THE
WIRELESS ENGINEER

VOL. XVII. MARCH, 1940 No. 198

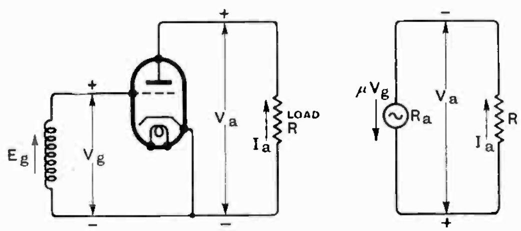
Editorial

The Phase Convention of Currents and Voltages in Valve Circuits

OUR attention was recently drawn to some correspondence in which a radio engineer sought an authoritative opinion on a statement which he regarded as incorrect. On p. 349 of Terman's "Radio-Engineering" and also on p. 192 of the same author's "Fundamentals of Radio," in connection with phase relationship in oscillators, it is stated that "in general, the voltage fed back from the output and applied to the grid of the tube must be approximately 180° out of phase with the voltage existing across the load impedance in the plate circuit of the amplifier." Now, if anyone asks if this is a correct statement, we can only reply that it is correct if the conventions adopted are such as to make it correct.

There are some cases in which it is not a matter of convention; for example, two electromotive forces acting in a simple circuit can definitely be said to be in phase if they both tend to produce current in the same direction around the circuit at every moment, but if there is any tapping from the circuit between the two sources of e.m.f. an element of uncertainty is immediately introduced. If we consider two alternators working in parallel, looked at from the point of view of a consumer taking power from the station the electromotive forces of the two machines are in phase, or very nearly so, whereas to the station engineer thinking of the current circulating between the two machines due to inequalities in the turning-moments of the prime-movers, their electromotive forces are in opposition, or nearly so. With potential differences the necessity of stating the convention adopted is even greater and in most cases any statement is meaningless unless the convention is stated; this is even more so when one is comparing things in two different circuits.

The words "positive" and "negative" are often used in a very loose or meaningless manner, e.g., in the correspondence referred to, the following statement was made: "a self-induced e.m.f. is regarded as negative and lags on the current by 90°, while the applied voltage is positive and leads 90°." If a continuous current flowing through an inductive resistance is increasing, the induced e.m.f. may be regarded as negative, since it is in the opposite direction to the current, but if the current is decreasing, the induced e.m.f. is positive, and there is no justification for saying that the self-induced e.m.f. is negative; with alternating current the self-induced e.m.f. lags 90° behind the current, but to add that it is negative is meaningless; it is equally meaningless to say that the applied voltage is positive. The applied voltage reaches its positive maximum a quarter-cycle before the current, whilst the self-induced e.m.f. reaches its positive maximum a quarter-cycle after the current, it being assumed that a certain direction through the coil is to be regarded as positive. It is indefinite to draw a rotating vector to represent the p.d. between two points unless it is clearly stated which of the points is to be at the higher potential when the vector is above the horizontal and the instantaneous value therefore positive. Perhaps the simplest way of avoiding ambiguity is to say that V_{ab} always means the amount by which the potential at a exceeds that at b or simply $V_{ab} = V_a - V_b$ where V_a and V_b represent the potentials with respect to earth. For current and e.m.f. arrows can always be drawn on the circuit diagram to indicate which directions are to be regarded as positive; when the vector is below the horizontal, it simply means that the current or e.m.f. at that moment is negative, i.e., in the opposite direction to that shown as positive on the circuit diagram.



(a) (b)

Fig. 1.

The ordinary valve circuit introduces special difficulties which lead to the adoption of strange conventions. In Fig. 1 (*a*) we show a valve operating as an amplifier under the simplest conditions and the standard text-book formula is $I_a = (V_a + \mu V_g)/R_a$, so that V_a and V_g are reckoned to be positive when they tend to increase I_a. As we are only concerned with alternating components we omit batteries and steady components. Now, says the text-book, if we put $V_a = -RI_a$, we obtain $I_a = \dfrac{\mu V_g}{R_a + R}$.

These are definitely stated (see Mallett's "Telegraphy and Telephony") to be vector equations, and it will be noted that the relation between the p.d. across a resistance and the current through it is not $V = RI$ but $V = -RI$. In Chaffee's "Theory of Thermionic Vacuum Tubes" (p. 192) the p.d. between the anode and cathode is called e_p and that across the load e_b, and it is stated that $de_p = -de_b$, which is strange, since, except for the battery, e_p and e_b are really one and the same, but merely looked at from a different point of view. It is equivalent to the obviously correct statement that $V_{ab} = -V_{ba}$. If one writes $V_a = -RI_a$ then when the current I_a is a positive maximum the p.d. V_a must be a negative maximum and the two are necessarily to be regarded as 180° out of phase. If the current is regarded as positive when the grid voltage V_g is positive, then V_a and V_g must be regarded as 180° out of phase. Terman says "the plate circuit can be replaced by an equivalent generator of voltage $-\mu e_s$ acting from the cathode toward the plate," which is, of course, the same as our $+\mu V_g$ acting downwards in Fig. 1 (*b*). He expresses it in this way because he reverses the current convention and says "a positive value for I_p means a current flowing in opposition to the steady direct current." He therefore writes $I_p = \dfrac{-\mu E_s}{R_p + Z_L}$, which again looks rather strange. But it may be asked, is there no alternative to these seemingly topsy-turvy conventions? Yes, as soon as one neglects the d.c. components, and regards the valve as an a.c. generator with an internal resistance R_a and an equivalent e.m.f. μV_g, one can adopt the usual convention as regards the terminal p.d. of a generator, as shown in Fig. 1 (*b*). When V_g is a positive maximum, I_a will be a positive maximum and the cathode terminal must be regarded as being at its maximum positive potential. We now have $V_a = RI_a$ without any minus sign and V_a and V_g are in phase. The only point to remember is that the resultant p.d. between the anode and the cathode is then the difference between the d.c. and a.c. components and not their sum. One cannot pretend that the valve, and not the battery, is the source of power without paying the penalty somewhere. For most purposes, however, one is only interested in the a.c. components and everything is perfectly straightforward with no jarring minus signs apparently doing violence to Ohm's law.

G. W. O. H.

Two-Way Radio-Telephony*

A New "Two-Wire, Four-Wire" Control Terminal

By Ing. Matei G. Marinesco

(Polytechnic School, Bucharest, Roumania)

SUMMARY.—It is shown how by applying the feed-back principle (negative and positive) to a certain circuit, in conjunction with the introduction of small amounts of a certain amplitude distortion (which can be kept at a very low value if only sufficient feed-back is introduced), a two-wire, four-wire control terminal is obtained, specially adapted for two-way radio-telephone communication, as it eliminates almost completely echo and singing troubles met with in the conventional "hybrid-coil, balancing network" type of control terminal.

I.—Introduction

IT is well known that in any two-way telephone or radio-telephone transmission, where amplification must occur both ways, the gain is limited by the unavoidable regeneration which occurs between input and output of the same amplifier and which degenerates into singing of the whole transmission system if a certain amount of gain is exceeded. This is specially the case with telephone communication with radio-links, where on account of radio noise and because transmission efficiency must be kept at a high level (radio-transmitter fully loaded in spite of large variations in subscriber's voice level), the gain of the transmission amplifier must be varied between large limits. In this case the simple control "terminal" consisting of hybrid-coil and balancing-network is no more of practical use. To avoid echoes or singing when noise level is high or subscriber level low, the terminal is provided with "Vodas" (voice operated devices anti-singing) installations[1,2,3]. But these devices are of a complicated nature, of a limited practical performance, and require severe maintenance conditions. A simple control terminal, suppressing almost completely regeneration in spite of large gain variation, would offer therefore, as concerns radio-telephone transmission, the marked advantage of eliminating from the terminal installations, the "Vodas" or echo-suppressor devices, necessary in the case of conventional type of terminal.

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

Moreover, as concerns electric circuit theory, it is interesting to point out the possibility of the reversible amplifier, that is to say a two-wire amplifier, the gain of which in both directions should not be limited by line impedance equilibration or in other words by external conditions.

Further, so far as linear net-works are concerned, the reversibility is not possible, but it becomes so as soon as small amounts of amplitude distortion and large feed-back voltages are introduced.

II.—Voltages and Voltage-gain of a Two-way, Two-wire Amplifier System

Any two-way radio-telephone communication system may be reduced to the basic scheme of Fig. 1. We see from this figure that the two separate one-way radio circuits, *H-E* and *F-G*, are combined at each end into a single two-way, two-wire communication circuit, L_C and L_D, through a six pole terminal T_C and T_D.

As such a terminal contains unidirectional elements (the transmitter and receiver amplifier are to be included in the terminals), the three pairs of poles are not interchangeable.

Thus for terminal T_D, at *G* a p.d. can only be applied, at *H* only produced, at *D* applied or produced, or both. Therefore, each terminal may be characterised by a relation giving the voltage produced at one pair of poles in terms of the voltages applied at the other two pairs of poles.

Suppose therefore an e.m.f. e_D to be impressed upon the system at *D*, we may write for terminal T_D:

$$v_H = f(e_D, v_G)$$

where: v_G is the p.d. applied at G (we will call this voltage the feed-back voltage) and v_H, the p.d. produced at H.

If this relation, which we will call the characteristic equation of the terminal, be linear, we may write it:

$$v_H = k_{GH} \,.\, v_G + k_{DH} \,.\, e_D \quad .. \quad (1)$$

where: k_{GH}, k_{DH}, are constants.

For terminal T_C, we will have:

$$v_F = k_{EF} \,.\, v_E \quad .. \quad .. \quad (2)$$

$$v_C = k_{EC} \,.\, v_E \quad .. \quad .. \quad (3)$$

where: v_E, is the p.d. applied at E; v_C, v_F the p.d. produced at C and F respectively and k_{EF}, k_{EC}, constants.

Further, let: $v_E = k_{HE} \,.\, v_H$, $v_G = k_{FG} \,.\, v_F$, where: k_{HE}, k_{FG} are constants of the radio-links of the transmission.

It must be pointed out here, to avoid any misunderstanding, that k_{HE}, k_{FG} are constants with respect to the voltages applied or produced, although they may vary with time because of changes in atmospheric conditions.

Eliminating v_E, v_F and v_G between (1) and (2), we get:

$$v_H = \frac{1}{1-\lambda} \,.\, v_{1H} \quad .. \quad (4)$$

where:

$$\lambda = k_{EF} \,.\, k_{FG} \,.\, k_{GH} \,.\, k_{HE} = \frac{v_F}{v_E} \,.\, \frac{v_G}{v_F} \,.\, \frac{v_E}{v_H} \,.\, \left[\frac{v_H}{v_G}\right]_{e_D=0};$$

and: $v_{1H} = k_{DH} \,.\, e_D = [v_H]_{v_G=0}$

For any other of the six voltages of the loop: $ECFGDHE$, we will have a relation similar to (4). Thus at C, we may write:

$$v_C = \frac{1}{1-\lambda} \,.\, v_{1C} \quad .. \quad (4')$$

where:

$$v_{1C} = k_{EC} \,.\, k_{HE} \,.\, k_{DH} \,.\, e_D = k_{EC} \,.\, k_{HE} \,.\, v_{1H};$$

Calling: $\frac{1}{1-\lambda}$ the feed-back factor, we may state the following rule: the voltage, at any point of a system like that of Fig. 1, due to the impressed e.m.f. at D or C, is equal to the voltage at that point, due to the impressed e.m.f. only, that is to say in the absence of the feed-back voltage, multiplied by the feed-back factor. This rule is valid only when the characteristic equations of the terminals are linear, or when we may neglect higher order voltage terms from such equations.

Further, if we put: $g_{DC} = k_{DH} \,.\, k_{HE} \,.\, k_{EC}$, we have:

$$v_{1C} = g_{DC} \,.\, e_D$$

and: $$v_C = \frac{1}{1-\lambda} g_{DC} \,.\, e_D = G_{DC} \,.\, e_D$$

g_{DC} is the gain from D to C, in the absence of feed-back voltage, and G_{DC} is the total gain from D to C. We see, therefore, that the total gain is equal to the gain in the absence of feed-back multiplied by the feed-back factor.

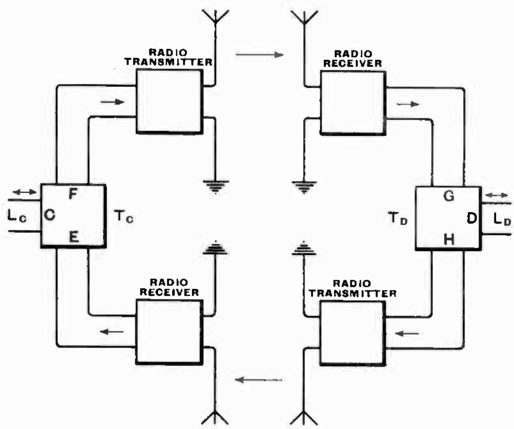


Fig. 1.

From the expressions for λ and g, we may find a relation between these two quantities by eliminating k_{FG} and k_{HE}; thus:

$$\lambda = \frac{k_{EF}}{k_{EC}k_{CF}} \,.\, \frac{k_{GH}}{k_{GD}k_{DH}} \,.\, g_{DC} \,.\, g_{CD} = \kappa \,.\, g_{DC} \,.\, g_{CD}$$

where: $g_{CD} = k_{CF}\, k_{FG}\, k_{GD}$, is the gain without feed-back from C to D. If: $g_{CD} = g_{DC} = g$,

$$\lambda = \kappa g^2$$

In practice, for stable working of the system, $\lambda < 1$ for all frequencies (4), otherwise for a certain frequency $\lambda = 1$ and the feed-back factor becomes infinite and singing occurs. For the "hybrid-coil, balancing-network" terminal: $\kappa = 4\frac{Z_{C'} - Z_C}{Z_{C'} + Z_C} \,.\, \frac{Z_{D'} - Z_D}{Z_{D'} + Z_D}$, and if:

$$Z_{D'} \approx Z_D\,;\; Z_{C'} \approx Z_C,\; \kappa \approx \frac{Z_{C'} - Z_C}{Z_C} \cdot \frac{Z_{D'} - Z_D}{Z_D}\,;$$

where Z_C, Z_D are the impedances of the lines L_C and L_D; $Z_{C'}$, $Z_{D'}$ the impedances of the corresponding balancing networks. Practically in this case $\kappa \approx 10^{-2}$; therefore for stable work $g < 10$. If g increases beyond this value singing may occur. The problem is therefore to decrease the κ of the terminal. This is what the new terminal achieves.

III.—The New "Terminal" Circuit

(a) Description and definition of symbols used.

The basic scheme of the new terminal circuit is seen in Fig. 2 representing terminal T_D. A_1 A'_1 A_2 A'_2 are amplifiers, the arrows in the figure indicating the directions in which amplification occurs; B_D $B_{D'}$ C_H C'_H are feed-back networks so that B_D $B_{D'}$ introduce negative feed-back and C_H C'_H positive feed-back. Further, it is seen from the same figure that the p.d. applied at A_1 is equal but opposite in sign to the p.d. applied at A'_1. Let μ_1, R_1 be the amplification factor and internal resistance of A_1 and A'_1; μ_2 R_2, those of A_2 and A'_2, β_D $\beta_{D'}$ γ_H γ'_H the voltage ratios (output to input of network) of B_D $B_{D'}$ C_H C'_H respectively; we will suppose that the input impedance of the feed-back networks is great with respect to the output impedance of the amplifiers and that the output impedance of the networks is small with respect to the input impedance of the amplifiers.

