparatus for measuring Phase Distortion.—Levy. (*See* 2323.)

2371. Testing Amplifier Output Valves by means of the Cathode-Ray Tube.—van der Ven. (*See* 2270.)

2372. The Wien Bridge applied to the Measurement of Distortion [based on Its Property of Attenuating the Frequency to which It is Tuned].—M. Santoro. (*Boll. del Centro Volpi*, English Edition, July/Aug./Sept. 1939, Year 2, No. 3, p. 321d.)

2373. Measurement of the Harmonic Content of Alternating Voltages [particularly for Testing Installations: Survey of Methods, leading to Description of P.T.R. Use of Linckh Wave-Form Bridge].—C. Moerder. (*E.T.Z.*, 25th Jan. 1940, Vol. 61, No. 4, pp. 77–82.)

2374. Increasing the Sensitivity of Measuring Instruments by means of "Retroaction."—E. Perucca. (*Nuovo Cimento*, Dec. 1939, Vol. 16, No. 10, pp. 489–496.) A summary was dealt with in 1546 of April.

2375. Probe Valve Voltmeter [Simple Additions make possible Extremely Accurate Calibration].—B. Groom: Harris. (*Wireless World*, May 1940, Vol. 46, No. 7, p. 257.) *See* 1972 of May.

2376. High-Tension Meter for 600 Kilovolts [on Guard-Ring Condenser Principle: Attracting Force measured by Magnetic-Induction Ultra-Micrometer Device].—Rogowski & Böcker. (*Zeitschr. V.D.I.*, 17th Feb. 1940, Vol. 84, No. 7, pp. 119–120.)

2377. Compensated Thermocouple-Type High-Frequency Instruments [Necessity for Compensation of Temperature-Variations in Terminals & Surrounding Air, when measuring Large H.F. Currents (*e.g.* 100 Amperes): Method Adopted].—M. Tuzita. (*Jap. Journ. of Engineering, Abstracts*, Vol. 18, 1939, pp. 98–99.)

2378. Criticism and Discussion on "The Determination of the Inertia of Thermocouples."—Levitskaja & others. (*Journ. of Tech. Phys.* [in Russian], No. 13, Vol. 9, 1939, p. 1242.) *See* 272 of 1938.

2379. An Easily Constructed, Rugged, Sensitive Thermopile [with Sensitivity of 0.097 Volt per Watt per Sq. Cm: Chromel *p*-Constantan Junctions], *and* A Vacuum Thermocouple [of Improved Design].—Launer: Moore & Webb. (*Review of Scient. Instr.*, March 1940, Vol. 11, No. 3, pp. 98–101: pp. 101–102.)

2380. On the Construction of a Highly Sensitive Thermoelement for Radiation Measurement [Elements with $0.8\ \mathrm{mm}^2$ Surface have Three Times the Sensitivity of Previously Known Elements].—G. Rosenthal. (*Zeitschr. f. Instrumentenkunde*, Nov. & Dec. 1939, Vol. 59, pp. 432–439 & 457–463.) Based on Cartwright's work (*see*, for example, Abstracts, 1931, p. 109: 1932, pp. 297 & 651.)

SUBSIDIARY APPARATUS AND MATERIALS

2381. The Amplidyne Generator—a Dynamo-electric Amplifier for Power Control.—Alexanderson & others. (*See* 2498.)

2382. On a Special Type of Step-Up Rotary Convertor with Double Commutation, and Its Applications [Three Models, of about 5, 12, & 50 Watts D.C. Output (150, 175, & 700 Volts): Efficiencies 48, 70, & 75%: Specially Suitable for Military & Aircraft Wireless Purposes].—Giulietti. (*L'Elettrotecnica*, 25th Nov. 1939, Vol. 26, No. 22, pp. 704–706.)

A special application is to the feeding of the writer's cathode-ray indicator for aircraft inductor compasses (2376 of 1939).

2383. Concerning Thermionic Regulation of D.C. Generators.—Danforth. (*See* 2203.)

2384. Velocity-Modulated Electron Beams in Crossed Deflecting Fields, *and* Papers on Electron Lenses at Ultra-High Frequencies.—Kockel & Mayer: Recknagel: Nesslinger. (*See* 2218 & 2219.)

2385. Velocity Changes of the Electrons in the Deflecting Condenser at Ultra-High Frequencies, *and* Model Tests on the Electron Motion in Alternating Fields.—Döring: Brüche & Döring. (*See* 2220 & 2221.)

2386. New Investigations on Cathode-Ray Oscillographs: VI—The Hollmann Inversion Spectrograph: Electron-Optical Spectrum Analysis of High-Frequency Oscillations.—Thoma. (*Funktech. Monatshefte*, Feb. 1940, No. 2, pp. 23–29.) For previous parts *see* 1165 of March.

2387. Maintaining Spot Focus in Cathode-Ray Tubes.—E.M.I. Laboratories. (*See* 2329.)

2388. Automatic Cathode-Ray Oscillographs for the Recording of Lightning Currents.—Flowers. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, p. 560: abstract only.)

2389. Accurate Cathode-Ray Tube Assembly [aided by Inwardly-Sloping Longitudinal Depressions in Envelope: etc.].—E.M.I. Laboratories. (*Electronics and Television & Short-Wave World* [formerly *Television*], March 1940, Vol. 13, No. 145, p. 114.)

2390. The Cossor Double-Beam Oscilloscope: a Comprehensive Instrument [Model 3339].—Cossor Company. (*Electronics and Television & Short-Wave World* [formerly *Television*], March 1940, Vol. 13, No. 145, pp. 109–111.)

2391. Cathode-Glow-Discharge Oscillographs.—Parfent'ev. (*Journ. of Tech. Phys.* [in Russian], No. 15, Vol. 9, 1939, pp. 1433–1436.)

An experimental investigation of glow-discharge tubes suitable for measuring alternating currents and voltages of any wave-form, modulation depth, etc. A number of characteristics are shown, and from curve 2 of Fig. 2 it can be seen that, "contrary to the opinion of several authors," the relationship between the current through the tube, I, and the length of glow, l, covering the cathode is not linear. The discharge in the tube has been investigated in detail by cold probes (Langmuir method) and a formula (1) is derived determining the relationship between I and l. Tubes with neon, helium, argon, and nitrogen were experimented with, and the effect of varying the gas pressure was investigated. In conclusion a brief description is given of a new tube particularly suitable for measuring modulation depth (Fig. 8, facing p. 1425). For previous work *see* 3770 of 1939.

2392. Preparation of Luminescent Materials with Low-Melting Fluxes [possessing Cations with Large Atomic Volume: Mixed Phosphors (Sulphides/Selenides/Tellurides) with Definite Composition at Normal Atmospheric Pressure: Increased Brightness and Dissipation of Charges].—(*Electronics and Television & Short-Wave World* [formerly *Television*], March 1940, Vol. 13, No. 145, pp. 130 and 141.)

2393. The Phosphorescence of Various Solids [Decay Laws and Photoconductivity of Uranyl Salts, Tungstates, Inorganic Solids containing Manganese Impurity].—Randall & Wilkins. (*Proc. Roy. Soc.*, Series A, 1st Feb. 1940, Vol. 174, No. 957, pp. S7–S8: abstract only.)

2394. A Theory on Excitation of Phosphorescence by Cathode Rays.—Fano. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, p. 564: abstract only.)

2395. On the Polarised Fluorescence of Organic Compounds.—Mitra. (*Indian Journ. of Phys.*, Nov. 1939, Vol. 13, Part 5, pp. 349–390.)

2396. The Photoluminescence of Scheelites [Systematic Examination of Natural Minerals: Presence of Rare Elements, particularly Europium].—Servigne. (*Comptes Rendus*, 18th March 1940, Vol. 210, No. 12, pp. 440–442.) *See* also 3735 of 1939.

2397. On the Theory of Dielectric Breakdown in Alkali-Halide Crystals.—Seitz & Sampson. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, p. 558: abstract only.)

2398. CONDUCTIVITY MEASUREMENTS ON POTASSIUM HALIDES.—Brennecke. (*See* 2342.)

2399. PAPERS ON SECONDARY EMISSION OF ELECTRONS.—(*See* under "Valves & Thermionics").

2400. OPTICAL PROPERTIES OF EVAPORATED SILVER FILMS.—Strong & Dibble. (*See* 2337.)

2401. SINGLE-VALVE [H.F. Pentode] TIME-BASE CIRCUIT, ADAPTABLE FOR SAW-TOOTH OR RECTANGULAR WAVE-FORMS [nearly as Simple as Thyratron Circuit, with All Advantages of Hard-Valve Circuit: Easy to Synchronise even at 100 kc/s Frequency: Higher Frequencies attainable].—Fleming-Williams. (*Wireless Engineer*, April 1940, Vol. 17, No. 199, pp. 161–163.)

2402. ON THE SYNCHRONISATION OF A THYRATRON OSCILLATOR.—V. P. Gulyaev. (*Journ. of Tech. Phys.* [in Russian], No. 18, Vol. 9, 1939, pp. 1656–1661.)

The operation of a thyratron circuit (Fig. 1) generating saw-tooth oscillations is considered and the theory of the synchronisation of the circuit by the application of a sinusoidal e.m.f. to the grid of the thyratron is discussed (it is assumed that the discharge time of the condenser C through the thyratron is negligible). The regions of the synchronisation, as determined by the amplitude and phase of the synchronising e.m.f., are calculated and shown graphically in Fig. 4 for various values of $\theta = T/T_0$, where T and T_0 are the periods of the synchronising e.m.f. and of the natural frequency of the circuit. Curves (Figs. 6–9) are also plotted showing the relationship between θ and the maximum voltage on the condenser C.

2403. D.C. AMPLIFIER [with Successive Stages directly coupled without Use of Batteries].—Brubaker. (*Phys. Review*, 1st Feb. 1940, Series 2, Vol. 57, No. 3, p. 248: abstract only.)

2404. A SWITCHING CIRCUIT FOR THE OBSERVATION OF TWO SEPARATE PROCESSES BY THE CATHODE-RAY OSCILLOGRAPH.—Koller. (*Bull. Assoc. suisse des Élec.*, No. 6, Vol. 31, 1940, pp. 141–148: in German.)

The writer considers in turn three possible conditions of dual recording by a switching device: (1) when the switching frequency f_u is large compared with the time-base frequency f_t, (2) when it is small compared with f_t, and (3) when $f_u = \frac{1}{2} \cdot f_t$. He concludes that the third condition, in spite of the complication that the switching frequency must in this case be variable and synchronised, is the best, giving particularly clear, clean oscillograms; moreover, an equipment designed on this principle can also be employed for either of the other methods.

He then describes his own circuit (Fig. 2) in which the electronic switching device U is controlled by the multivibrator K, providing the narrow rectangular voltage pulses suitable for the control. The production of such pulses under the condition that the frequency must be continuously adjustable is discussed on pp. 144–145; one way is to use a pair of auxiliary valves (circuit Fig. 6), but this elaboration of the simple multivibrator circuit of Fig. 4 is rendered unnecessary (for switching frequencies up to 8000 c/s) by the employment of screen-grid valves. The whole arrangement thus becomes as represented in Fig. 3, where the multivibrator, with its two pre-amplifiers, is seen below, and the switching circuit, with its two pentodes, above. For reasons described on p. 146 these pentodes are controlled not by their real control grids but by their suppressor grids, and a symmetrically arranged double-diode is provided to give a peak-shunting path to each pentode input, thus eliminating (Fig. 9) the curvature of the control-pulse tops, unavoidably distorted by time-constant effects. Actually Fig. 6 shows a double-diode triode; the triode element of this is used for amplifying the synchronising voltage (p. 147). For other work on the same subject *see* Dorsman & de Bruin, 1161 of March.

2405. A NEW-STYLE IONISATION GAUGE [for Pressures approaching 10^{-8} mm: Increased Sensitivity & Other Advantages].—Morse & Bowie. (*Review of Scient. Instr.*, March 1940, Vol. 11, No. 3, pp. 91–94.)

2406. A SIMPLE MANOMETER FOR THE MEASUREMENT OF TOTAL PRESSURE [Development of the Thermojunction Principle].—Weiss & Westmeyer. (*Zeitschr. f. Instrumentenkunde*, Feb. 1940, Vol. 60, No. 2, pp. 53–54.)

2407. MEASUREMENTS IN THE PHILIPS RARE GAS PLANT [on Composition of Mixtures of Argon & Nitrogen: Specific-Weight & Vapour-Pressure Methods].—Holleman. (*Philips Tech. Review*, March 1940, Vol. 5, No. 3, pp. 88–91.)

2408. PROGRESS REPORT ON THE HIGH-VOLTAGE PRODUCTION OF POSITIVE ION AND ELECTRON BEAMS.—Van Atta, Van de Graaff, & others. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, p. 563: abstract only.)

2409. THE FORMATION AND MAINTENANCE OF ELECTRON AND ION BEAMS [Computations of Maximum Beam Current obtainable in Beam of Given Radius and Boundary Conditions: Method of Holding Beam Together during Initial Accelerations: Use of Electrostatic Lenses: Special Arrangements for Beam Convergence: Experimental Attempts at Low-Velocity Focusing].—Smith & Hartman. (*Journ. of Applied Phys.*, March 1940, Vol. 11, No. 3, pp. 220–229.)

2410. THE FOCUSING OF ION BEAMS BY ELECTROSTATIC LENSES [Theory of Passage of Charged Particles through Axially Symmetrical Electric Field: Curves of Potential Distribution along Axis of Two Equal Cylinders (by Laplace's Equation for Small Spacing, by Electrolytic Trough for Large): Resulting Empirical Equations used to determine Focal & Principal Points: Practical Formulae: Experimental Confirmation: etc.].—Petrie. (*Abstracts of Cambridge Dissertations*, 1938–1939, pub. 1940, pp. 158–160.) Printed at the University Press, Cambridge.