In these conditions the energy that the feed-back networks supply to the amplifiers is negligible.

Let finally Z_D be the impedance of the line L_D as seen from D, $Z_{D'}$ the impedance at D' and Z_H the impedance at H.

(b) Characteristic equation of the new terminal.

Following the above method, we will first find the characteristic equation of the terminal of Fig. 2. That is to say the function:

$$v_H = f(e_D, v_G)$$

Introducing a fundamental assumption as to the non-linearity of β_D $\beta_{D'}$ γ_H γ'_H and some auxiliary assumptions, we will show that the characteristic equation remains linear, if we neglect small second order voltage terms. This will give us λ and therefore κ for the terminal.

Applying Kirchhoff's rules to the circuit of A_1:

$$v_D = \frac{1}{1 + \alpha_D\beta_D}\, e'_D + \frac{\alpha_D}{1 + \alpha_D\beta_D}\, v_G + \frac{\alpha_D}{1 + \alpha_D\beta_D}\, \gamma_H \,.\, Z_H(i_2 + i'_2) \quad .. \quad (5)$$

where: $e'_D = \dfrac{e_D}{1 + Z_D/R_1}$; $\alpha_D = \dfrac{\mu_1}{1 + R_1/Z_D}$;

and: i_2, i'_2 are the plate currents of A_2 and A'_2. Applying the same to the circuit of A_2:

$$R_2 i_2 = - Z_H(i_2 + i'_2) + \mu_2 v_D \quad .. \quad (6)$$

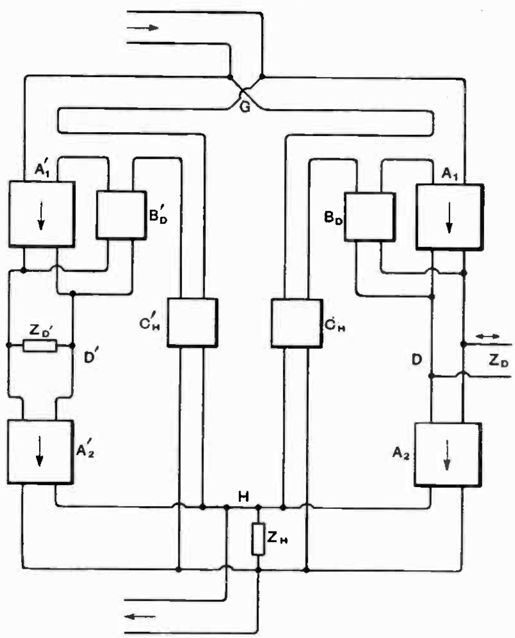


Fig. 2.

The elimination of v_D, between (5) and (6) gives:

$$\left[R_2 + \left(1 - \mu_2 \frac{\alpha_D}{1 + \alpha_D\beta_D}\,\gamma_H\right) Z_H\right] i_2 + \left[1 - \mu_2 \frac{\alpha_D}{1 + \alpha_D\beta_D}\,\gamma_H\right] Z_H i'_2 + \mu_2 \frac{\alpha_D}{1 + \alpha_D\beta_D}\left(1 - \frac{e'_D}{\alpha_D v_G}\right) v_G = 0 \quad .. \quad (7)$$

Further application of Kirchhoff's rules to circuits of A'_1 and A'_2, gives :

for A'_1

$$v_{D'} = \frac{\alpha_{D'}}{1 + \alpha_{D'}\beta_{D'}} v_G + \frac{\alpha_{D'}}{1 + \alpha_{D'}\beta_{D'}} \gamma'_H Z_H (i_2 + i'_2) \quad \ldots \quad (8)$$

for A'_2

$$R_2 i'_2 = - Z_H(i_2 + i'_2) + \mu_2 v_{D'} \quad \ldots \quad (9)$$

By eliminating $v_{D'}$, between (8) and (9)

$$\left[R_2 + (1 - \mu_2 \frac{\alpha_{D'}}{1 + \alpha_{D'}\beta_{D'}} \gamma'_H) Z_H\right] i'_2 + \left[1 - \mu_2 \frac{\alpha_{D'}}{1 + \alpha_{D'}\beta_{D'}} \gamma'_H\right] Z_H i_2 - \mu_2 \frac{\alpha_D}{1 + \alpha_{D'}\beta_{D'}} v_G = 0 \quad \ldots \quad (10)$$

where $$\alpha_{D'} = \frac{Z_{D'}}{R_1 + Z_{D'}} \mu_1$$

Solving (7) and (10) for i_2 and i'_2 since $v_H = Z_H(i_2 + i'_2)$, we get :

$$v_H = \frac{\dfrac{\alpha_{D'}}{1 + \alpha_{D'}\beta_{D'}} - \dfrac{\alpha_D}{1 + \alpha_D\beta_D}}{1 - \alpha_2\gamma_H \dfrac{\alpha_D}{1 + \alpha_D\beta_D} - \alpha_2\gamma'_H \dfrac{\alpha_{D'}}{1 + \alpha_{D'}\beta_{D'}}} \alpha_2 v_G + \frac{\dfrac{1}{1 + \alpha_D\beta_D}}{1 - \alpha_2\gamma_H \dfrac{\alpha_D}{1 + \alpha_D\beta_D} - \alpha_2\gamma'_H \dfrac{\alpha_{D'}}{1 + \alpha_{D'}\beta_{D'}}} \alpha_2 e'_D \quad \ldots \quad \ldots \quad (11)$$

where $$\alpha_2 = \frac{Z_H}{R_2 + 2Z_H} \mu_2 ;$$

and if $\alpha_D\beta_D,\ \alpha_{D'}\beta_{D'} \gg 1$

equation (11) becomes

$$v_H = \frac{\dfrac{1}{\beta_{D'}} - \dfrac{1}{\beta_D} + \dfrac{1}{\alpha_D\beta_D^2} - \dfrac{1}{\alpha_{D'}\beta^2_{D'}}}{1 - \alpha_2 \dfrac{\gamma_H}{\beta_D}\left(1 - \dfrac{1}{\alpha_D\beta_D}\right) - \alpha_2 \dfrac{\gamma'_H}{\beta_{D'}}\left(1 - \dfrac{1}{\alpha_{D'}\beta_{D'}}\right)} \alpha_2 v_G + \frac{1/\alpha_D\beta_D}{1 - \alpha_2 \dfrac{\gamma_H}{\beta_D}\left(1 - \dfrac{1}{\alpha_D\beta_D}\right) - \alpha_2 \dfrac{\gamma'_H}{\beta_{D'}}\left(1 - \dfrac{1}{\alpha_{D'}\beta_{D'}}\right)} \alpha_2 e'_D \quad \ldots \quad \ldots \quad (11')$$

equation (5) becomes

$$v_D = \frac{1}{\beta_D}\left(1 - \frac{1}{\alpha_D\beta_D}\right)\left(\frac{e'_D}{\alpha_D} + v_G + \gamma_H v_H\right) \quad (12)$$

and equation (8) becomes

$$v_{D'} = \frac{1}{\beta_{D'}}\left(1 - \frac{1}{\alpha_{D'}\beta_{D'}}\right)(v_G + \gamma'_H v_H) \quad \ldots \quad (13)$$

(c) *Fundamental assumption concerning the non-linearity of feed-back networks.*

We will assume that the phase angle of the output voltage with respect to the input voltage, for each feed-back network, varies in proportion to the amplitude of the input voltage, the ratio of the amplitudes of output to input voltages remaining constant.

Thus we will have for B_D, $B_{D'}$, C_H and C'_H, respectively :

$$\beta_D = \beta\ (\cos h_D V_D + j \sin h_D V_D)$$
$$\beta_{D'} = \beta'\ (\cos h_{D'} V_{D'} + j \sin h_{D'} V_{D'})$$
$$\gamma_H = \gamma\ (\cos h_H V_H + j \sin h_H V_H)$$
$$\gamma'_H = \gamma'\ (\cos h'_H V_H + j \sin h'_H V_H)$$

$V_D\ V_{D'}\ V_H$ are the amplitudes of voltages at $D\ D'$ and H and $h_D\ h_{D'}\ h_H\ h'_H\ \beta\ \beta'\ \gamma\ \gamma'$ are constants. For terminal T_C we will have four similar relations.

(d) *Auxiliary assumptions.*

These do not restrain in any way the general conclusions at which we shall arrive, but only simplify calculations. Thus, let us suppose, for terminal T_D, that $\beta' = \beta$, $\gamma' = \gamma$, $h_{D'} = h_D$, $h'_H = h_H = h$; $h_D = 2\alpha_2 h_H = 2\alpha_2 h$; $\alpha_2 \dfrac{\gamma}{\beta} = \frac{1}{2}$; and for terminal T_C, that $h_{C'} = h_C$; $h'_F = h_F = h$; $h_C = 2\alpha_2 h$; $Z_F = Z_H$; let us suppose also, that hV is a small angle such that

$$\cos hV + j \sin hV \simeq 1 + jhV ;$$

Finally, we shall assume $Z_{D'} \simeq Z_D$ and $Z_{C'} \simeq Z_C$; such that

$$2\frac{Z_{D'} - Z_D}{Z_{D'} + Z_D} = 2\frac{\alpha_{D'} - \alpha_D}{\alpha_{D'} + \alpha_D} \simeq \frac{\alpha_{D'} - \alpha_D}{\alpha_D} ;$$

and that

$$2\frac{Z_{C'} - Z_C}{Z_{C'} + Z_C} = 2\frac{\alpha_{C'} - \alpha_C}{\alpha_{C'} + \alpha_C} \simeq \frac{\alpha_{C'} - \alpha_C}{\alpha_C} ;$$

this is also the case in actual practice with conventional radio-telephone systems where $\kappa \simeq 10^{-2}$.

(*e*) *Calculation of characteristic equation on the foregoing assumptions.*

Equations (11), (12) and (13) become

$$v_H = \frac{1 + j\epsilon_D}{1 - j\eta_D}\delta_D g v_G + \frac{1}{1 - j\eta_D}\alpha_2 e'_D \quad (14)$$

$$v_D = \frac{e'_D}{\alpha_D\beta} + \left(1 - \frac{1}{\alpha_D\beta}\right)\frac{v_G}{\beta} + \left[1 + j\frac{\eta_D}{\alpha_D\beta} - \frac{1}{\alpha_D\beta}\right]\frac{v_H}{2\alpha_2} \quad .. \quad (15)$$

$$v_{D'} = \left(1 - \frac{1}{\alpha_{D'}\beta}\right)\frac{v_G}{\beta} + \left[1 + j\frac{\eta_D}{\alpha_D\beta} - \frac{1}{\alpha_{D'}\beta}\right]\frac{v_H}{2\alpha_2} \quad .. \quad (16)$$

where $\epsilon_D = \frac{\alpha_D\beta}{\delta_D} h_D(V_D - V_{D'})$;

$$\eta_D = \alpha_D\beta\alpha_2 h\left[\frac{V_H}{\alpha_2} - (3V_D - V_{D'})\right];$$

$$\delta_D = \frac{\alpha_{D'} - \alpha_D}{\alpha_D}; \; g = \frac{\alpha_2}{\beta}.$$

By analogy, for terminal T_C

$$v_F = \frac{1 + j\epsilon_C}{1 - j\eta_C}\delta_C g v_E \quad .. \quad (17)$$

$$v_C = \left(1 - \frac{1}{\alpha_C\beta}\right)\frac{v_E}{\beta} + \left[1 + j\frac{\eta_C}{\alpha_C\beta} - \frac{1}{\alpha_C\beta}\right]\frac{v_F}{2\alpha_2} \quad .. \quad .. \quad (18)$$

$$v_{C'} = \left(1 - \frac{1}{\alpha_{C'}\beta}\right)\frac{v_E}{\beta} + \left[1 + j\frac{\eta_C}{\alpha_C\beta} - \frac{1}{\alpha_{C'}\beta}\right]\frac{v_F}{2\alpha_2} \quad .. \quad .. \quad (19)$$

Where $\epsilon_C\ \eta_C\ \delta_C\ \alpha_C\ \alpha_{C'}$ have analogous values. Before going further we must point out here that in the absence of non-linearity in the feed-back networks, that is to say, for $h = 0$ the new terminal circuit has the same value of κ as the conventional "hybrid-coil, balancing-network" terminal, viz.:

$$4\frac{Z_{C'} - Z_C}{Z_{C'} + Z_C}\cdot\frac{Z_{D'} - Z_D}{Z_{D'} + Z_D} \approx \frac{Z_{C'} - Z_C}{Z_C}\cdot\frac{Z_{D'} - Z_D}{Z_D},$$

(see Section II). Indeed if $h = 0$, equation (14) becomes

$$v_H = \delta_D g v_G + \alpha_2 e'_D$$

and equation (17)

$$v_F = \delta_C g v_E$$

therefore

$$\lambda = \frac{v_F}{v_E}\cdot\frac{v_G}{v_F}\cdot\frac{v_E}{v_H}\cdot\left[\frac{v_H}{v_G}\right]_{e'_D = 0} = \delta_C\delta_D k_{FG}\,.\,g k_{HE}\,.\,g$$

but $k_{FG}\,.\,g\,.\,k_{HE}\,.\,g \approx g_{CD}\,.\,g_{DC}$ if $\delta_C,\ \delta_D < 1$ and therefore, if $\alpha_{D'} \approx \alpha_D,\ \alpha_{C'} \approx \alpha_C$; as is easily seen by computing g_{CD}, g_{DC} (see definition of these quantities in Section II) from equations (14), (17), (18).

Hence $\lambda = \delta_C\,.\,\delta_D g_{CD}\,.\,g_{DC}$

and

$$\kappa = \delta_C\delta_D \approx \frac{\alpha_{C'} - \alpha_C}{\alpha_C}\cdot\frac{\alpha_{D'} - \alpha_D}{\alpha_D} = \frac{Z_{C'} - Z_C}{Z_C}\cdot\frac{Z_{D'} - Z_D}{Z_D}$$

Taking h into account we have to solve the system of six equations, viz., (14) to (19), which together with $v_E = k_{HE}\,.\,v_H$ and $v_G = k_{FG}\,.\,v_F$, will give us the six p.d.s of the two "six pole" terminals, in terms of the impressed e.m.f.