2411. A High-Efficiency Ion Source [Efficiency increased by making the Ionising Electrons oscillate with Energies corresponding to Max. Ionisation Probability: Electronic Space Charge used to hold Ion Beam together].—Finkelstein. (*Review of Scient. Instr.*, March 1940, Vol. 11, No. 3, pp. 94–97.)

2412. A High-Efficiency Ion Source [producing Intense Ionic Beams of Any Material acquiring Appreciable Vapour Pressure below 2000° C].—Finkelstein & Smith. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, p. 563: abstract only.)

2413. A Constant Current Network for Supplying Power to a Cyclotron Oscillator [using Resonant Circuit for transforming Constant Voltage to Constant Current].—Allen & Franklin. (*Phys. Review*, 15th Feb. 1940, Series 2, Vol. 57, No. 4, p. 347: abstract only.)

2414. An Investigation of High-Vacuum Discharges at Impulse Voltages up to 2.5 Million Volts.—Zingermann & Korsunski: Zingermann. (*Journ. of Tech. Phys.* [in Russian], No. 15, Vol. 9, 1939, pp. 1345–1356: pp. 1357–1363.)

Two reports on experiments with special porcelain, mycalex, and other tubes, 0.4 to 5.0 m long, evacuated to between 10^{-2} and 10^{-6} mm Hg. Voltages ranging from 50 to 2500 kv were applied to the tubes, and a number of cathode-ray oscillograms are shown and discussed.

2415. Impulse Generator for Medium Voltages, *and* A New Method for the Investigation of Impulse Corona.—Balygin: Fertik. (*Journ. of Tech. Phys.* [in Russian], No. 18, Vol. 9, 1939, pp. 1683–1686: pp. 1687–1688.)

2416. On the Initial Intensity of the Negative D.C. Corona produced between a Circular Wire and a Plane Parallel to It.—Meer, Morokhovski, & Kaptsov. (*Journ. of Tech. Phys.* [in Russian], No. 15, Vol. 9, 1939, pp. 1364–1368.)

Experiments were carried out as a result of which equation (12) is derived. From this, the voltage gradient E_k at which the corona discharge commences can be determined.

2417. The Onset of Positive Point-to-Plane Corona in Pure A, N_2,H_2, and in Dry Air at 350 mm Pressure.—Weissler. (*Phys. Review*, 1st Feb. 1940, Series 2, Vol. 57, No. 3, p. 253: abstract only: for more details and extended pressure range see *ibid.*, 15th Feb. 1940, No. 4, pp. 340–341.)

2418. The Electric Strength of Gases, measured by Corona Discharge [Measurements reveal Groups of Gases in each of which the Energy of Ionisation by Collision starting Spark Discharge is Constant].—Thornton. (*Phil. Mag.*, Dec. 1939, Series 7, Vol. 28, No. 191, pp. 666–678.)

2419. The Dielectric Constant of Water Vapour at a Frequency of 42 Megacycles per Second.—Tregidga. (*See* 2355.)

2420. Gas Discharge Tubes in Quench Circuits.—Windred. (*Electronics and Television & Short-Wave World* [formerly *Television*], March 1940, Vol. 13, No. 145, pp. 134 and 136–138.)

2421. The Vacuum Glow Discharge as a Test Electrode [for H.T. Testing of Insulators].—Schaudinn. (*E.T.Z.*, 25th Jan. 1940, Vol. 61, No. 4, pp. 73–76.)

2422. The Local Field in Polarised Dielectrics [New Deduction for Lorentz Force].—Jaffé. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, p. 558: abstract only.)

2423. Physics and Electrical Insulation [with 35 Literature References].—Thomas. (*Journ. of Scient. Instr.*, April 1940, Vol. 17, No. 4, pp. 77–83.) Special Article from the E.R.A.

2424. The Chemist and Electrical Insulation [Progress in New Materials demands Appreciation, by Chemists, of Physical Significance of Electrical Properties].—Mersey. (*Electrician*, 15th March 1940, Vol. 124, pp. 212–213.) Summary only.

2425. Theory of the Critical Field of a Solid Dielectric [Criticism of Zener's Theory: New Treatment, leading to Formula for Probability of Transition of Electron through Zone of Forbidden Energy: Application to Cold Emission].—Cernuschi. (*Abstracts of Cambridge Dissertations*, 1938/1939, pub. 1940, pp. 97–98.) Printed at the University Press, Cambridge. For a previous paper *see* 3172 of 1936.

2426. The Propagation of Electron Waves in Ionic Single Crystals [studied by Electrical Breakdown Effects: Disproof of Wave-Mechanical Theory of Breakdown Process].—von Hippel & Davisson. (*Phys. Review*, 15th Jan. 1940, Series 2, Vol. 57, No. 2, pp. 156–157.)

2427. Glass as an Electrical Insulator [Chemical and Physical Characteristics of Various Glasses: Electrical Properties of Glass in Bulk as Distinct from Fibre Glass: Characteristics of Fibre Glass Electrical Insulation].—Phillips. (*Journ. of Applied Phys.*, March 1940, Vol. 11, No. 3, pp. 173–181.)

2428. "Glas" [Vol. II: Book Review].—Thiene. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 21, 1940, pp. 51–52.)

2429. Electrical Properties of Some Solid Dielectrics [Micalex, Securit, Pyrex, Hypertrolitul, Frequenta, etc: Frequencies to about 4 kc/s].—Tabaracci. (*L'Elettrotecnica*, 10th Oct. 1939, Vol. 26, No. 19, pp. 649–652.)

2430. Standard Apparatus and Procedure for Testing the Porosity of Ceramic Materials.—(*Bull. de l'Assoc. suisse des Élec.*, No. 25, Vol. 30, 1939, pp. 779–780: in French.)

2431. Electric Cables and Fire Risks [Recent Developments: Self-Extinguishing Dielectrics, etc.].—Melsom. (*Electrician*, 15th March 1940, Vol. 124, p. 204.) Summary of an I.E.E. paper.

2432. New Results with Wires and Cables Insulated and Sheathed with Synthetic Materials [particularly the Use of Igelite]. —Berger. (*E.T.Z.*, 1st Feb. 1940, Vol. 61, No. 5, pp. 97–100.)

2433. Thermal and Electrical Properties of the Coatings of Synthetic Resins [Comparative Data].—Shimizu & Inai. (*Jap. Journ. of Engineering, Abstracts*, Vol. 18, 1939, p. 77.)

2434. Dielectric Loss in Simple Alkyl Resins.—Pelmore & Simons. (*Proc. Roy. Soc.*, Series A, 28th March 1940, Vol. 175, No. 960, pp. S17–S18: abstract only.)

2435. The Resistance to Chemical Action of "Hartpapieren" [Composite Insulating Materials formed of Layers of Cellulosic Fibre with Binding Medium].—Paul. (*E.T.Z.*, 8th Feb. 1940, Vol. 61, No. 6, p. 138: summary only.)

2436. Necessary Qualities of Condensers as affecting the Choice of Dielectric [with Particular Attention to Impregnated Paper], *and* The Foil-Cooled Pressure Condenser [with Impregnated Paper Dielectric]. —Swerup: Hansson. (*Sci. Abstracts*, Sec. B, 25th March 1940, Vol. 43, No. 507, p. 107: pp. 107–108.)

2437. The Shape of the Characteristic Curve of the Rotating Condenser and Its Influence on the Synchronism.—Pitsch. (*See* 2235.)

2438. The Electrophysical Properties of Transformer Oil at Low Temperatures. —Vorobjev & Prikhodko. (*Journ. of Tech. Phys.* [in Russian], No. 15, Vol. 9, 1939, pp. 1369–1376.)

2439. On the Mutual Electrical Energy of Two Colloidal Particles: General Theory, using Approximate Debye-Hückel Equation [in Electrolyte Theory: Metallic and Insulating Particles].—Levine & Dube. (*Phil. Mag.*, Feb. 1940, Series 7, Vol. 29, No. 193, pp. 105–128.)

2440. The Temperature Coefficients of Copper-Oxide Rectifiers, *and* On the Relationship between the Temperature Coefficients of Copper-Oxide Rectifiers and the Load.—Vitenberg. (*Journ. of Tech. Phys.* [in Russian], No. 14, Vol. 9, 1939, pp. 1315–1324: No. 18, 1939, pp. 1671–1676.)

In the first paper formulae are derived, from experimental curves, determining the following temperature coefficients for a temperature range of -20° C to $+50^\circ$ C: (1) α_n of forward resistance for constant currents of densities from 3 to 56 mA/cm² (eqn. 7); (2) α_o of backward resistance for constant voltages from 1 to 5 v per element (eqn. 9); (3) α_u of forward resistance for constant voltages of the order of 1 v per element (eqn. 13a); (4) α_k of rectification coefficient for voltages of the order of 1 v per element (eqn. 15).

Experiments have shown that α_u and α_k vary with the type of rectifier and the load applied to it, while α_n and α_o are practically independent of these factors. In the second paper, however, it is shown that with small current densities (from 0.001 mA/cm²) and low voltages per element (from 0.02 v) the effect of the load becomes important and accordingly modified formulae determining α_n (eqn. 6) and α_o (eqn. 10) are derived. The variation of α_u when the voltage per element varies from 0.004 v to 1.5 v is also discussed.

2441. Gravimetric Study of Lead Accumulators [to decide the Double-Sulphating Problem]. —Denina. (*Boll. del Centro Volpi*, English Edition, July/Aug./Sept. 1939, Year 2, No. 3, pp. 7–12.)

2442. Electrolytic and Subsidiary Phenomena in Accumulators.—Kriéger. (*Bull. de la Soc. franç des Élec.*, Feb. 1940, Series 5, Vol. 10, No. 110, pp. 68–74.)

2443. Effect of Iron Content of Manganese Ores on Dry Cell Characteristics.—Verman & others. (*Current Science*, Bangalore, Feb. 1940, Vol. 9, No. 2, pp. 64–65.)

2444. A New Type of Thermo-Regulator [Mercury Capillary Type].—Klein. (*Zeitschr. f. Instrumentenkunde*, Dec. 1939, Vol. 59, No. 12, pp. 469–471.)

2445. An Equipment for the Precision Measurement of Thermal Expansion (A Highly Sensitive, Rapidly Acting Thermostat).—Fischer. (*Zeitschr. f. Instrumentenkunde*, Sept. & Oct. 1939, Vol. 59, Nos. 9 & 10, pp. 341–357 & 385–396.)

2446. Materials with Special Temperature Coefficient of the Modulus of Elasticity [Iron-Nickel-Chromium Alloys].—Fahlenbrach & Meyer. (*See* 2363.)

2447. An Apparatus for the Testing of Permanent Magnets.—Biffi. (*L'Elettrotecnica*, 25th Nov. 1939, Vol. 26, No. 22, pp. 700–704.) For correspondence see *ibid.*, 10th Feb. 1940, Vol. 27, No. 3, pp. 67–68.

2448. On the Permeability of Iron and Nickel for Hertzian Oscillations: Extension of Previous Paper.—Lindman. (*See* 2130.)

2449. The Outer, Initial Permeability of Nickel from 10 to 70 Megacycles [Measurements show Decrease with Increasing Frequency].—Hoag & Glathart. (*Phys. Review*, 1st Feb. 1940, Series 2, Vol. 57, No. 3, p. 240.) For previous work *see* 2982 of 1939. *Cf.* 2130.

2450. A New Method of Measuring the Magnetic Permeability of Iron and Permalloy in Very Weak Magnetic Fields [down to 0.001 Oersted: Frequencies 7.5 to 23 Mc/s].—Loshakov. (*See* 2365.)

2451. An Apparatus for Determining the Orientation of Crystals by X-Rays [with Examples for Cold-Rolled Permalloy].—Haworth. (*Review of Scient. Instr.*, March 1940, Vol. 11, No. 3, pp. 88–91.)

2452. "Texturen metallischer Werkstoffe" [and the Rapid Development of Knowledge of Their Important Influence on Electrical, Magnetic, & Other Properties of the Materials: Book Review].—Wassermann. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 21, 1940, p. 51.)

2453. On Some Magneto-Magnetic and Magneto-Torsional Effects in Alternating Currents [Survey of Effects in Ferromagnetic Wires, including the Writer's Results].—Valle. (*Nuovo Cimento*, Dec. 1939, Vol. 16, No. 10, pp. 515–517.) *Cf.* 1552 of April and back reference.

2454. Phase Orientation due to the Reduction of Magnetite by Hydrogen.—Buinov & others. (*Journ. of Tech. Phys.* [in Russian], No. 18, Vol. 9, 1939, pp. 1649–1655.)

2455. Optical and Magnetic Properties of a Magnetite Suspension.—Heaps. (*See* 2326.)

2456. The Inductor with Air-Gapped Magnetic Circuit.—G.W.O.H: Glazier. (*Wireless Engineer*, April 1940, Vol. 17, No. 199, pp. 145–146.) Editorial prompted by Glazier's paper (354 of January).

2457. Crosstalk Balancing Coils for the Type K Carrier System [with Dual Magnetic Cores & Unusual Winding Arrangement].—Slade. (*Bell Lab. Record*, March 1940, Vol. 18, No. 7, pp. 199–202.)

Constituting "a device in which the mutual inductance may be adjusted to either a positive or a negative value within the desired range" which is ± 1.4 and ± 1.0 μH for the two types. Good longitudinal balance is obtained by inherent symmetry, and the self-inductance of each pair varies less than ± 2% over the useful range.