Before doing this, some preliminary remarks will simplify our task. Our interest lies chiefly in the fact that η_D and ϵ_D should be smaller than unity. As seen from equation (14), this is necessary in order that the amplitude distortion should be small, as η_D and ϵ_D are functions of e'_D and v_G. A second important condition is that η_C should be greater than unity and that $\epsilon_C < \eta_C$. Equation (17) shows that this is necessary in order that λ should be small. Solving, therefore, equations (17), (18) and (19) with the aid of the conditions $\eta_C > 1,\ \epsilon_C < \eta_C$ (see Appendix 1), we obtain

$$\eta_C = -\alpha_C\beta 2ghV_E,\ \epsilon_C = -2ghV_E$$

whence it can be seen that

$$\epsilon_C < \eta_C \text{ since } \alpha_C\beta \gg 1.$$

From equation (17) we have

$$\frac{v_F}{v_E} = \frac{1 - j2ghV_E}{1 + \alpha_C\beta j2ghV_E}\delta_C g \quad .. \quad (20)$$

We see from (20) that v_F/v_E diminishes with increasing hV_E and if $2ghV_E > 1$, we obtain

$$\frac{v_F}{v_E} = -\frac{\delta_C g}{\alpha_C\beta} \quad .. \quad .. \quad (21)$$

For v_C, equations (2_a) and (7_a) give

$$v_C = \frac{v_E}{\beta} \quad .. \quad .. \quad (21')$$

(*f*) *Calculation of* λ.

In Appendix 2 it is shown that if $g_{DC} \cdot \delta_D > 1$ and $\frac{4\delta_C g_{CD} g_{DC}}{\alpha_C \beta} < 1$ then η_D and ϵ_D are negligible and equation (14) becomes

$$v_H = \delta_D g v_G + \alpha_2 e'_D \quad .. \quad (22)$$

which together with (21) and

$$v_G = k_{FG} v_F \; ; \; v_E = k_{HE} \cdot v_H,$$

gives by eliminating v_G, v_F and v_E

$$v_H = \frac{\alpha_2}{1 - \lambda} e'_D \; .. \quad .. \quad (23)$$

where

$$\lambda = -\frac{\delta_C \delta_D}{\alpha_C \beta} g^2 k_{FG} k_{HE} = -\frac{\delta_C \delta_D g_{DC} g_{CD}}{\alpha_C \beta} \quad (24)$$

From (21′), (23) and with reference to the definition of g_{DC} (see Section II) we obtain $g_{DC} = \frac{\alpha_2}{\beta} k_{HE} = g k_{HE}$, and by analogy $g_{CD} = g k_{FG}$. From (24) we see immediately that echo and singing troubles are reduced in the new system compared with the conventional system, in proportion to the amount of negative feed-back introduced. Thus if $\alpha_C \beta = 10^4$ the value of g_{DC} or g_{CD} must be 10^4 times greater than the value it has in conventional systems, before any echo or singing troubles will be experienced, assuming that δ_C and δ_D have the same values in

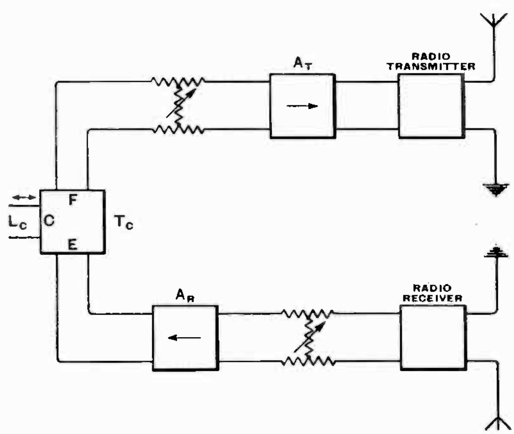


Fig. 3.

both systems. According to this result, the "schematic" of Fig. 1 may be modified as shown in Fig. 3, where the transmitter amplifier—included into the terminal in the case of Fig. 1—is split up into two separate amplifiers, viz.: (1) a fixed gain amplifier which remains in the terminal and satisfies the condition $\alpha_2 \frac{\gamma}{\beta} = \frac{1}{2}$ (see Section III, paragraph *d*); and (2) a variable gain amplifier A_T, which provides the necessary gain adjustment (see Section I). This amplifier may be equipped with a "Vogad" (voice operated gain adjusting device[5]). The reception amplifier, also included in the terminal in Fig. 1, may be split up similarly into two amplifiers, a constant and a variable one, to provide gain adjustment when reception is too weak or too strong.

IV.—Amplitude of Self-sustained Oscillation

We have assumed so far that there is an impressed e.m.f. acting upon the system, so that $\eta_C = \alpha_C \beta 2 g h V_E > 1$, when the e.m.f. is impressed at *D* (equation (20)). In the absence of this impressed e.m.f., the λ of the system has the same value as in conventional systems, namely, $\lambda = \delta_C \delta_D g_{CD} g_{DC}$ (see calculation of λ for $h = 0$) and we may have $\lambda > 1$ for at least one frequency, so that the system may be instable. Supposing, therefore, that there is instability, an oscillation will start, but as the amplitude of this oscillation increases, V_F/V_E and V_H/V_G and consequently λ decrease (equation (20)). The maximum amplitude of oscillation will occur when $\lambda = 1$. If $V'_E V'_F V'_G V'_H$ be the maximum amplitudes of oscillation at *EFG* and *H* respectively, we may write

$$\lambda = \frac{V'_F}{V'_E} \cdot \frac{V'_H}{V'_G} \cdot \frac{V'_G}{V'_F} \cdot \frac{V'_E}{V'_H} = 1 \quad .. \quad (25)$$

also from equation (20)

$$\frac{V'_F}{V'_E} = \frac{\sqrt{1 + (2ghV'_E)^2}}{\sqrt{1 + (2\alpha_C \beta g h V'_E)^2}} \delta_C g \; ;$$

$$\frac{V'_H}{V'_G} = \frac{\sqrt{1 + (2ghV'_G)^2}}{\sqrt{1 + (2\alpha_D \beta g h V'_E)^2}} \delta_D g \; ;$$

and assuming $2\alpha_C \beta g h V'_E > 1$, $2ghV'_E < 1$; $2\alpha_D \beta g h V'_G > 1$, $2ghV'_G < 1$, we obtain

$$\frac{V'_F}{V'_E} = \frac{\delta_C g}{2\alpha_C \beta g h V'_E} \; ; \; \frac{V'_H}{V'_G} = \frac{\delta_D g}{2\alpha_D \beta g h V'_G} \quad .. \quad (26)$$

Equations (25) and (26), together with $V'_G = k_{FG} V'_F$, $V'_E = k_{HE} V'_H$, will give us each of the four maximum amplitudes of oscillation, namely, $V'_E V'_F V'_G V'_H$. Thus by elimination of $V'_F V'_G V'_H$ we get

$$V'_E = \frac{\delta_D k_{HE}}{2\alpha_D \beta h} \quad \ldots \quad \ldots \quad (27)$$

Introducing this value of V'_E into $2\alpha_C \beta gh V'_E > 1$ and into $2gh V'_E < 1$ we obtain

$$\frac{\alpha_C}{\alpha_D} g_{DC}\delta_D > 1 \; ; \; \frac{g_{DC}\delta_D}{\alpha_D \beta} < 1$$

We see immediately that $\frac{\alpha_C}{\alpha_D} g_{DC}\delta_D > 1$ represents the necessary condition for the oscillation to start. Indeed, together with $\frac{\alpha_D}{\alpha_C} g_{CD}\delta_C > 1$, it shows that $\lambda > 1$; further equation (27) shows that if an oscillation starts, its maximum amplitude may be made as small as we wish if $\alpha_D \beta h$ is great enough. When an impressed e.m.f. acts upon the system, say at D, the self-sustained oscillation disappears, provided that either

$$V_H \geqslant V'_H \quad \text{or} \quad e'_D \geqslant \frac{\delta_D}{2\alpha_D \beta h \alpha'_2}$$

(see equations (14) and (27)) as in this case $\lambda < 1$; but we can, if necessary, make the audible self-sustained oscillation disappear also in the non-speaking condition by providing some super-audible frequency, derived from the radio transmitter, to act permanently upon the non-linear networks. If such impressed e.m.f.s are applied at E and G, their amplitudes must be at least equal to $\frac{\delta_D k_{HE}}{2\alpha_D \beta h}$ and $\frac{\delta_C k_{FG}}{2\alpha_C \beta h'}$ respectively, before the audible oscillation will be suppressed.

V.—Conclusions

A new "two-wire, four-wire" terminal has been developed, which enables two-way radio-telephone communication to be carried out without echo or singing troubles. This was achieved through introduction of a certain non-linear feed-back. The feed-back factor of such a system may be made to approach unity as closely as is necessary to allow large gain variation, if only sufficient feed-back is introduced. The amount of amplitude distortion may also be reduced to negligibly small values by increasing the feed-back.

If singing arises, its amplitude can be reduced to any extent by making $\alpha_D \beta h$ sufficiently great. Any singing stops as soon as the impressed e.m.f. exceeds a certain very small value.

Any singing may also be suppressed in the non-speaking state if only a small super-audible frequency, derived from the radio transmitter, be allowed to act permanently upon the system, at the input of each terminal.

A question arises, however: is it possible by simple means to realise the non-linear networks of which only the theoretical non-linear characteristic is given here? To this question we answer affirmatively, and hope to be able to publish shortly experimental data on the performance of the new terminal circuit.

APPENDIX 1

Calculation of: ϵ_C and η_C.

(a) Let us first assume: $\eta_C > 1$; $\epsilon_C < 1$;

In this case, eq. (17), becomes:

$$v_F = j\frac{\delta_C g}{\eta_C} v_E \quad \ldots \quad \ldots \quad (1_a)$$

Eliminating v_F, from (1_a) and (18) we obtain:

$$v_C = \left(1 - \frac{1}{\alpha_C \beta} - \tfrac{1}{2}\frac{\delta_C}{\alpha_C \beta} + j\tfrac{1}{2}\frac{\delta_C}{\eta_C}\right)\frac{v_E}{\beta} \quad (2_a)$$

Eliminating v_F, from (1_a) and (19),

$$v_{C'} = \left(1 - \frac{1}{\alpha_{C'} \beta} - \tfrac{1}{2}\frac{\delta_C}{\alpha_C \beta} + j\tfrac{1}{2}\frac{\delta_C}{\eta_C}\right)\frac{v_E}{\beta} \quad (3_a)$$

The amplitudes of v_F, v_C and $v_{C'}$, will be:

$$V_F = \frac{\delta_C g}{\eta_C} V_E \quad \ldots \quad \ldots \quad (1'_a)$$

$$V_C = \frac{V_E}{\beta}\sqrt{\left(1 - \frac{1}{\alpha_C \beta} - \tfrac{1}{2}\frac{\delta_C}{\alpha_C \beta}\right)^2 + \left(\tfrac{1}{2}\frac{\delta_C}{\eta_C}\right)^2}$$
$$= \frac{V_E}{\beta}\left(1 - \frac{1}{\alpha_C \beta} - \tfrac{1}{2}\frac{\delta_C}{\alpha_C \beta} + \ldots\right) \quad \ldots \quad (2'_a)$$

$$V_{C'} = \frac{V_E}{\beta}\sqrt{\left(1 - \frac{1}{\alpha_{C'} \beta} - \tfrac{1}{2}\frac{\delta_C}{\alpha_C \beta}\right)^2 + \left(\tfrac{1}{2}\frac{\delta_C}{\eta_C}\right)^2}$$
$$= \frac{V_E}{\beta}\left(1 - \frac{1}{\alpha_{C'} \beta} - \tfrac{1}{2}\frac{\delta_C}{\alpha_C \beta} + \ldots\right) \quad \ldots \quad (3'_a)$$

Therefore:

$$\epsilon_C = 2\frac{\alpha_C \beta}{\delta_C}\alpha_2 h\left(\frac{1}{\alpha_{C'} \beta} - \frac{1}{\alpha_C \beta}\right)\frac{V_E}{\beta} = -2gh V_E \quad (4_a)$$

and:

$$\eta_C = \alpha_C \beta \alpha_2 h\left[\frac{\delta_C}{\eta_C} - 2 + \frac{\delta_C}{\alpha_C \beta} + \ldots\right]\frac{V_E}{\beta}$$
$$= -2\alpha_C \beta gh V_E \quad \ldots \quad \ldots \quad (5_a)$$

(b) Let us assume now:

$$\eta_C > 1\ ;\ \epsilon_C > 1\ ;\ \epsilon_C < \eta_C\ ;$$

Eq. (17) becomes:

$$v_F = -\frac{\epsilon_C}{\eta_C}\delta_C g v_E \quad \ldots \quad \ldots \quad (6_a)$$

Eliminating v_F from (6_a), (18) and (19), we obtain:

$$v_C = \left(1 - \frac{1}{\alpha_C\beta} - \frac{1}{2}\frac{\epsilon_C}{\eta_C}\delta_C\right)\frac{v_E}{\beta} - j\left(\frac{1}{2}\frac{\epsilon_C}{\alpha_C\beta}\delta_C + \ldots\right)\frac{v_E}{\beta} \quad \ldots \quad (7_a)$$

$$v_{C'} = \left(1 - \frac{1}{\alpha_{C'}\beta} - \frac{1}{2}\frac{\epsilon_C}{\eta_C}\delta_C\right)\frac{v_E}{\beta} - j\left(\frac{1}{2}\frac{\epsilon_C}{\alpha_C\beta}\delta_C + \ldots\right)\frac{v_E}{\beta}$$

therefore:

$$V_C = \frac{V_E}{\beta}\left[1 - \frac{1}{\alpha_C\beta} - \frac{1}{2}\frac{\epsilon_C}{\eta_C}\delta_C + \frac{1}{2}\left(\frac{1}{2}\frac{\epsilon_C}{\alpha_C\beta}\delta_C\right)^2 + \ldots\right]$$

and:

$$V_{C'} = \frac{V_E}{\beta}\left[1 - \frac{1}{\alpha_{C'}\beta} - \frac{1}{2}\frac{\epsilon_C}{\eta_C}\delta_C + \frac{1}{2}\left(\frac{1}{2}\frac{\epsilon_C}{\alpha_C\beta}\delta_C\right)^2 + \ldots\right]$$

Further $\quad V_C - V_{C'} = -\dfrac{\delta_C}{\alpha_C\beta}\cdot\dfrac{V_E}{\beta}$

and:

$$\frac{V_F}{\alpha_2} - 2V_C - (V_C - V_{C'}) = \left[-\frac{\epsilon_C}{\eta_C}\delta_C - 2\left(1 - \frac{1}{\alpha_C\beta} - \frac{1}{2}\frac{\epsilon_C}{\eta_C}\delta_C\right) + \frac{\delta_C}{\alpha_C\beta}\right]\frac{V_E}{\beta} = -2\frac{V_E}{\beta}.$$

Finally: $\epsilon_C = -2ghV_E\ ;\ \eta_C = -2\alpha_C\beta ghV_E$

We see therefore that ϵ_C and η_C have the same value in both case (a) and (b), and eq. (17) may be written:

$$v_F = \frac{1 - j2ghV_E}{1 + j\alpha_C\beta 2ghV_E}\delta_C\cdot g\cdot v_E \quad \ldots \quad (8)$$

where: $2ghV_E \gtrsim 1$ and $\alpha_C\beta 2ghV_E > 1$, which remains the necessary condition for λ to be small.