2458. The Most Economical Transformer [of Least Annual Cost for Given Load Relations and Current Costs: Method of Design].—Unger. (*Arch. f. Elektrot.*, 10th Jan. 1940, Vol. 34, No. 1, pp. 20–30.) For previous work on practical transformer design *see* 3341 of 1939.

STATIONS, DESIGN AND OPERATION

2459. Application of Composite Modulation to Problems of Sideband-Width Contraction [Theoretical & Experimental Investigation of Combined Frequency & Amplitude Modulation: Separation of Frequency-Modulated Wave by "Special Synchronising Oscillator": etc.].—Hayasi & Yamagiwa. (*Jap. Journ. of Engineering, Abstracts*, Vol. 18, 1939, pp. 83–84.) *Cf.* Tetelbaum, 2460, below.

2460. A Special Method for Increasing the Efficiency of Radio-Communication [by Simultaneous Amplitude and Frequency Modulation].—Tetelbaum. (*Journ. of Tech. Phys.* [in Russian], No. 17, Vol. 9, 1939, pp. 1548–1556.) An English version was dealt with in 1244 of March.

2461. Recent Advances in Frequency Modulation [Distortion dependent on Linearity of Transformers, Not of Valve Characteristics: Results during Thunderstorms: etc.].—Armstrong. (*Proc. Inst. Rad. Eng.*, Feb. 1940 Vol. 28, No. 2, pp. 93–94.) Short summary of lecture.

2462. On the Detection of Frequency-Modulated Oscillations.—Milstein. (*See* 2231.)

2463. A High-Frequency Broadcast-Station Field-Coverage Survey [W8XNU, on about 26 Mc/s].—Leydorf & others. (*See* 2132.)

2464. Wire Broadcasting Investigations at Audio and Carrier Frequencies [Technical Progress by General Post Office].—Walmsley. (*Electrician*, 8th March 1940, Vol. 124, p. 184.) Summary of an I.E.E. paper. *See* also *Nature*, 16th March 1940, Vol. 145, pp. 434–435.

2465. High-Frequency Wire Broadcasting in Germany.—Budischin & Deklotz. (*Génie Civil*, 6th April 1940, Vol. 116, No. 14, p. 237.) Long summary of the German paper dealt with in 4741 of 1939.

2466. The Monitoring of Broadcasting Transmitters [Equipment at the Sottens Station].—(*See* 2228.)

2467. Two-Way Radio-Telephony [and the Use of Two Westectors as Amplitude Filters: New Terminal gives 23 db Gain beyond That given by Conventional Systems].—Marinesco. (*Wireless Engineer*, April 1940, Vol. 17, No. 199, pp. 164–165.) Supplementing the paper dealt with in 2070 of May.

2468. Secrecy by Inversion of Syllables [Inverter Circuit: Intelligibility as Function of Number of Inversions per Second].—Marro. (*Phil. Mag.*, Feb. 1940, Series 7, Vol. 29, No. 193, pp. 205–207.) Further development of the work dealt with in 4228 of 1939 ("Two-Way Speech by Wireless").

2469. The Bearing of Recent Ionospheric Studies on Commercial Short-Wave Communication.—Ohno. (*See* 2151.)

2470. The Burning Down of the Schwarzenburg Short-Wave Transmitting Station [Discussion of Possible Causes of Fire in H.F. Installations].—(*Bull. de l'Assoc. suisse des Élec.*, No. 20, Vol. 30, 1939, pp. 664–666: in German.)

2471. Remotely Controlled Radio Receiving Systems [for Ship-to-Shore Links: Use of the Codan: etc.].—Mossman & others. (*Proc. Inst. Rad. Eng.*, Feb. 1940, Vol. 28, No. 2, p. 94: short summary only.) *Cf.* 1651 of April.

2472. Government Regulation of Radio.—Jolliffe. (*Proc. Inst. Rad. Eng.*, Feb. 1940, Vol. 28, No. 2, p. 94: short summary only.)

GENERAL PHYSICAL ARTICLES

2473. Radiation from a Point Charge revolving [with Uniform Velocity] in a Circular Orbit [Rigorous Derivation from Classical Electromagnetics: Work related to Calculations of Natural Frequency of Electrical Oscillations of a Thin Ring].—Poritsky. (*Phil. Mag.*, Dec. 1939, Series 7, Vol. 28, No. 191, pp. 617–631.) The work of Japolsky on "rotating electromagnetic waves," etc. (810 of 1936 and back references), is also discussed.

2474. Evaluation of *e*, *m*, and *h* [Method based on Logarithms of Quantities Concerned: Results].—Darwin. (*Nature*, 30th March 1940, Vol. 145, p. 517: abstract of recent Physical Society paper.)

2475. On the Ratio of *c*, *e*, and *h* [Relation between Universal Constants reduced to Eigenvalue Problem].—Landé. (*Phys. Review*, 15th March 1940, Series 2, Vol. 57, No. 6, pp. 562–563: abstract only.)

2476. A Corpuscular Theory of the Electrical Conductivity of Metals [on Hypothesis that Electron Diameter varies inversely as Velocity: Numerical Results].—Jonescu. (*Comptes Rendus*, 1st April 1940, Vol. 210, No. 14, pp. 502–504.) For work on the photoelectric constant *see* 1520 of April.

2477. Light incident on Particles falling in Magnetic Field produces Motion along Lines of Force, *and* Light can exert Attractive Force on Matter.—Ehrenhaft. (*See* 2175.)

2478. Brownian Movement and the Einstein Formula.—Duclaux. (*Journ. de Phys. et le Radium*, March 1940, Series 8, Vol. 1, No. 3, pp. 81–84.)

2479. On the Covariant Derivative of Tensor-Undors.—Belinfante. (*Physica*, April 1940, Vol. 7, No. 4, pp. 305–324: in English.) For previous papers *see* 388 of January.

2480. Theory of Generalised Relativity on Trial [Michailov's Total-Eclipse Results "rather confirm the Sulaiman Theory"].—(*Sci. & Culture*, Calcutta, March 1940, Vol. 5, No. 9, p. 527.)

2481. On the Nature of the Geometrical, Mechanical, and Physical Entities: Importance of the Consideration of Symmetries and Dissymmetries [Reply to Brylinski & Karpen: Further Observations by the Former].—Bouthillon. (*Bull. de la Soc. franç. des Élec.*, Feb. 1940, Series 5, Vol. 10, No. 110, pp. 75–102.) *See* 870 of February.

2482. Non-Adiabatic Processes in an Oscillating Magnetic Field [Quantum-Mechanical Treatment: the Resonance Phenomena].—Caldirola. (*Nuovo Cimento*, No. 5, Year 16, 1939, pp. 242–252.)

2483. Replacement of the Two "Three-Finger" Rules by a Single Rule [based on Motion of Electrons].—Herrmann. (*E.T.Z.*, 1st Feb. 1940, Vol. 61, No. 5, pp. 105–106.)

MISCELLANEOUS

2484. "Operatorenrechnung nebst Anwendungen in Physik und Technik" [Book Review].—Wagner. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 21, 1940, p. 49.) For a paper on the same subject *see* 1665 of April.

2485. "Vektor- und Dyadenrechnung für Physiker und Techniker" [Book Review].—Lohr. (*Zeitschr. f. tech. Phys.*, No. 2, Vol. 21, 1940, p. 50.)

2486. Statistical Considerations on Acceptance Tests on Samples.—Lucchi. (*L'Elettrotecnica*, 10th Nov. 1939, Vol. 26, No. 21, pp. 673–680.)

2487. Formulation of an Experimental Law: Calculation of the Coefficients of the Formula: Determination of the Mean Value of the Experimental Function. Regularity of a Series of Experimental Values [General Theory].—Vernotte. (*Comptes Rendus*, 27th March 1940, Vol. 210, No. 13, pp. 475–477.) For previous work *see* 2092 of May, and for further development (ending with "The Continuous Method of Least Squares") see *ibid.*, 15th April 1940, No. 16, pp. 565–567.

2488. On the Natural Frequencies of Vibrating Systems [Calculation of Upper and Lower Limits to Natural Frequencies: Paradox presented by Rayleigh's Second Theorem regarding Effect of Constraint: Extension of "Relaxation" Technique], *and* Relaxation Methods applied to Engineering Problems: VI—The Natural Frequencies of Systems having Restricted Freedom.—Southwell: Pellew & Southwell. (*Proc. Roy. Soc.*, Series A, 8th March 1940, Vol. 174, No. 959, pp. 433–457: 28th March 1940, Vol. 175, No. 960, p. S14—abstract only.)

2489. On the Theory of [Mechanical] Auto-Oscillations produced by Forces effective by Virtue of Their Position only.—Strelkov. (*Journ. of Tech. Phys.* [in Russian], No. 17, Vol. 9, 1939, pp. 1564–1573.)

A harmonic oscillator is considered consisting of a mass *m* located in a plane field of forces whose effect is determined by their position only. In addition to these forces, *m* is subjected to the action of friction and of an elastic force directed towards the origin of the coordinates (Fig. 1). It is shown that under certain conditions *m* may develop a special type of oscillation called "auto-rotation," *i.e.* it may start moving along a closed trajectory, usually an ellipse or a circle. This phenomenon may be observed in a taut string under the action of a jet of air, in the shafts of rotating machines ("whip"), etc. In the present paper equations (4) determining the movement of the system are derived, and using the van der Pol method their approximate solutions are found. The stationary states of the system in a particular case (the field of forces symmetrical with respect to an axis) are discussed in detail; conditions for their stability, depending on the parameters of the system, are established and the possible movements of the system determined (Fig. 7).

2490. Plans for the Palace of Radio and Television at the 1942 World's Fair in Rome.—Gallarati & Ramasso. (*Radio e Televisione*, Sept. 1939, Vol. 4, No. 2, pp. 61–81: in Italian.)

2491. Authors' Abstracts [Extent to which They have been Adopted: Necessity for Authors to regard Them as Separate Entities, like the Abstracts in an Abstract Journal: etc.]. —Fulcher. (*Science*, 23rd Feb. 1940, Vol. 91, p. 191.)

2492. The National Centre of Technical Documentation of the C.N.R. [National Research Council].—(*Alta Frequenza*, Feb. 1940, Vol. 9, No. 2, p. 128.) A new institution for the assistance of Italian engineering, industry, and agriculture.

2493. Scientific Publications needed in France [Letter on the *Service de Documentation Scientifique* and Its Work for Those on Military Service].—Gregg. (*Science*, 15th March 1940, Vol. 91, pp. 264–265.)

2494. "Mitteilungen aus der Forschungsanstalt der Deutschen Reichspost" [German P.O. Research Department (First Half of 1939): Book Review].—(*E.T.Z.*, 8th Feb. 1940, Vol. 61, No. 6, p. 140.)

The items mentioned by the reviewer have all been dealt with in 1939 Abstracts, as follows:—Beckmann, Menzel, & Vilbig, and Scholz & Egersdörfer (propagation of waves, including u.h.f. waves), 2650, 3877, & 2634; Groszkopf, 1893 (feeders); Rösseler & others, 3564 (aerials: tests on models); Haberkant & Meinel, 2994 (single-sideband distortion); Reusse, 3626 (cathode-ray charge distribution); 4237 (a monitoring rack); and a survey by Gehrts of television developments at the beginning of 1939 (*cf.* 1073, 1603, 1980, & 4556).

2495. Some Applications of Multi-Stage Photocells with Secondary Emission to the Measurement of Light of Low Intensity.—Rodionov: Kubetski. (*Journ. of Tech. Phys.* [in Russian], No. 13, Vol. 9, 1939, pp. 1180–1187.)

Experimental characteristics of multi-stage photocells developed by Kubetski (*see*, for example, 2583 of 1937 and back reference) are plotted and it is shown that the integral sensitivity of some of these cells is 12 A/lumen, while the dark current does not exceed 2×10^{-8} A. It is stated that this type of cell can be used for measuring currents of the order of 1×10^{-8} A, corresponding to light fluxes of the order of 1×10^{-9} lm, and the following two pieces of apparatus, utilising these cells and developed by the author, are described: (a) a spectrophotometer (Fig. 9) for measuring absorption on wavelengths between 1000 mμ and 250 mμ when I_0/I varies from 1.1 to 100 (I_0 is the incident light and I the light passed by the absorbing liquid), and (b) an albedo-meter (Fig. 10) for measuring reflection from the skin on wavelengths from 320 mμ to 1100 mμ.

2496. The Use of Antimony-Caesium Photocells for the Registration of Stars.—Luk'yanov. (In paper dealt with in 2346, above.)

2497. Stroboscopic Measuring Instrument for Frequencies and Revolutions [also for Slip Measurements, Mechanical Vibrations, etc: Long Cylindrical Drum with Series of Circles of Perforations, illuminated by Stationary Axial Stroboscopic Tube and driven by Synchronous Motor].—Sturm. (*E.T.Z.*, 1st Feb. 1940, Vol. 61, No. 5, pp. 103–105.)

The synchronous motor is driven from the mains (this frequency nowadays seldom varies more than ± 0.2%), but if a constant enough supply is not available the motor is replaced by a special synchronous motor designed for a tuning-fork frequency and rigidly coupled to a universal motor, which provides the self-starting and most of the power. The drum is coupled to the motor by a two-speed gear, thus increasing the frequency range of the instrument. In the model illustrated the difference in the number of holes, from circle to circle, is constant and equal to 2% of the whole range. A vibrating-reed frequency meter is included in the instrument to give a rough indication of the frequency under test, so as to eliminate the ambiguity of the stroboscopic indication.