APPENDIX 2

To determine the necessary conditions for ϵ_D and η_D to be smaller than unity, we introduce into eq. (15) and (16) the value of v_H given by (23) and that of v_G given by elimination of v_H between (22) and (23), viz.:

$$v_G = \frac{\lambda}{1-\lambda}\frac{\alpha_2}{\delta_{D}g}e'_D.$$

To simplify the formulæ we shall assume $\alpha_C\beta$ to be so great that $\lambda \ll 1$; then

$$v_H = \alpha_2 e'_D \text{ and } -v_G = \frac{\lambda}{\delta_D g}\alpha_2 e'_D.$$

We thus have:

$$v_D = \frac{e'_D}{\alpha_D\beta} + \left(1 - \frac{1}{\alpha_D\beta}\right)\frac{\lambda}{\delta_D}e'_D + \frac{1}{2}\left(1 - \frac{1}{\alpha_D\beta}\right)e'_D = \left(\frac{1}{2} + \frac{\lambda}{\delta_D}\right)e'_D + \left(\frac{1}{2} - \frac{\lambda}{\delta_D}\right)\frac{e'_D}{\alpha_D\beta}$$

$$v_{D'} = \left(1 - \frac{1}{\alpha_{D'}\beta}\right)\frac{\lambda}{\delta_D}e'_D + \frac{1}{2}\left(1 - \frac{1}{\alpha_{D'}\beta}\right)e'_D = \left(\frac{1}{2} + \frac{\lambda}{\delta_D}\right)e'_D - \left(\frac{1}{2} + \frac{\lambda}{\delta_D}\right)\frac{e'_D}{\alpha_{D'}\beta}$$

where higher powers of $1/\alpha_D\beta$ are neglected.

Therefore:

$$V_D - V_{D'} = \frac{1}{2}\left(\frac{1}{\alpha_D} + \frac{1}{\alpha_{D'}}\right)\frac{E'_D}{\beta} = \frac{E'_D}{\alpha_D\beta}$$

and finally: $\epsilon_D = 2\dfrac{\alpha_2 hE'_D}{\delta_D}$, which must be smaller than unity.

But we found in Appendix 1, that

$$\epsilon_C = 2ghV_E = 2gh_{HE}\alpha_2 hE'_D \gtrsim 1.$$

In order that $\epsilon_C > 1$ and $\epsilon_D < 1$, we must therefore have $g_{DC}\cdot\delta_D > 1$. This inequation and the similar one g_{CD}, $\delta_C > 1$, form one of the necessary conditions for the amplitude distortion to be small, only if $2ghV_E > 1$; it is also interesting to note that the same relation applied to conventional systems corresponds to the instability of such systems, that is to say the state for which the λ of these systems is larger than unity.

A second necessary condition is obtained by calculating η_D. Thus:

$$\frac{V_H}{\alpha_2} - 2V_D - (V_D - V_{D'}) = (1 - \tfrac{1}{2}\eta^2_D)E'_D - 2\left(\frac{1}{2} + \frac{\lambda}{\delta_D}\right)E'_D - 2\left(\frac{1}{2} - \frac{\lambda}{\delta_D}\right)\frac{E'_D}{\alpha_D\beta} - \frac{E'_D}{\alpha_D\beta}$$
$$= 2\frac{\delta_C g_{CD} g_{DC}}{\alpha_C\beta}E'_D - \tfrac{1}{2}\eta^2_D E'_D$$

where higher powers of $1/\alpha_D\beta$ are again neglected.

Therefore:

$$\eta_D = 2\delta_C\cdot g_{DC}\cdot g_{CD}\cdot\frac{\alpha_D}{\alpha_C}\alpha_2 hE'_D - \tfrac{1}{2}\eta^2_D\alpha_D\beta\alpha_2 hE'_D$$

and: $\quad \eta^2_D = 4\dfrac{\delta_C g_{DC} g_{CD}}{\alpha_C\beta} < 1.$

This inequation forms, therefore, the second necessary condition for the amplitude distortion to be small.

REFERENCES

(1) S. B. Wright: "The Vodas," *Bell S. Tech. Journ.*, Oct., 1937, Vol. 16, pp. 456–74.

(2) C. N. Anderson and H. M. Pruden: "Radio-telephone System for Harbor and Coastal Services," *Proc. Inst. Rad. Eng.*, April, 1939, Vol. 27, No. 4.

(3) M. Marinesco: "Telefonul cu Difuzor," *Buletinul Soc. Politechnice din Romania*, August, 1939, No. 8.

(4) H. Nyquist: "Regeneration Theory," *B.S.T.Y.*, January, 1932.

(5) S. B. Wright, S. Doba, A. L. Dickieson: "'Vogad' for Radio-Telephone Circuits," *Proc. Inst. Rad. Eng.*, April, 1939, Vol. 27, No. 4.

Ganging Superheterodyne Receivers *

By Dr. Ing. Martin Wald

THE superheterodyne principle requires the tuning difference between the oscillator circuit and the radio-frequency input circuits to be constant and equal to the intermediate frequency in every position of the variable condenser. In order to realise this condition, the circuit diagram, shown in Fig. 1, will be generally used in practice. C is the variable condenser, the capacitance of which in every position is supposed to be equal to that of the input circuits. C_p is the padding condenser connected in series with C.

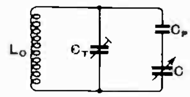


Fig. 1.—*Diagram of the oscillator circuit.*

C_T is the trimmer condenser connected across the coil L_0, the self capacitance of which is supposed to be included in C_T. It can be shown that by this circuit arrangement the correct oscillator frequencies can be achieved, at the most, in three positions of the variable condenser by choosing suitable values for L_0 C_T and C_p. At every other position of the variable condenser C, the oscillator frequency will differ more or less from the correct value, so that ganging faults will occur. The ganging fault Δf as a function of the input frequency f gives the well-known padding curve shown in Fig. 2; α_1, α_2 and α_3 are the three input frequencies at which Δf becomes zero and so correct ganging will be obtained. f_1, f_2, f_3 and f_4 are the four input frequencies at which the extreme values of Δf occur. As is well known, ganging faults cause the sensitivity of the receiver to drop considerably at the corresponding input frequencies. Generally a uniform sensitivity over the whole frequency range will be desired. Therefore reducing the ganging fault at any point of the frequency range is of the same importance. Any system of the values L_0 C_T and C_p determines its own padding curve. The problem to be solved is, to find that system of values L_0 C_T and C_p which gives the most satisfactory padding curve. To make this problem definite we must define some measure of the quality of a padding curve, so that we can say which of two given padding curves is the better one. Such a measure we will hereinafter call the "fault factor." The practical value of the results obtained by calculation depends on the correct definition of this fault factor. One might consider the fault factor to be the sum of the absolute values, irrespective of the sign, of the ganging faults Δf in the whole frequency range. This means geometrically the area included by the padding curve, as shown in Fig. 2. The mathematical expression for this area is given by:

$$E = \int_{f_1}^{f_4} |\Delta f| \, . \, df \qquad \ldots \qquad \ldots \quad (1)$$

The definition of the fault factor according to equation (1) is not very satisfactory. This will be made clear if we imagine the loss of sensitivity as a function of the ganging faults Δf. According to the well-known shape of the resonance curve, the loss of sensitivity is very small at first, but increases very rapidly with larger value of Δf. It is therefore necessary that the fault factor should be determined mainly by the larger values of Δf. In order to fulfil this requirement we replace equation (1) by:

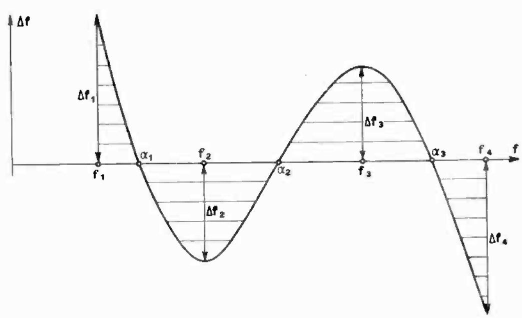


Fig. 2.—*An arbitrary padding curve.*

$$E^n = \int_{f_1}^{f_4} | \Delta f |^n \, . \, df \qquad \ldots \qquad \ldots \quad (2)$$

where $n > 1$.

* MS. accepted by the Editor, July, 1939.

The integral in equation (2) represents the sum of elementary components $|\Delta f|^n . df$. It is clear that the higher the exponent n is selected, the more will be the weight given to the components with high values of Δf, whilst the components with small values of Δf can be neglected. Finally in the extreme case of increasing the exponent n to infinity, the integral in (2) will be reduced to a single component, containing the maximum value Δf_{max} of all the ganging faults occurring at any point of the whole frequency range. In this case the fault factor will be given by:

$$E = \Delta f_{max} = \lim_{n=\infty} \sqrt[n]{\int_{f_1}^{f_4} |\Delta f|^n . df} \quad .. \quad (3)$$

The following considerations will be based upon the definition of the fault factor according to equation (3), since this leads to simple and summary results. The question whether definition (2) with a finite value of $n > 1$, would give more satisfactory practical results, may be investigated in a later article.

We first will transform equation (3). We suppose the exponent of Δf to pass through the series of all the even integral numbers up to infinity. The sign of the absolute value can be omitted in this case, since an even exponent always gives a positive value. Further, we will divide the range of integration within the limits f_1 up to f_4, into four sub-intervals f_1 up to α_1; α_1 up to α_2; α_2 up to α_3; and α_3 up to f_4. The intermediate points α_1, α_2 and α_3 are the input frequencies at which the ganging fault Δf becomes zero (see Fig. 2). For the limiting case $2n = \infty$, each of these integrals will be reduced to the highest value of Δf which occurs in the corresponding sub-interval. With respect to Fig. 2 we can therefore write:

$$E = \Delta f_{max} = \lim_{2n=\infty} \sqrt[2n]{\Delta f_1^{2n} + \Delta f_2^{2n} + \Delta f_3^{2n} + \Delta f_4^{2n}} \quad .. \quad .. \quad (4)$$

Equation (4) represents the mathematical expression for the maximum ganging fault occurring at any point of the whole frequency interval f_1 up to f_4 and which must be equal to one of the four extreme faults Δf_1, Δf_2, Δf_3 or Δf_4. Now, the three circuit components L_0 C_T and C_p ought to be selected, so that the expression on the right hand of equation (4) becomes a minimum.

For the sake of simplicity in the expression for Δf we will introduce the three extreme faults Δf_1, Δf_2 and Δf_3 instead of the parameters L_0 C_T and C_p. Indeed, the latter can be calculated in a simple way when the values of Δf_1, Δf_2, Δf_3, at the input frequencies f_1, f_2 and f_3, are given. As the oscillator frequencies at these three points are known their substitution in the well-known formula $2\pi f = \frac{1}{\sqrt{LC}}$ gives the values L_0, C_T and C_p.

Therefore the ganging fault Δf can be represented as a function of the parameters Δf_1, Δf_2, Δf_3 and of the variable input frequency f, so that it can be written:

$$\Delta f = \phi(\Delta f_1, \Delta f_2, \Delta f_3, f) \quad .. \quad .. \quad (5)$$

On setting $f = f_4$ we obtain for the ganging fault at the input frequency f_4:

$$\Delta f_4 = \phi_4(\Delta f_1, \Delta f_2, \Delta f_3) \quad .. \quad .. \quad (6)$$

where ϕ_4 is a function with only three independent variables. Now, in equation (4) we will replace Δf_4 by the expression (6) and so the fault factor $E = \Delta f_{max}$ becomes also a function of the three parameters Δf_1, Δf_2 and Δf_3. The necessary condition for a function of several variables to become a minimum is, that the first partial derivation with respect to each of the parameters becomes zero. With regard to (4) and (6) this condition gives the following three equations:

$$\left.\begin{aligned} \frac{\delta E^{2n}}{\delta \Delta f_1} &= \Delta f_1^{2n-1} + \Delta f_4^{2n-1} \frac{\delta \phi_4}{\delta \Delta f_1} = 0 \\ \frac{\delta E^{2n}}{\delta \Delta f_2} &= \Delta f_2^{2n-1} + \Delta f_4^{2n-1} \frac{\delta \phi_4}{\delta \Delta f_2} = 0 \\ \frac{\delta E^{2n}}{\delta \Delta f_3} &= \Delta f_3^{2n-1} + \Delta f_4^{2n-1} \frac{\delta \phi_4}{\delta \Delta f_3} = 0 \end{aligned}\right\} \text{ when } n \to \infty$$

which can be written in the form:

$$\left.\begin{aligned} \frac{\Delta f_1}{\Delta f_4} &= \lim_{n=\infty} \sqrt[2n-1]{-\frac{\delta \phi_4}{\delta \Delta f_1}} \\ \frac{\Delta f_2}{\Delta f_4} &= \lim_{n=\infty} \sqrt[2n-1]{-\frac{\delta \phi_4}{\delta \Delta f_2}} \\ \frac{\Delta f_3}{\Delta f_4} &= \lim_{n=\infty} \sqrt[2n-1]{-\frac{\delta \phi_4}{\delta \Delta f_3}} \end{aligned}\right\} \quad .. \quad .. \quad (7)$$

It can be easily shown that all the expressions on the right hand side of (7) amount to $+1$ or -1. We suppose k to be an arbitrary finite number, so that the expression $\sqrt[2n-1]{k}$, for $n = 1, 2, 3 \ldots$ has the same sign as k itself. The absolute amount of $\sqrt[2n-1]{k}$ approaches 1 with an increasing n. This will be obvious if we write $\sqrt[2n-1]{k} = k^{\frac{1}{2n-1}}$ where the exponent $\frac{1}{2n-1}$ becomes zero in the limiting case $n = \infty$ and $k^0 = 1$ for any arbitrary k. Therefore from equation (7) we obtain:

$$\left.\begin{aligned} |\Delta f_1| &= |\Delta f_4| \\ |\Delta f_2| &= |\Delta f_4| \\ |\Delta f_3| &= |\Delta f_4| \end{aligned}\right\} \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

The relations (8) represent the solution of our problem and show that the best padding curve—that with the smallest value of Δf_{max}—will be obtained if the four extreme values of Δf are made equal to each other. Here, it should be pointed out that this result is independent of the special form of the function ϕ in equation (5). The result expressed by relations (8) is therefore generally applicable, regardless of the special form of the padding curve, the only assumption being that the fault factor E is defined according to equation (3) as the largest ganging fault Δf_{max} that occurs in the padding curve in question. In equation (8) we imagine Δf_1, Δf_2, Δf_3 and Δf_4 to be expressed by L_0, C_T and C_p giving three equations from which these circuit components can be calculated. In practice, however, the circuit components L_0 C_T and C_p will be adjusted at the three input frequencies α_1, α_2, α_3 where the ganging fault Δf ought to be zero and therefore it will be of interest to calculate directly the adjusting frequencies α_1, α_2 and α_3 from equations (8). For this purpose Δf ought to be expressed as a function of α_1, α_2 and α_3. The exact formula for Δf is complicated and therefore we will start from an approximate formula which we will deduce at the end of this article. This formula is as follows:

$$\Delta f = \lambda \frac{(f - \alpha_1)(f - \alpha_2)(f - \alpha_3)}{f + f_i} \quad \ldots \quad (9)$$

where f_i is the intermediate frequency and λ a constant factor independent of f. From the condition found in (8), viz., that the four extreme values of Δf should be equal to each other, we will calculate α_1, α_2 and α_3. In Fig. 3 f_1, f_2, f_3, f_4 denote the four input frequencies at which the extreme ganging fault $\pm \Delta f_{max}$ occurs, $\alpha_1, \alpha_2, \alpha_3$ the adjusting frequencies, that is, the points with $\Delta f = 0$, and M the mid point of the frequency range f_1 to f_4. Instead of α_1, α_2, α_3 we introduce