2498. The Amplidyne Generator—a Dynamo-electric Amplifier for Power Control [Amplification of 10 000 : 1, with Practically Limitless Extension in combination with Radio Amplifiers: Operating Characteristics, etc.].—Alexanderson & others. (*Gen. Elec. Review*, March 1940, Vol. 43, No. 3, pp. 104–106.) For a preliminary note *see* 1558 of April. The present paper is followed (pp. 107–119) by two others, on the design characteristics and industrial applications (machine-tool control, etc.) of the amplidyne.

2499. An Electrodynamic Detector of Mechanical Vibrations, and Its Applications.—Giulietti. (*See* 2293.)

2500. A Distance and Velocity Meter based on a Curious Optical Effect.—Lau. (*See* 2282.)

2501. Pyrometric Telescope [Infra-Red Spectrometer picking-out 8.8μ Radiation] measures Temperatures of Distant Objects.—Strong. (*Sci. News Letter*, 16th March 1940, Vol. 37, No. 11, p. 175.)

Wireless Patents

A Summary of Recently Accepted Specifications

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each

AERIALS AND AERIAL SYSTEMS

517 935.—High-frequency feed-line, say for an aerial, and means for varying and controlling the distribution of standing-wave systems set up along it.

Standard Telephones and Cables (assignees of A. Alford). Convention date (U.S.A.) 8th September, 1937.

518 684.—Method of earthing and screening an aerial against static interference.

A. B. Hewitt and A. G. Head. Application date 31st August, 1938.

DIRECTIONAL WIRELESS

517 860.—Radio direction-finder with hydraulic remote-control for the rotatable frame-aerial.

F. J. Cleveland (Bendix Aviation Corpn.). Application date 7th May, 1938.

517 982.—Directive aerials enclosed in a streamlined casing, particularly for aircraft installation.

Standard Telephones and Cables and C. W. Earp. Application date 12th August, 1938.

518 211.—Locating the position of an invisible object which is radiating infra-red waves.

G. Krausz. Application date 25th April, 1939.

518 714.—Directive aerial system for radiating a pair of overlapping beams which define a navigational course.

Bendix Aviation Corpn. Convention date (U.S.A.) 2nd July, 1937.

518 824.—Generating short-wave " impulses " used for the location of invisible objects by the so-called radio-echo method.

Marconi's W.T. Co. (assignees of W. D. Hershberger). Convention date (U.S.A.) 30th September, 1937.

518 829.—Feed-lines and associated switching means for a directive aerial array of the bilateral or reversible type.

Marconi's W.T. Co.; O. Bohm; and N. Wells. Application date 5th September, 1938.

518 850.—Method of utilising the radiation from a single beacon transmitter for locating the position of a moving craft.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 6th October, 1937.

518 881.—Determining the altitude of an aeroplane in flight by utilising reflected wireless waves.

J. H. Hammond, Junr. Convention date (U.S.A.) 16th September, 1937.

519 350.—Directive " array " built up from a series of frame-aerial units.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 6th December, 1937.

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

517 845.—Receiver with means for shifting the received frequency-band relatively to the transmitted carrier-wave in order to avoid interference by adjacent signals.

Aga-Baltic Radio A-B. Convention date (Sweden) 10th August, 1937.

517 909.—Wireless receiver in which interference is suppressed by blocking the amplifying circuits for those short periods during which the disturbance is present.

Magyar Wolframlampa. Convention dates (Hungary) 24th September, 1937, and 18th March, 1938.

517 966.—Means for increasing the accuracy with which a remotely-controlled oscillatory circuit can be tuned, particularly for radio receivers.

L. L. de Kramolin. Convention dates (Germany) 8th and 10th May, 1937.

518 031.—Visual indicator for automatic tuning control combined with means for cyclically varying the tuning element of a wireless receiver and for arresting the movable element at a desired point.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 9th September, 1937.

518 128.—Automatic volume control system combined with means for " muting " a wireless receiver during interstation tuning.

E. P. Rudkin. Application date 11th August, 1938.

518 214.—Valve amplifier circuit utilising negative feed-back to give a straight-line response and stable operation over a wide range of frequencies.

Marconi's W.T. Co. and O. E. Keall. Application date 14th June, 1938.

518 229.—Means for ensuring the stoppage of the driving motor of a push-button tuning system precisely at the selected station.

E. K. Cole and G. Bradfield. Application date 17th August, 1938.

518 308.—Automatic gain or volume controls including main and auxiliary rectifiers for a wireless receiver (divided out of 518 128).

E. P. Rudkin. Application date 11th August, 1938.

518 427.—Differential cord-and-pulley driving-gear for the tuning control of a wireless receiver.

Telefunken Co. Convention date (Germany) 25th August, 1937.

518 433.—Method of limiting noise in signal reception, based on the principle that the amplitude of the disturbance varies inversely with its frequency.

A. A. Thornton (communicated by Philco Radio and Television Corpn.). Application date 26th August, 1938.

518 434.—Means for limiting the amplitude, steepness of wave-front, and energy-content of inductive disturbances and interfering signals.

A. A. Thornton (communicated by Philco Radio and Television Corpn.). Application date 26th August, 1938.

518 437.—Automatic volume control circuit, particularly designed for the reception of C.W. signals.

Standard Telephones and Cables (communicated by C. Vinogradoff). Application date 26th August, 1938.

518 480.—Automatic tuning control depending upon the application of a continuous and uniform frequency-modulation to the local oscillator of a superhet receiver.

J. E. Rhys-Jones ; J. O. G. Barrett ; and The Plessey Co. Application date 23rd July, 1938.

518 635.—Receiver in which the field-winding of the tuning motor is included in the smoothing-circuit from the A.C. mains supply.

Kolster-Brandes and W. A. Beatty. Application date 30th August, 1938.

518 890.—Remote tuning control of a wireless receiver through the electric supply mains.

E. K. Cole and A. Herczeg. Application date 7th September, 1938.

518 941.—Push-button tuning system in which the positioning is effected in two stages of which the first is approximate and the second accurate.

Philco Radio and Television Corpn. (assignees of J. H. Pressley). Convention date (U.S.A.) 9th September, 1937.

518 968.—High-frequency coupling, particularly for a superhet receiver, in which the degree of coupling can be varied without altering the overall inductance.

Johnson Laboratories Inc. (assignees of A. Crossley). Convention date (U.S.A.) 12th August, 1937.

518 979.—Tuning dial with accurate means for indicating the setting for short-wave working.

The General Electric Co. ; W. R. Rose ; F. Clark ; and A. D. Forbes. Application dates 10th September, 1938, *and 5th January*, 1939.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

517 756.—Preventing the impact on the sensitive screen of a cathode-ray tube of secondary electrons produced inside the tube.

Electrical Research Products Inc. Convention date (U.S.A.) 19th February, 1938.

517 815.—Rectifying tube with two cathodes and a common anode for supplying two different D.C. voltages from an A.C. mains supply, particularly for television receivers.

The General Electric Co. and D. C. Espley. Application date 2nd August, 1938.

517 839.—Cathode-ray tube arrangement for generating oscillations of saw-tooth form without the use of a storage condenser.