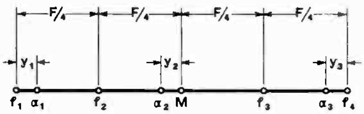


Fig. 3.—*Showing the assumed positions of f_2 and f_3.*

the differences y_1, y_2 and y_3 (see Fig. 3) since the latter are small with respect to the whole frequency range $F = f_4 - f_1$ and this circumstance allows us to simplify the calculation considerably. Moreover, we assume both f_2 and f_3 to be situated $\frac{F}{4}$ from the corresponding end of the frequency range, so that we write:

$$f_2 - f_1 = f_4 - f_3 = \frac{F}{4} \quad \ldots \quad \ldots \quad (10)$$

The fault resulting from this assumption is practically negligible, since the real maxima lie near these points and the padding curve is very flat in the neighbourhood of the maxima. With the notation of Fig. 3 we obtain from equations (8), (9) and (10):

$$\frac{|\Delta f_2|}{|\Delta f_1|} = 1 = \frac{\left(\frac{F}{4} - y_1\right)\left(\frac{F}{4} - y_2\right)\left(\frac{3}{4}F - y_3\right)\left(f_1 + f_i\right)}{y_1\left(\frac{F}{2} - y_2\right)(F - y_3)(f_2 + f_i)}$$

$$\frac{|\Delta f_3|}{|\Delta f_4|} = 1 = \frac{\left(\frac{3}{4}F - y_1\right)\left(\frac{F}{4} + y_2\right)\left(\frac{F}{4} - y_3\right)(f_4 + f_i)}{(F - y_1)\left(\frac{F}{2} + y_2\right)y_3(f_3 + f_i)}$$

$$\frac{|\Delta f_3|}{|\Delta f_2|} = 1 = \frac{\left(\frac{3}{4}F - y_1\right)\left(\frac{F}{4} + y_2\right)\left(\frac{F}{4} - y_3\right)(f_2 + f_i)}{\left(\frac{F}{4} - y_1\right)\left(\frac{F}{4} - y_2\right)\left(\frac{3}{4}F - y_3\right)(f_3 + f_i)} \quad \ldots \quad \ldots \quad (11)$$

We take $\frac{y_1}{F}$, $\frac{y_2}{F}$ and $\frac{y_3}{F}$ as our unknowns, each of them being much smaller than 1 so that products and higher powers can be neglected. Equations (11) can be reduced to three linear relations:

$$\left.\begin{aligned}\left(\frac{32}{3}\cdot\frac{f_2+f_i}{f_1+f_i}+4\right)\frac{y_1}{F}+2\frac{y_2}{F}+\frac{1}{3}\frac{y_3}{F}&=1\\ \left(\frac{32}{3}\frac{f_3+f_i}{f_4+f_i}+4\right)\frac{y_3}{F}-2\frac{y_2}{F}+\frac{1}{3}\frac{y_1}{F}&=1\\ 8\frac{y_2}{F}+\frac{8}{3}\left(\frac{y_1}{F}-\frac{y_3}{F}\right)&=\frac{f_3-f_2}{f_2+f_i}\end{aligned}\right\}\quad \ldots (12)$$

which give for $\frac{y_1}{F}, \frac{y_2}{F}$ and $\frac{y_3}{F}$ the following expressions:

$$\frac{y_1}{F}=\frac{1.25-\frac{f_3+f_i}{4(f_2+f_i)}}{10.66\frac{f_2+f_i}{f_1+f_i}+3.33};\ \frac{y_3}{F}=\frac{0.75+\frac{f_3+f_i}{4(f_2+f_i)}}{10.66\frac{f_3+f_i}{f_4+f_i}+3.33}$$

$$\frac{y_2}{F}=\frac{f_3-f_2}{8(f_2+f_i)}+\frac{1}{3}\left(\frac{y_3}{F}-\frac{y_1}{F}\right)\quad \ldots\ \ldots (13)$$

To obtain an idea of the practical importance of these approximations we will calculate an example:—

Given: $f_1 = 536$ kc/s; $f_4 = 1{,}500$ kc/s; $f_i = 470$ kc/s.

To determine: α_1, α_2 and α_3 the three

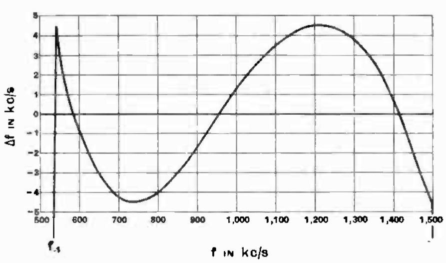


Fig. 4.—*The best padding curve, obtained by calculation for the case in which: $f_1 = 536$ kc/s; $f_4 = 1{,}500$ kc/s; $f_i = 470$ kc/s.*

adjusting frequencies, where correct ganging ought to be established in order to obtain the best padding curve.

From Fig. 3:

$$F = f_4 - f_1 = 964 \text{ kc/s}$$

$$f_2 = f_1 + \frac{F}{4} = 777 \text{ ,,}$$

$$f_3 = f_4 - \frac{F}{4} = 1{,}259 \text{ ,,}$$

which values introduced in (13) give:

$$y_1 = 52.4 \text{ kc/s}$$
$$y_2 = 58.5 \text{ ,,}$$
$$y_3 = 83.5 \text{ ,,}$$

and therefore:

$$\alpha_1 = f_1 + y_1 = 588.4 \text{ kc/s}$$
$$\alpha_2 = \frac{f_1+f_4}{2} - y_2 = 959.5 \text{ kc/s}$$
$$\alpha_3 = f_4 - y_3 = 1{,}416.5 \text{ kc/s}$$

From these frequencies a simple calculation gives the circuit components L_0 C_T, C_p and also any point of the padding curve. The padding curve calculated in this manner is shown in Fig. 4. The four extreme ganging faults are:

$\Delta f_1 = +3.92$ kc/s; $\Delta f_2 = -3.92$ kc/s; $\Delta f_3 = +4.05$ kc/s and $\Delta f_4 = -4.27$ kc/s.

They are thus practically equal, which proves the usefulness of the approximate formula (13).

APPENDIX

Deduction of an Approximate Formula for Δf.

The circuit diagram Fig. 1 gives for the oscillator frequency f_0 the relation:

$$(2\pi f_0)^2 \cdot L_0\left\{C_T + \frac{CC_p}{C+C_p}\right\} = 1 \quad \ldots (16)$$

Put:

$$\left.\begin{aligned}x_1 = \frac{L_0}{L};\ x_2 = \frac{1}{4\pi^2}\cdot\frac{1}{LC_T};\ x_3 = \frac{1}{4\pi^2}\cdot\frac{1}{LC_p};\\ \text{and } f^2 = \frac{1}{4\pi^2}\cdot\frac{1}{LC}\end{aligned}\right\}\quad \ldots (17)$$

where L is the inductance and f the tuning frequency of the input circuit. From (16) and (17):

$$f_0^2 = \frac{\frac{x_2}{x_1}(f^2+x_3)}{f^2+x_2+x_3} \quad \ldots\ \ldots\ \ldots (18)$$

Furthermore

$\Delta f = f_0 - (f + f_i)$ which we can also write:

$$\Delta f = \frac{f_0^2 - (f+f_i)^2}{2(f+f_i)+\Delta f} \quad \ldots\ \ldots\ \ldots (19)$$

In the denominator of (19), Δf can be neglected, since in all practical cases Δf will be under 1 per cent. of $(f + f_i)$. With this approximation we obtain from (18) and (19):

$$\Delta f = \frac{(f+f_i)^2\cdot(f^2+x_2+x_3) - \frac{x_2}{x_1}(f^2+x_3)}{-2(f+f_i)(f^2+x_2+x_3)} \quad \ldots (20)$$

By putting the numerator in (20) equal to zero we obtain an equation of the 4th degree in f, the roots of which give the frequencies for which Δf becomes zero. Denoting the 4 roots by α_1, α_2, α_3, α_4 we thus have

$$\Delta f = \frac{(f-\alpha_1)(f-\alpha_2)(f-\alpha_3)(f-\alpha_4)}{-2(f+f_i)(f^2+x_2+x_3)} \quad .. \quad (21)$$

The expressions (20) and (21) must be identical for all values of f. We imagine the numerator to be arranged according to the powers of f, so the coefficients of the same power of f must be equal in both expressions. We write this down for the coefficients of the third and first power of f and obtain :

$$-(\alpha_1+\alpha_2+\alpha_3+\alpha_4) = 2f_i$$

$$\text{or } -\alpha_4 = 2f_i + \alpha_1 + \alpha_2 + \alpha_3 \quad .. \quad .. \quad (22)$$

$$\text{and } \pi_3 = -(\alpha_1\alpha_2\alpha_3 + \alpha_2\alpha_3\alpha_4 + \alpha_3\alpha_4\alpha_1 + \alpha_4\alpha_1\alpha_2)$$
$$= 2f_i(x_2 + x_3)$$

$$\text{or } x_2 + x_3 = \frac{\pi_3}{2f_i} \quad .. \quad .. \quad .. \quad .. \quad (23)$$

where the abbreviation π_3 is introduced. Substituting these in (21) we have

$$\Delta f = \frac{(f-\alpha_1)(f-\alpha_2)(f-\alpha_3)(f+2f_i+\alpha_1+\alpha_2+\alpha_3)}{-2(f+f_i)\left(f^2+\frac{\pi_3}{2f_i}\right)} \quad .. \quad .. \quad (24)$$

Equation (24) does not contain the circuit parameters x_1, x_2, x_3, but it expresses Δf by means of the adjusting points α_1, α_2 and α_3. This formula is very suitable for calculating the padding curve and for deducing graphical methods of constructing the padding curve. The usual method of calculating the oscillator frequency f_0 at any point by means of the circuit components L_0 C_r and C_p and the ganging fault as $\Delta f = f_0 - (f + f_i)$, requires a high degree of precision. This will be clear when we consider that an error of 1 per cent. in the oscillator frequency gives more than 100 per cent. error in Δf. Therefore the exactness of a graphical construction on this basis is not satisfactory. Formula (24) represents Δf in the form of a product and so an error of 1 per cent. in the factors or in the multiplication causes also in Δf an error of not more than 1 per cent. A graphical construction deduced from formula (24) will therefore be satisfactory. If no great accuracy is required, formula (24) can be further simplified. The expression

$$\frac{f+2f_i+\alpha_1+\alpha_2+\alpha_3}{f^2+\pi_3/2f_i}$$

varies only a little with f in the interval in question, since $2f_i + \alpha_1 + \alpha_2 + \alpha_3$ is large compared with f and in the denominator $\frac{\pi_3}{2f_i}$ is much larger than f^2. Therefore without much error we can replace f in this expression by an average value of f_m and so obtain the approximate relation :

$$\left.\begin{aligned} \Delta f &= \lambda\frac{(f-\alpha_1)(f-\alpha_2)(f-\alpha_3)}{f+f_i} \\ \lambda &= \frac{f_m+2f_i+\alpha_1+\alpha_2+\alpha_3}{-2\left(f_m^2+\pi_3\frac{1}{2f_i}\right)} \end{aligned}\right\} \quad .. \quad (25)$$

where λ is a constant factor independent of f. The approximate formula (25) was used in equation (9) in this article.

Air Force Wireless Expansion

A LARGE number of Radio Mechanics are required for the installation and maintenance of wireless apparatus in the Royal Air Force. Applicants, who are required to pass a test that should be within the capabilities of a broadcast receiver service man, are graded immediately after enlistment as Leading Aircraftmen at a daily rate of pay of 5/6, plus allowances. Applications should be made to the candidate's nearest Combined Recruiting Office, or to the Air Ministry Information Bureau, Kingsway, London, W.C.2.

A number of vacancies also exist for Signal Officers, who should possess science degrees or similar qualifications.

Long-Distance Broadcasting

SIR NOEL ASHBRIDGE, B.B.C. Controller of Engineering, in a Friday evening discourse at the Royal Institution on January 26th, opened his lecture on Long-Distance Broadcasting with an explanation of the functions of the ionosphere in the propagation of waves round the curvature of the earth. He pointed out that the knowledge accumulated during past few years enabled engineers to choose with certainty the optimum wavelength for transmission between any two points at any time of the day or season of the year.

The necessity for flexibility both as regards wavelength and direction of transmission was exemplified by slides showing the complex aerial systems and "antenna exchange" at the pre-war B.B.C. Empire station.

Recordings of reception in South Africa, America and Australia illustrated the fact that whilst speech can be transmitted with good intelligibility, we had not yet reached the stage where music could be transmitted over long distances to the satisfaction of the critical ear.

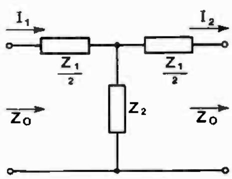
Correspondence

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

Simple Treatment of Band-Pass Filters

To the Editor, The Wireless Engineer

SIR,—In developing a course of lectures for National Certificate students in electro-communication, I have recently had occasion to look for a simple method of deriving the frequency discriminative properties of filters. I have consulted a number of text-books which, in general, indicate that the usual practice is to employ complex hyperbolic functions in the more advanced treatments, and in the elementary works to assume the expression from which the pass and attenuate bands may be determined. It often seems to be overlooked that the condition for a pass band (Z_1/Z_2 to lie between zero and -4) can be demonstrated with the aid of nothing more complicated than an appreciation of the meaning of the operator j. The argument is as follows:



Following the usual method for the infinite chain of T sections:

$$Z_0 = \frac{Z_1}{2} + \frac{\left(\frac{Z_1}{2} + Z_0\right)Z_2}{\frac{Z_1}{2} + Z_0 + Z_2}$$

from which $Z_0 = \sqrt{Z_1 Z_2 + \frac{Z_1^2}{4}}$

The ratio of the current I_1 entering the section to the current I_2 leaving it is given by:

$$\frac{I_1}{I_2} = \frac{\frac{Z_1}{2} + Z_0 + Z_2}{Z_2}$$

$$= \frac{Z_1}{2Z_2} + 1 + \sqrt{\frac{Z_1}{Z_2} + \frac{Z_1^2}{4Z_2^2}}$$

This ratio will, in general, be a complex quantity of the form $a + jb$ but, if the network is composed of pure reactance elements and has a non-attenuating band, the absolute magnitude of *the ratio in this band must be unity*, i.e. the input and output currents of a single section must be equal in magnitude, but may of course be changed in phase.

As $\frac{Z_1}{2}$ and Z_2 are pure reactance arms, $\frac{Z_1}{Z_2}$ must be real.

$\therefore \quad \frac{Z_1}{2Z_2} + 1$ is real for all frequencies.

If $\frac{Z_1}{Z_2}$ lies between zero and -4, the expression under the root is negative and the ratio can be rewritten:

$$\frac{I_1}{I_2} = \frac{Z_1}{2Z_2} + 1 + j\sqrt{-\frac{Z_1}{Z_2} - \frac{1}{4}\left(\frac{Z_1}{Z_2}\right)^2}$$

$$= a + jb.$$

The absolute magnitude of this quantity is

$$\sqrt{a^2 + b^2} = \frac{Z_1^2}{4Z_2^2} + \frac{Z_1}{Z_2} + 1 - \frac{Z}{Z_2} - \frac{1}{4}\left(\frac{Z_1^2}{Z_2^2}\right) = 1.$$

Thus, in this range, the current leaving any section is equal in magnitude to the current entering it, but is changed in phase, i.e. there is free transmission without attenuation.

If Z_1/Z_2 is positive, or is negative and greater in magnitude than 4, the quantity under the root sign is necessarily positive, so that the root is real but may be positive or negative. Thus the output current I_2 is necessarily in phase or anti-phase with I_1. Now it is physically impossible that I_2 should be greater than I_1 for, in an infinite structure, the impedance at both input and output of any section is identical, i.e. Z_0 and, if the network is dissipative to any degree, *however small*, more power would leave the section than entered it, if I_2 were greater than I_1. Therefore, the magnitude of the ratio I_1/I_2 must be either unity or greater than unity. This determines which sign is admissible for

$$\sqrt{\frac{Z_1}{Z_2} + \frac{1}{4}\left(\frac{Z_1}{Z_2}\right)^2}.$$

Thus, outside the range between zero and -4 for the value of Z_1/Z_2, attenuation is necessarily present and the pass band therefore lies between these limits. Substitution of a few numerical values serves to remove any apparent indefiniteness of the argument resulting from the ambiguity of sign.

This type of argument seems to offer some advantages where the student is unfamiliar with the hyperbolic functions of complex quantities.

JAMES GREIG.

Northampton Polytechnic Institute,
London, E.C.1.

Velocity-Modulated Beams

To the Editor, The Wireless Engineer.

SIR,—Dr. D. Martineau Tombs in his article on Velocity-Modulated Beams in the February issue of *The Wireless Engineer* gives very instructive diagrams showing the electron density distributions as functions of various depths of modulation (m).

But the graphical method which he employs is too insensitive to give the correct solution for the position of maximum density, described as S'. The distance over which the average was made is by far too large.

It is however possible to find the exact solution for S' mathematically with the following result, using Dr. D. Martineau Tombs' symbols:

$$S' = \frac{1}{\pi} \cdot \left(\frac{2\pi}{\omega}\right)\frac{U_0}{m}$$

This formula holds good for any value of m.

I intend to publish a way to derive it in the near future.

RUDOLF KOMPFNER.

London, S.E.24.

Book Review

The Cyclotron

By W. B. MANN. Pp. 92 + VIII, with 31 Figs. Methuen & Co., Ltd., 36, Essex Street, London, W.C.2. Price, 3s.

This is one of a series of monographs on physical subjects, "intended to supply readers of average scientific attainment with a compact statement on the modern position in each subject."

There are six chapters. Chap. I is introductory and historical; Chap. II explains the principles of magnetic resonance acceleration of ions, etc; Chap. III describes the actual chamber and magnet of the cyclotron at Berkeley, California; Chap. IV deals with the H.F. valve generators which are used to supply the power to the cyclotron and discusses the use of quarter-wave resonant lines for frequency stabilisation, and of non-reflecting transmission lines between the generator and the cyclotron; this chapter also deals with the methods of obtaining a supply of ions at the centre of the cyclotron. Chap. V discusses electrostatic and magnetic focusing and the various adjustments of the cyclotron. The final chapter gives a necessarily cursory survey of some of the many applications of the cyclotron in physics, chemistry, and biology and indicates the enormous field of research lying before it. There is a good bibliography and an index.

Reference is made to the target chamber T in Fig. 2, but the lettering appears to have been omitted; the reader's doubt as to what is intended is just about to be removed when he gets to Fig. 7 which shows a chamber T, but he is then told that the targets are inserted into the port P in another part of the vacuum chamber which he had probably assumed was the pumping port.

We fear that something has been omitted from Fig. 14 which illustrates the automatic control of the magnet current of the cyclotron. A circuit is shown containing a battery, a resistance, and two photo-electric cells, but there is only a single connection between this circuit and the thermionic valve that it is supposed to control. In Fig. 31 the lettering referred to in the text has been omitted, but the reader will be able to guess which is C and R.

Without failing to appreciate the limitations imposed by 92 pages for 3s., we feel that the utility of the book would have been greatly enhanced if the author had devoted two or three pages at the beginning to a brief explanation of the difference between hydrogen, helium and deuterium and other things which the reader is assumed to know all about. Incredible although it may sound to a nuclear physicist, there are many people of "average scientific attainment" who have but a very vague idea of the difference between α, β and γ particles, to say nothing of deuterons, neutrons and protons. Most of these things occur in the first few pages and the reader is left to grope his way along in the dark. Two pages of simple explanation of the raw material on which the cyclotron operates would have illuminated the whole book.

G. W. O. H.

Direction-Finding Terminology

THE British Standards Institution has recently issued an addendum of the terms and definitions used in radio direction finding, to the British Standard Glossary of Terms used in Electrical Engineering (No. 205-1936). These terms and definitions, prepared by the Direction-Finding Committee of the Radio Research Board, are published at the request of the Department of Scientific and Industrial Research.

Copies of this Addendum, which will be included in the body of the Glossary when revised, can be obtained from the British Standards Institution, Publications Department, 28, Victoria Street, London, S.W.1, price 1s. 2d. post free.

I.E.E. Meetings Resumed

MR. T. L. Eckersley, B.A., B.Sc., F.R.S., of Marconi's Wireless Telegraph Co., analysed the effect of "scattering" in radio transmission when addressing, on February 7th, the first of the monthly meetings of the Wireless Section of the Institution of Electrical Engineers to be held since the outbreak of the war.

He suggested that the phenomenon, which he considered a major factor in practically all transmissions, rendered the MUSA system of reception ineffective at distances greatly in excess of 3,000 miles.

The March meeting of the Wireless Section will be held at 6 p.m. on the sixth of the month, when Mr. T. Walmsley, Ph.D., B.Sc., of the G.P.O., will deliver his paper on "Wire Broadcasting Investigations at Audio and Carrier Frequencies."

At an informal meeting at 6 p.m. on April 1st, Mr. P. G. A. H. Voigt, B.Sc.(Eng.), will open the discussion on "Electro-Acoustics in Practice."

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

905. THE FUNDAMENTAL ELECTRICAL OSCILLATION OF CYLINDRICAL CAVITIES.—F. Borgnis. (*Hochf:tech. u. Elek:akus.*, Oct. 1939, Vol. 54, No. 4, pp. 121–128.)

For previous work on the general theory of the oscillation conditions of cavities *see* 3874 of 1939. This theory is here specialised to the case of the fundamental electrical oscillation of a cylindrical cavity of arbitrary cross-section (Fig. 1). The cases of circular, rectangular, and elliptical cross-section are worked out numerically; the quantities calculated include the natural wavelength, the attenuation, the equivalent attenuation resistance, the dynamic capacity, the dynamic self-induction, and the wave impedance (analogous to the wave impedance in the propagation of plane waves along Lecher wires). For similar geometrical shapes, the natural wavelengths are found to vary with the square roots of the cross-sectional areas. The variation of the wavelengths with the ratio of the sides (for rectangular cross-section) and of the principal axes (for elliptical cross-section) is discussed. The oscillations in these two cases are analysed into equivalent wave-trains.

906. MEASUREMENTS OF THE PROPAGATION VELOCITY OF ELECTROMAGNETIC WAVES ALONG A TWO-WIRE CIRCUIT IN AN INHOMOGENEOUS MEDIUM.—Malov. (*See* 1127.)

907. THE PROPAGATION OF WIRELESS WAVES ROUND THE EARTH [Atmosphere taken as Homogeneous Dielectric: No Sharp Cut-Off Effect at Horizon except for Wavelengths round 1 cm: etc.].—B. van der Pol & H. Bremmer. (*Philips Tech. Review*, Sept. 1939, Vol. 4, No. 9, pp. 245–253.)

Giving "an abstract and a review of the numerical results of our calculations which have been published elsewhere" [*Phil. Mag:* see 2249 of 1939 & back ref.].

908. A STUDY OF THE IONOSPHERE AND THE PROPAGATION OF HIGH-FREQUENCY RADIO WAVES [about 9 m to 150 m].—K. Maeda. (*Res. of Electrotech. Laboratory*, Tokyo, No. 426, 1939, 387 pp.: in Japanese, with English summary.)

In four parts: (1) Experimental studies of the ionosphere (and the derivation of an approx. equation for the F_2 electron distribution: suggested existence of attenuation region at E-region level and lower: relationships between upper-atmospheric ionisation and solar radiation: discussion of experimental results on sporadic reflection, G-region reflection, and Dellinger effect: etc.) (2) Theoretical considerations on the relationship between the ionosphere and the propagation of short waves (including the treatment of scattering, on the assumption of the existence of dielectric spheres of slightly increased electron density and of dimensions small compared with the wavelength): theoretical treatment of the two kinds of attenuation (on penetration and on reflection), using the electron-distribution equation of (1), and an equivalent ("third kind") attenuation for scattered reflections. (3) Charts of attenuation against frequency, propagation-distance, season, and time of day (yielding field intensity) and contour maps (yielding max. frequency or min. distance): examples of application to practical cases, including direction-finding. (4) Problem of employment of 20–30 Mc/s waves for practical purposes (weakness of received field intensity of scattered waves, and their slow & rapid fading: "these points are considered from experimental results, and some methods are given for making the received field intensity sufficiently great. From considerations of fading and received wave-form, it is concluded that there is a possibility of employing the scattered waves for wireless telegraphy. But more detailed studies of the rapid fading, together with its influences on the quality of telephony, are left for future investigation"). For about 20 papers (most of them in English) published by Maeda in the years covering the observations here used, *see* past "Abstracts & References."

909. MEASUREMENTS OF THE LOWER IONOSPHERE [Development of "Sharp Impulse" Generator (Twin-Circuit Arrangement giving 5-Microsecond Rectangular Pulses) and 1000 c/s (synchronised by 50 c/s Mains Supply) Time Sweep for C-R Oscillograph: Some Results & Conclusions regarding C, C', & D Regions].—K. Maeda, T. Kohno, & T. Ohmori. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 74–81.) The carrier frequency throughout was 3 Mc/s.

910. THE MEASUREMENT OF LIGHT SCATTERED BY THE UPPER ATMOSPHERE FROM A SEARCH-LIGHT BEAM [modulated for Photocell/Tuned-A.C.-Amplifier Method of Measurement: Good Agreement with Theory allows Future Extension to Heights up to 70–90 km].—E. A. Johnson, R. C. Meyer, & others. (*Journ. Opt. Soc. Am.*, Dec. 1939, Vol. 29, No. 12, pp. 512–517.) *See* also 471 of February.

911. AUSTRALIAN RADIO RESEARCH BOARD: 11TH ANNUAL REPORT.—(*Journ. of Council for Sci. & Indust. Res.*, Australia, Nov. 1939, Vol. 12, No. 4, pp. 348–353.)

Polarisation of anomalous echo on frequencies below the gyro-frequency; connection between F_2-region conditions and meteorological conditions at the ground; "pulse-phase" equipment for recording very small ionospheric-height changes; pulse-recurrence-frequency method of distance measuring; the researches of Bailey & his co-workers (including abbreviated methods of computation, general graphic methods of solving differential equations, and the "Vectinvertor," combining mechanical & graphical methods for computation of polarisation, refractive indices, & coefficients of absorption; laboratory demonstration of gyro-frequency resonance; etc.); absorption by atmospheric gases of hydrogen radiation (1215.6 A.U.), thought to be concerned in production of fade-out ionisation; reflection of atmospherics and the effect on the wave-form (previous suggestion confirmed by South African observations—3063 of 1939); refractive indices of gases for ultra-short (2–5 m) waves: etc.

912. THE IONOSPHERE AT HUANCAYO, PERU, APRIL, MAY, AND JUNE, 1939, *and* AT WATHEROO, WESTERN AUSTRALIA.—Wells: Parkinson & Prior. (*Terr. Mag. & Atmos. Elec.*, Dec. 1939, Vol. 44, No. 4, pp. 395–399: pp. 401–403.)

913. SUMMARY OF THE YEAR'S WORK, DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION [including Work in Collaboration with Australian R.R.B. and the Watheroo Discovery of Movements & Separation of Ion-Banks occurring in Absence of Direct Sunlight].—J. A. Fleming. (*Terr. Mag. & Atmos. Elec.*, Dec. 1939, Vol. 44, No. 4, pp. 405–410.) This discovery "opens a new field for theoretical work on physics of the upper atmosphere."

914. THE LORENTZ "POLARISATION" CORRECTION IN THE IONOSPHERE.—D. F. Martyn & G. H. Munro. (*Terr. Mag. & Atmos. Elec.*, March 1939, Vol. 44, No. 1, pp. 1–6.) For a *Nature* letter *see* 889 of 1939.

915. ON SOME PROPERTIES OF AN ELECTRON GAS IN A MAGNETIC FIELD [by Quantum Theory].—Achieser. (*See* 1250.)

916. ELECTRON CONCENTRATION AND TEMPERATURE IN THE MERCURY HIGH PRESSURE COLUMN AND THEIR DETERMINATION BY THE BROADENING OF SPECTRAL LINES DUE TO ELECTRON COLLISIONS.—P. Schulz. (*Zeitschr. f. Physik*, No. 7/8, Vol. 114, 1939, pp. 435–447.)

917. THE CONTINUOUS SPECTRUM OF THE CARBON ARC [Variation with Frequency, Temperature, & Electron Pressure of the Continuous Absorption Coefficient in the Plasma of a Stabilised Arc: Continuum arises from Free Electron Transfers].—H. Maecker. (*Zeitschr. f. Physik*, No. 7/8, Vol. 114, 1939, pp. 500–514.)

918. HYDROGEN SHOWERS IN THE AURORAL REGION [Spectrophotograms indicate Occasional Presence of Considerable Quantities of Hydrogen in Auroral Region: Possibly due to Hydrogen Showers from Sun].—L. Vegard. (*Nature*, 30th Dec. 1939, Vol. 144, pp. 1089–1090.)

919. THE ANTARCTIC ZONE OF MAXIMUM AURORAL FREQUENCY [Approximate Position & Radius].—F. W. G. White & M. Geddes. (*Terr. Mag. & Atmos. Elec.*, Dec. 1939, Vol. 44, No. 4, pp. 367–377.)

920. A NEW RADIATION PYROMETER [for Ozone Temperatures].—Strong. (*See* 1152.)

921. THE E REGION OF THE IONOSPHERE DURING THE ANNULAR SOLAR ECLIPSE OF APRIL 7TH, 1940.—E. O. Hulburt. (*Terr. Mag. & Atmos. Elec.*, Dec. 1939, Vol. 44, No. 4, pp. 379–381.)