Fernseh Akt. Convention date (Germany) 7th August, 1937.

517 888.—Coupling arrangement for preventing interaction between the sound and vision input circuits of a television receiver.

Baird Television and C. E. Maitland. Application date 15th August, 1938.

518 120.—Transformer coupling for handling a wide band of currents, as in television, without phase distortion.

Marconi's W.T. Co. and C. D. Colchester. Application date 13th June, 1938.

518 210.—Valve circuit for generating high-frequency oscillations for application to a light-modulating cell of the supersonic pressure-wave type, as used in television.

I.M.K. Syndicate and P. Nagy. Application date 14th May, 1938.

518 341.—Television system utilising a " floating " carrier-wave to transmit a signal characteristic of the mean brightness of the picture.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 25th September, 1937.

518 378.—Negative feed-back circuit arranged to minimise distortion in a valve oscillator generating saw-toothed waves as used for scanning in television.

E. L. C. White. Application date 23rd August, 1938.

518 588.—Construction of a screen designed to become incandescent under the impact of the electron stream passing through a cathode-ray tube.

Marconi's W. T. Co. (assignees of H. W. Kaufmann). Convention date (U.S.A.) 31st August, 1937.

518 615.—Television cabinet with means for screening the big end of the cathode-ray tube when pictures are not being received.

Kolster-Brandes ; C. N. Smyth ; and P. A. Tiller. Application date 23rd August, 1938.

518 616.—Movable shutter for screening at will either the cathode-ray tube or the tuning dial on the cabinet of a combined sound and vision receiver.

Kolster-Brandes and C. N. Smyth. Application date 23rd August, 1938.

518 643.—Stabilising the frequency of the time-base oscillator of a television receiver in spite of variations in output amplitude.

Fernseh Akt. Convention date (Germany) 1st September, 1937.

518 672.—Negative feed-back circuit for correcting frequency-attenuation in a cable carrying a wide band of frequencies, e.g., television signals.

F. W. Cackett. Application date 2nd August, 1938.

518 740.—Television receiver with a system of automatic gain control which is based on the framing signals only.

Radio-Akt. D. S. Loewe (K. Schlesinger). Convention date (Germany) 30th August, 1937.

519 330.—Auxiliary magnetic coil for automatically focusing the electron beam in a cathode-ray tube with changes of brightness.

Kolster-Brandes and W. A. Beatty. Application date 20th September, 1938.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

518 088.—Electrode arrangement of a valve particularly adapted for use as a " mixer " in a superhet set. (Addition to 514 686).

Marconi's W. T. Co. (assignees of R. J. Erichsen). Convention date (U.S.A.) 13th August, 1937.

518 277.—Construction and arrangement of the electrode system of a cathode-ray tube.

The General Electric Co.; J. E. B. Jacob; and L. C. Jesty. Application dates 19th August, 1938, *and 9th June*, 1939.

518 553.—Electron-multiplier tube with means for preventing the deposition of barium (from the cathode) on to the secondary-emission electrodes (addition to 511 449).

Marconi's W. T. Co. and G. B. Banks. Application date 26th August, 1938.

518 574.—Electrode arrangement for focusing the stream through a cathode-ray tube without producing spherical aberration.

Marconi's W. T. Co. (assignees of L. B. Headrick). Convention date (U.S.A.) 20th August, 1937.

518 580.—Electrode system for preventing the passage of secondary electrons on to the fluorescent screen of a cathode-ray tube.

F. H. Nicoll. Application date 26th August, 1938.

518 221.—Cathode-ray tube designed to prevent the fluorescent screen from being damaged by the bombardment of ions and other heavy charged particles.

Ferranti; J. L. Miller; and H. Wood. Application date 12th August, 1938.

518 898.—Screen-grid and other valves with an electrode system designed to minimise " mush " or noise due to fluctuations in the electron stream.

Telefunken Co. Convention date (Germany) 7th September, 1937.

518 990.—Single-stage electron-multiplier in which a guiding grid is located between the photo-electric cathode and the anode.

The General Electric Co. and W. H. Aldous. Application date 14th September, 1938.

519 278.—Electrode arrangement for a valve generator designed to give a large output of short-wave energy.

Marconi's W. T. Co. (assignees of W. G. Wagener). Convention date (U.S.A.) 19th October, 1937.

SUBSIDIARY APPARATUS AND MATERIALS

517 971.—Electromagnetic relay of the resonance type, particularly for the selective remote control of apparatus by A.C. currents superposed on a mains supply line.

D. R. Price; G. L. Woolnough; and Metropolitan Vickers Electrical Co. Application dates 12th July, 8th November, and 17th December, 1938, *and 17th May*, 1939.

518 161.—Photo-electric cell for picture scanning, in which a tubular cathode and ring-shaped anode are mounted in an annular glass tube.

The Associated Press. Convention date (U.S.A.) 10th February, 1938.

518 200.—Potentiometer circuit for controlling the biasing voltage applied to thermionic amplifiers and photo-electric cells.

R.C.A. Photophone and J. L. Underhill. Application date 19th August, 1938.

518 202.—Assembly and construction of a unit or stack of dry-surface contact rectifiers.

Westinghouse Electric and Manufacturing Co. Convention date (U.S.A.) 30th September, 1937.

518 240.—Means for controlling the wave-form generated by a valve circuit of the " relaxation " type (addition to 485 120).

Standard Telephones and Cables and D. H. Black. Application date 19th August, 1938.

518 491.—Construction of a vibrating-armature system suitable for a loudspeaker or phonograph pick-up.

C. E. Eichhorn. Application date 18th August, 1938.

518 665.—Generating " peaked " oscillations by an intermittent control of the electron stream through a thermionic valve.

G. Jobst. Convention dates (Germany) 26th May, 1st June and 28th August, 1937.

518 713.—Rectifying and smoothing circuit for polyphase currents.

E. A. Nind and P. A. T. Bevan. Application date 2nd July, 1938.

518 766.—Method of welding highly-refractory metals, such as molybdenum and nickel in the manufacture of thermionic and like discharge tubes.

Ferranti; A. L. Chilcot; and S. Jackson. Application date 25th August, 1938.

518 815.—Construction of a throat microphone and means for attaching it to the wearer.

S. Ballantine. Application date 3rd June, 1938.

518 851.—Sound-transmission device forming a high-pass acoustic filter.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon.). Convention date (France) 9th September, 1937.

518 951.—Electron microscope in which the object under examination is scanned by a beam a thousandth of a millimetre in diameter.

M. von Ardenne and Siemens & Halske Akt. Convention date (Germany) 11th September, 1937.

519 334.—Construction of electric condenser to give a temperature-coefficient which can be varied at will.

Dubilier Condenser Co. and P. R. Coursey. Application date 20th September, 1938.

518 945.—High-frequency tuning coil, particularly for radio-transmitters, with an open-ended powdered-iron core made in separate sections.

W. J. Polydoroff. Application date, 9th September, 1938.