Berkner has suggested that this more "accessible" eclipse would be as suitable for ionospheric purposes as the total eclipse dealt with by Hulburt in 2647 of 1939. The present paper therefore gives E-region ionisation curves worked out for this annular eclipse for assumed values of α; it is also pointed out that observations may yield information concerning the hypothesis of ionising radiations from the flocculi (Goodall, 3437 of 1939 & 24 of January: Mohler, 4305 of 1939).

922. AERONAUTICAL RADIO COMMUNICATION DURING THE DELLINGER PHENOMENON [Signals from Aeroplane 1000–2000 m above Ground practically Unaffected: etc.].—K. Umeda & S. Otani. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, p. 118: summary only.)

923. NOTE ON EARLY FADE-OUT INVESTIGATIONS [Marconi Company, Telefunken, & Other Observations of the Fade-Out of Oct. 1928: Brown & Eckersley's Suggested Explanations: etc.].—A. M. Braaten. (*Terr. Mag. & Atmos. Elec.*, Dec. 1939, Vol. 44, No. 4, pp. 389–390.)

924. The Association of Radio Fade-Outs with Solar Eruptions.—R. G. Giovanelli & A. J. Higgs. (*Terr. Mag. & Atmos. Elec.*, June 1939, Vol. 44, No. 2, pp. 181–187.)

925. Solar Activity, Cosmic Rays, and Terrestrial Magnetism.—G. Abetti. (*La Ricerca Scient.*, July/Aug. 1939, Year 10, No. 7/8, pp. 741–742.) Letter prompted by the papers of Kolhörster (1804 of 1939) and Miczaika (*Zeitschr. f. Astr.*, Vol. 18, 1939, p. 146.)

926. Selective Fading in [Short-Range] Broadcast Reception.—Alsleben: Feldtkeller & Mayer. (*See* 998.)

927. Fading of Received Signals produced by Moving Railway-Trains [Observations and Suggested Explanations].—Oxenfart. (*Funktech. Monatshefte*, Nov./Dec. 1939, No. 11/12, pp. 309–310.)

An editorial introduction hopes that this article may lead to further investigations of the phenomena. The receiver was situated at about 300 m from the nearest point on the railway line, distant parts of which were visible: seven different medium-wave broadcasting stations were received. The first fade occurred when a train was 7 km away, and was followed by several fades (varying with the speed and number of coaches, and with the wavelength of the station) until the train reached the nearest point: as the distance increased again a similar series of fades occurred, roughly the inverse, as regards magnitude and duration, of the first series. That the phenomenon was not due to a warming and ionisation of the air masses above the train by the steam and smoke from the locomotive was shown by the fact that Diesel-electric trains produced the same effect, and also that fades occurred when the train was running freely down a steep slope. The writer suggests that the cause is ionisation due to friction between the walls of the train and the air: the editorial note says that it is quite possible that a rapidly moving train may cause a "streakiness" in the atmosphere pronounced enough to affect wave propagation.

928. The Propagation of Electromagnetic Waves in Transmission Lines running within Rectangular Screens.—Ya. N. Feld. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 9, 1939, pp. 587–600.)

It is pointed out that the so-called telegraph equations, determining the operation of a long line, should only be used if the electromagnetic field surrounding the line is taken into account. In the present paper, starting from the general Maxwell equations, methods are indicated for determining the electromagnetic field inside a rectangular screen enclosing either an asymmetrical two-wire line (Fig. 1) or a single-wire line (Fig. 2). Formulae are then derived determining the distribution of charges, currents, and voltages on the line, the travelling wave, and the characteristic impedance of the line. The calculation of Green's function G for different values of the argument is also discussed.

929. Propagation of Waves in a Liquid possessing "Maxwell Viscosity."—M. A. Issakovich. (*Comptes Rendus* (*Doklady*) *de l'Acad. des Sci. de l'URSS*, No. 8, Vol. 23, 1939, pp. 783–787: in English.)

930. Explanation of the Anomalies of the Optical Constants of Thin Metallic Films [Anomalies caused by Oscillators with Natural Frequencies continuously distributed over Infra-Red and Visible Region: These Frequencies assumed to be Electrical Dipole Oscillations of Single Metal Grains].—E. David. (*Zeitschr. f. Physik*, No. 7/8, Vol. 114, 1939, pp. 389–406.)

931. Coherence Problems [Zernicke's "Coherence" identical with Author's "Correlation": Extension to Non-Monochromatic Light: Visibility of Interference: etc.].—P. H. van Cittert. (*Physica*, Dec. 1939, Vol. 6, No. 10, pp. 1129–1138: in German.) *See* 3862 of 1938.

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

932. Recording Radiogoniometer for Atmospherics.—Ranzi. (*See* 1031.)

933. Australian Radio Research Board: Work on Atmospherics. (*See* 911.)

934. Geographical Distribution of Lightning Strokes and Hail in the Ariège Department.—C. Dauzère. (*Comptes Rendus*, 11th Dec. 1939, Vol. 209, No. 24, pp. 896–897.) The results obtained resemble those of previous reports (3485 of 1939).

935. Recent Lightning Storms: I [Formation of Thunderclouds: Effect of "Anvil" Snow Cap: etc.].—J. F. Shipley. (*Distribution of Electricity*, Jan. 1940, Vol. 12, No. 137, pp. 336–339.)

936. The Effects of Thunderstorms and Lightning Discharges on the Earth's Electric Field.—T. W. Wormell. (*Phil. Trans. Roy. Soc.*, Series A, 19th Sept. 1939, Vol. 238, No. 791, pp. 249–303, with Plates.)

The observations here described and discussed refer to the potential gradient near the ground during thunderstorms; they extend over the years 1926–36 and were mostly made during the summer months. The method of observation is to obtain "a continuous photographic record of the induced charge on a conductor exposed to the electric field and maintained always at zero potential." The apparatus and technique are described; in the discussion of results, the flashes which cause a field change, including changes of both signs, are termed *complex discharges;* when the components of a field change are all of the same sign it is termed a *simple field-change*. Examples of individual storms are discussed in detail; the records obtained are shown in the plates and the results tabulated (Table III). The electric field at the ground during a thunderstorm and the behaviour of the predischarge potential gradient are analysed; Table IV gives the durations of positive and negative predischarge potential gradients, Table v the magnitude of this gradient. The numerical results are summarised and compared with those of some earlier investigations. Fig. 2 gives the curve of mean pre-discharge potential gradient for varying distance from a thunderstorm. The interpretation of field-change observations is based on the principles stated by C. T. R. Wilson, which are briefly given.

Revised figures are given for the estimates made by Wilson for some of the fundamental quantities in a thundercloud; the experimental method used by Simpson & Scrase (3605 of 1937) is criticised. It is found that "the regular occurrence of positive charge in the base of the cloud cannot, therefore, be considered to be yet established with certainty. There is, on the other hand, no ambiguity about the distribution of charge in the main portion of the cloud, and the question as to the mechanism by which these charges are produced. The induction process suggested by Wilson . . . is the only theory producing electrification of the correct sign which has been developed in any detail. . . While no attempt has been made to re-describe the Wilson mechanism in detail in the presence of ice crystals, sufficient has perhaps been said to indicate that the criticisms raised by Simpson & Scrase are inadequate reasons for rejecting it."

937. DAILY COURSE OF THE EARTH'S ELECTRIC FIELD IN ROME.—Medi. (*La Ricerca Scient.*, Nov. 1939, Year 10, No. 11, pp. 1005–1009.)

938. MEASUREMENTS OF THE IONISATION OF THE AIR AT LACCO AMENO (ISLE OF ISCHIA) [Radioactive Zone].—G. Imbò. (*La Ricerca Scient.*, July/Aug. 1939, Year 10, No. 7/8, pp. 684–686.)

939. SUMMARY OF THE YEAR'S WORK, DEPARTMENT OF TERRESTRIAL MAGNETISM, CARNEGIE INSTITUTION.—Fleming. (*See* 913.)

940. PRINCIPAL MAGNETIC STORMS, JULY/SEPT. 1939.—(*Terr. Mag. & Atmos. Elec.*, Dec. 1939, Vol. 44, No. 4, pp. 399–400, 470, & 491–496.)

941. THE MAGNETIC CHARACTER OF THE YEAR 1938, REVIEW OF THE YEARS 1928/1938, AND THE NUMERICAL MAGNETIC CHARACTER OF DAYS 1938.—G. van Dijk. (*Terr. Mag. & Atmos. Elec.*, Dec. 1939, Vol. 44, No. 4, pp. 391–393.) On the annual review of the "Caractère magnétique de chaque Jour," with extracts. *See* also p. 491.

942. THE THREE-HOUR-RANGE INDEX MEASURING GEOMAGNETIC ACTIVITY, *and* MAIN FEATURES OF DAILY MAGNETIC VARIATIONS AT SITKA . . . WATHEROO.—Bartels, Heck, Johnston. (*Terr. Mag. & Atmos. Elec.*, Dec. 1939, Vol. 44, No. 4, pp. 411–454: pp. 455–469.)

"Incidentally, a geomagnetic solar-flare effect was found preceding the outbreak of the intense storm on 16th Jan. 1938; the time-interval suggests 22 hours as an upper limit for the travel-time of the solar corpuscles."

943. "TERRESTRIAL MAGNETISM AND ELECTRICITY" [Book Review], *and* "GEOMAGNETISM" [Book Preview].—J. A. Fleming (edited by): S. Chapman & J. Bartels. (*Terr. Mag. & Atmos. Elec.*, Dec. 1939, Vol. 44, No. 4, pp. 383–388.) In this article Chapman reviews the first book and compares it with the forthcoming second book.

944. "SWEDISH POLAR YEAR EXPEDITION, SVEAGRUVAN, SPITZBERGEN, 1932–1933: GENERAL INTRODUCTION, TERRESTRIAL MAGNETISM" [Book Review].—(*Terr. Mag. & Atmos. Elec.*, Dec. 1939, Vol. 44, No. 4, p. 378.)

945. WORLD-WIDE VARIATIONS OF THE EARTH'S MAGNETIC FIELD AND THE INTENSITY OF COSMIC RADIATION [Fluctuations may be due to Variations in Intensity of Ionospheric Currents: Assumed Current Scheme leads to Estimate of Variation of Cosmic-Ray Intensity: High-Latitude Discrepancies may be due to Sun's Magnetic Field].—O. Godart. (*Phys. Review*, 1st Dec. 1939, Series 2, Vol. 56, No. 11, pp. 1074–1077.)

946. COSMIC-RAY OBSERVATIONS IN THE STRATOSPHERE WITH HIGH-SPEED COUNTERS [Apparatus & Results].—L. F. Curtis & others. (*Journ. of Res. of Nat. Bur. of Stds.*, Nov. 1939, Vol. 23, No. 5, pp. 585–595.)

947. REPORT ON PROGRESS IN METEOROLOGY.—D. Brunt. (*Reports on Progress in Physics*, Physical Society, Vol. 5, pub. 1939, pp. 100–120.)

PROPERTIES OF CIRCUITS

948. [Ultra-] SHORT-WAVE WIDE-BAND AMPLIFICATION.—Strutt & van der Ziel. (*See* 1120.)

949. THE INTERNAL NOISE OF RECEIVERS AND AMPLIFIERS [Survey of Present Knowledge, and Original Measurements on Two Broadcast Receivers: Advantage (particularly at the Higher Frequencies) of H.F. Amplifier Stage in front of Mixing Stage, especially with Use of Low-Noise Pentode].—A. Klemt. (*Funktech. Monatshefte*, Nov./Dec. 1939, No. 11/12, pp. 298–304.)

950. IMPEDANCE MATCHING AT THE OUTPUT TERMINALS, AND THE MAXIMUM OVERLOAD OUTPUT OF THE FEEDBACK AMPLIFIER.—K. Kobayashi. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 121–122: summary only.)

When negative feedback is applied to improve the non-linearity of the output valve, it is not enough to base the condition for impedance matching and maximum output on equality of the output and load impedances: the maximum overload output must be taken into consideration, as here described.

951. Feedback Amplifier with Frequency Response of Constant Inclination (Feedback Equaliser) [Analysis & Experimental Investigation of Arrangements with One or Two Resonant Circuits in Feedback Circuit].—K. Kobayashi & T. Kurokawa. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, p. 122: summary only.)

952. Transient Phenomena of Simplex Feedback Amplifiers [Single- and Double-Stage Tuned Selective Amplifiers and Resistance-Capacity-Coupled Wide-Band Amplifiers: Analysis & Experimental Oscillograms].—Y. Watanabe & S. Okamura. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 59–66.) For previous work *see* 4347 of 1939.

953. A Theorem of the Laplace Function Transformation on the Division into Steady and Transient Phenomena with Direct and Alternating Current, and the Theorem of Transients of the Complex Transformation.—H. W. Droste. (*E.N.T.*, Oct. 1939, Vol. 16, No. 10, pp. 253–257.)

The complex transformation here denotes the substitution of the exponential function with imaginary argument for the simple harmonic function in the solution of linear equations with constant coefficients. Theorems on the use of the Laplace function transformation are here first recapitulated. The theorem found by the present writer (2705 of 1939) is concerned with the appropriate transformation of a product of two Laplace integrals, each extending to infinity at one integration limit, of which the integrand of one is a sine function. The parts of the product which give the stationary state and the transient phenomenon respectively are distinguished. The theorem of transients of the complex transformation gives an expression for deducing the transient phenomenon from the known form of the stationary condition in the case when the initial values are zero. Examples given are the solutions of an ordinary differential equation and of the partial differential equations of a transmission line, leading to the expression for the transient current in a matched line (eqn. 18).

954. The Phase Relationship at the Parametric Regeneration in Valve Circuits.—I. U. Lyubchenko. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 9, 1939, pp. 565.)

Three types of back-coupled valve circuits are considered in which the natural frequency is adjusted by varying (a) the resistance (Fig. 1), (b) the capacity (Fig. 2), and (c) the inductance (Fig. 3) of the tuned anode circuit. In practice the variation is made by applying an external e.m.f. to the circuit and in the present paper it is assumed that this has two components whose frequencies bear a simple numerical ratio. The non-linearity of the valve characteristic is taken into account, and for each of the above cases non-homogeneous, non-linear differential equations of the second order with periodically varying coefficients are derived determining the operation of the system. Solutions of these equations are then found for the cases when $\omega_1 : \omega_2 : \omega_0$ is (a) 2 : 1 : 1, and (b) 2 : 3 : 1, where ω_0 is the natural frequency of the circuit and ω_1 and ω_2 are the applied frequencies. Experiments were made to check the theoretical results, and a number of experimental curves are shown.

The main conclusion reached is that the amplitude of the oscillations in these circuits is definitely dependent on the phase difference between the external e.m.fs. These circuits can therefore be used for measuring the phase difference between two frequencies, an important application of which is the determination of distances by the radio-interference method. For another method of measuring these phase differences *see* 2038 of 1939.

955. On a Differential Equation with a Limiting Cycle.—N. N. Bautin. (*Journ. of Tech. Phys* [in Russian], No. 7, Vol. 9, 1939, pp. 601–611.)

The differential equation of the type $\ddot{x} + x = \alpha\dot{x} + \beta x\dot{x} + \gamma\dot{x}^2 + \delta x^2$ is of importance in the theory of auto-oscillations, since equations of a number of oscillating systems can be reduced to this type provided that the characteristics of the system can be approximately represented by polynomes not containing terms of any power higher than the second. A qualitative analysis of the equation is given, showing that for certain values of α, β, γ, and δ this equation has a stable periodic solution corresponding to the limiting cycle on the phase plane x, $\dot{x}$. For the so-called "small" values of these coefficients a solution is found by using quantitative Poincaré methods, and the stability of this solution is investigated. For "large" values of the coefficients the quantitative analysis is carried out by the method of isoclinic lines. As an illustration of the latter method, the limiting cycle and the corresponding solution are plotted for certain particular values of the coefficients.

956. On the Natural Frequencies of Vibrating Systems [Imposition of Lower Limits: Extension of "Relaxation" Technique: Continuous Systems governed by Differential Equations].—R. V. Southwell. (*Proc. Roy. Soc.*, 18th Dec. 1939, Vol. 173, No. 954, S 131: abstract only.)

957. Matrix Theory of Oscillatory Networks.—L. A. Pipes. (*Journ. of Applied Physics*, Dec. 1939, Vol. 10, No. 12, pp. 849–860.)

958. On the New Filter-Design Methods [for a Given Input Impedance: with Special Application to Wave Separators].—R. Kamiya: Piloty. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 95–102.)

"In this method, the circuit is not constructed directly by the hyperbolic parameters, therefore it is entirely different from the existing filter designs." It gives fewer elements than Zobel's method; a ladder-type structure similar to composite filters; the same number of elements and the same general form as those given by Cauer and Piloty (2477 & 3623 of 1937 and 2226 of 1938: *see* also 959, below). Thus the method possesses "two excellent points of existing methods and yet an entirely different starting point from their theories."

959. WAVE FILTERS, PARTICULARLY SYMMETRICAL AND "ANTIMETRICAL," WITH PREDETERMINED PERFORMANCE.—H. Piloty. (*T.F.T.*, Oct. 1939, Vol. 28, No. 10, pp. 363–375.)

Further development of the method of treatment dealt with in 46 of January. By "antimetrical" is meant a filter which on rotation (exchange of input & output) does not remain unaltered as a symmetrical filter does, but changes into its "dual" form, differing from the original only in that for an unaltered polarity of H the sign of K is changed: H & K stand for $\frac{1}{2}(M + N)$ & $\frac{1}{2}(M - N)$ respectively, where M is the "current-transmission factor" & N the "voltage-transmission factor."

960. NEW PRINCIPLES FOR PRACTICAL COMPUTATION OF FILTER ATTENUATIONS BY MEANS OF FREQUENCY TRANSFORMATIONS.—T. Laurent. (*Ericsson Technics*, No. 3, 1939, pp. 57–72.)

"While the effective attenuation in a realisable filter is mainly made up of the non-dissipation attenuation, yet at the same time account must be taken of the additional attenuation due to dissipation in coils and condensers, of the winding & earth capacitances, and of the reflections at the input & output terminals. The present paper will demonstrate how this may be carried out conveniently, in conjunction with the shaping of the image attenuation curve" by the method dealt with in 1339 of 1938.

961. REPORT ON PROGRESS IN ELECTRIC WAVE FILTERS.—N. F. Astbury. (*Reports on Progress in Physics*, Physical Society, Vol. 5, pub. 1939, pp. 334–347.)

962. THE TRANSMISSION PROPERTIES OF A CROSS-CONNECTED MESH OF RESISTANCE-RECIPROCAL IMPEDANCES [Equalising Network], WITH SPECIAL CONSIDERATION OF THE TIME OF TRANSIT.—K. H. Krambeer & K. Erdniss. (*T.F.T.*, Nov. 1939, Vol. 28, No. 11, pp. 395–403.)

Authors' summary:—The time of transit of a resistance-reciprocal section with complex resistances which consist of a series or parallel connection of a resistance and a reactance of the order n [such a section is seen in Fig. 1, and is thereafter referred to as an R-X-section] can always be represented as half the algebraic sum of the time-of-transit curves of more amenable resistance-reciprocal meshes of pure reactances of the first and second order.

Attenuation and phrase of the R-X-network are given in the form of locus curves. A corresponding representation of the time of transit cannot, in general, be carried through. A survey of the over-all behaviour of the circuit is obtained if the relations between attenuation, phase equivalent, and time of transit are represented in suitable graphical form. Further, the surfaces of negative time of transit and the corresponding attenuation distortion are brought into relation.

963. ON THE GRAPHICAL SOLUTION OF NATURAL FREQUENCIES AND DAMPING FACTORS FOR CONDENSIVE OR INDUCTIVE COUPLED CIRCUITS.—S. Nakai. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, p. 119: summary only.)

964. IMPROVEMENT ON THE FILTER REPEATING COIL [Transformer/Condenser Combination: Addition of Resonant & Antiresonant Circuits to improve Image-Impedance Characteristic].—A. Matsumoto. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 120–121: summary only.)

965. DIFFERENTIAL MAGNETOSTRICTION FILTER [using Laminated Vibrators: Number of Elements in Bridge-Type Filter halved by Use of Two Coils, Differentially Connected, on Each Element: Wider & Better Band by connection of Parallel Condenser: etc.].—K. Fukushima & T. Koitibara. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 84–86.) Further development of the work dealt with in 4336 of 1939.

966. ON QUARTZ CRYSTAL VIBRATORS AS ELEMENTS FOR ELECTRICAL WAVE-FILTERS [Curves of Relationships between Plate Dimensions and Equivalent-Circuit Constants, for X, YT, & $-18° 30'$ Cuts: Holder Requirements, and Some Experimental Results].—Z. Kamayachi & T. Ishikawa. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 103–106.)

967. SIMPLIFICATION OF SWITCHING CIRCUITS IN GENERAL [by "Shorting," "Combination," and "Network Formation": Theory: Examples].—H. Piesch. (*Arch. f. Elektrot.*, 10th Nov. 1939, Vol. 33, No. 11, pp. 733–746.)

TRANSMISSION

968. THE THEORY OF KLYSTRON OSCILLATIONS [Principles: General Equations applied to maximising Power Output from Oscillator, minimising Power Input for Ideal Regenerative Amplifier, and determining Stability of Frequency against Changes in Cathode Potential].—D. L. Webster. (*Journ. of Applied Phys.*, Dec. 1939, Vol. 10, No. 12, pp. 864–872.) For previous work *see* 3950 of 1939 and back references.

969. THE CUT-OFF CHARACTERISTIC OF THE SINGLE-ANODE MAGNETRON.—A. F. Harvey. (*Proc. Camb. Phil. Soc.*, Nov. 1939, Vol. 35, Part 4, pp. 637–651.)

The purpose of this paper is to discuss the cause of the rounded "knee" and "foot" of the anode-potential/anode-current "cut-off" magnetron characteristic (Fig. 5a, curve A). "Possible causes of the knee and foot are (a) emission velocity of electrons; (b) magnetic field not parallel to the axis; (c) the cathode not an equipotential cylinder; (d) cathode eccentric and/or not parallel to the axis of the anode; (e) presence of space charge; (f) fringing of electric field at the ends of the electrodes; (g) high-frequency oscillations of small amplitude." These are studied, in particular (b), for which the electron paths are worked out analytically for a plane electrode system; calculated cut-off curves are plotted (Fig. 3) and show that "a slight inclination of the field may be an important factor in producing the knee and foot of the 'cut-off' curve." This is found to be the only cause which plays a considerable part in the production of the knee and foot; curves (Fig. 4b) are given which "emphasise once more that cut-off occurs at the calculated value of V or H only when the emission current is considerable, though it should be independent of emission. Can it be that space-charge tends to damp oscillations which are in fact always present, no matter how much care is taken to prohibit them?"

970. The Magnetron as a Generator of Ultra-Short Waves [Analysis of Electron-Motion in Magnetic Field: in Magnetic & Electric Fields: Lower-Frequency (Negative-Resistance) Magnetron Oscillations: U.H.F. Oscillations, Tangential & Radial (Correct Phase Selection by Oblique Magnetic Field): etc.].—G. Heller. (*Philips Tech. Review*, July 1939, Vol. 4, No. 7, pp. 189–197.)

971. Parasitic Oscillation as a By-Product of the Mixer Process in Frequency-Changer Valves, and Its Practical Utilisation as a Generator of Ultra-Short Waves [Use of the Tungsram APP4C Triple-Grid Output Valve as Space-Charge-Coupled Oscillator to give 5 Watts at 250 Mc/s, for 8 Watts Input].—J. A. Sargrove. (*Journ. of British I.R.E.*, Dec. 1939, Vol. 1, No. 1, pp. 18–29.)

The original (100 Mc/s) circuit used a Tungsram frequency-changing octode. A push-pull oscillator for higher powers on 300 Mc/s is now being developed. For a previous paper *see* 4397 of 1939.

972. Frequency Modulation: Success of Triple Relay Experiment.—Warner. (*See* 1243.)

973. On a Certain Method for Increasing the Effectiveness of Wireless Communication [by "Optimum Amplitude-Phase Modulation"].—Tetelbaum. (*See* 1244.)

974. Scintillation [Carrier-Frequency Fluctuation due to Amplitude Modulation].—Koike. (*See* 1245.)

975. Frequency Variations in a Self-Oscillator due to Space-Charge in the Tube [Experiment with Duplicate "Test" Valve (without H.T. Supply) connected to Oscillating Circuit].—T. Sakamoto. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, p. 120: summary only.)

When the filament of the "test" valve was switched on, at a certain temperature the oscillator frequency began to vary. Negative potentials applied to the "test" valve, to prevent the flow of current due to the h.f. voltage, decreased the capacitance and caused a very small (below 10^{-5}) increase of oscillator frequency. When the oscillation voltage was increased, a conduction current was produced in the "test" valve, so that an equivalent parallel resistance appeared across the oscillating circuit and caused a large decrease of frequency; thus the frequency variation due to space charge was much less than that caused by conduction.

976. The Deviation of the Frequency of a Valve Oscillator from the Natural Frequency of the Linear Circuit.—B. K. Shembel. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 9, 1939, pp. 566–580.)

Using the method of reactive powers, an investigation is made of the change in the frequency of a self-excited oscillator caused by the non-linear impedances of the grid and anode of the valve. An equivalent circuit (Fig. 1) for a valve with three or more electrodes is considered and a general formula (28) derived for determining this deviation. The Meissner, Colpitts, and Hartley types of oscillating circuit are then discussed and corresponding formulae derived for oscillators (a) without grid current (30, 31, 32) and (b) with grid current (43, 44, 45). It is pointed out that formulae 30, 31 & 32 differ considerably from those derived by other authors. A numerical example is added.

977. "Bug" Keys [Lateral-Movement Morse Keys]: What They Are and What They Do.—W. A. Roberts. (*Wireless World*, Dec. 1939, Vol. 46, No. 2, pp. 44–46.)

RECEPTION

978. Observations and Investigations on Crystal Detectors.—H. Klumb. (*Physik. Zeitschr.*, 15th Oct. 1939, Vol. 40, No. 20, pp. 640–643.)

The aim of the work was the production of sensitive, constant crystal detectors for rectification of frequencies between 10^8 and 10^{11} c/s. A large number of crystal detectors (chiefly tungsten/silicon) were tested for sensitivity of detection and for the causes of sensitivity variations. It was found that these variations, which are due chiefly to mechanical and thermal strains and disturbances, could be almost completely eliminated by enclosing the crystal/metal detector in viscous or plastic substances; detectors were thus made which could be used in a frequency range 10^1 to 10^{11} c/s for d.c. output currents from 1 to 5 mA.

979. Reception of Frequency-Modulated W1XOJ in England, on 43.1 Mc/s.—(*Wireless World*, Dec. 1939, Vol. 46, No. 2, p. 66.) In an article on "Short-Wave Reception."

980. The Ultra-Short-Wave Interference Suppression of the Electrical Ignition Systems of Motor Vehicles.—W. Scholz & G. Faust. (*T.F.T.*, Nov. 1939, Vol. 28, No. 11, pp. 409–414.)

In television and ultra-short-wave telephony the place of interference due to atmospherics, commutator-machines, switches, defective insulators, and other enemies of reception on wavelengths from "short" to "long" is taken by two main types of disturbance—that due to ignition systems and that produced by u.s.w. diathermy apparatus. The present paper deals with the German Post Office's campaign to develop the simplest means of eliminating the first of these, with special reference to reception between 40 & 60 Mc/s. The minimum distance between the vehicle and the receiving aerial was taken as 10 m horizontally and 5 m vertically (a reasonable assumption, since in this wave-range vertical polarisation and screened aerial leads are generally employed). Preliminary tests were made to determine the horizontal radiation diagrams of a small transmitter (representing the ignition system) under the bonnet of the car in various positions (Figs. 3 & 4): these tests showed clearly the important effects of changing the position of the ignition leads and the consequent difficulty in making comparative measurements of various suppressing arrangements.

It was recognised that the known plan of screening the whole ignition system, or at any rate its important components, was too expensive as a general solution; that the introduction of h.f. chokes merely displaced the interference to longer wavelengths (Neubauer, 407 of 1935: this paper also gives further literature references); and that the use of condensers large enough to be effective (*i.e.* above about 100 pF) reduces the efficiency of the motor. Resistances, therefore, seemed the only hope: they had already been found effective for car-receiver installations on the broadcast band. But the suppressing action of added resistances decreases for waves below about 20 m, because their capacitive leakage resistance becomes lower than their ohmic value. Another way, however, of using resistance is to increase the ohmic value of the leads themselves uniformly along their whole length, by making them of spirally wound resistance wire on an insulating core: the bottom curve of Fig. 7 shows the improvement in potential distribution along the lead (measured with the signal-generator arrangement of Fig. 6) produced by such a high-resistance (5 to 10 kilohms—about 10 kilohms per metre) spiral lead of iron wire, combined with a condenser of only 10 pF and a series resistance of 2 kilohms to suppress the wavelengths above 20 m, to which the maximum interference energy was displaced by the inductance of the spiral.

Finally, for combination with such a high-resistance lead, a special sparking-plug was developed containing a built-in wire-free (compressed powder) resistance of about 2 kilohms with a cover which formed a capacity of about 10 pF with the lead terminal. Fig. 10 shows the experimental model: in the final form the resistance and its cover are definitely fixed inside the plug, the springs shown being eliminated. The complete system gave, at a distance of 7 m, an interfering field strength so small that it could not be measured, compared with 32 mv/m for the un-treated car, 13.3 mv/m for ordinary suppression by 10-kilohm composite resistances, and 4.3 mv/m for high-resistance leads and 2-kilohm resistances, with the ordinary sparking plug: at 3 m distance it gave 3.2 mv/m. Tests on several vehicles and motors showed that the arrangement had no effect on the efficiency.

981. Combating Radio Interferences [at Source: Prevention of Penetration into Mains: at Receiver: Practical Examples].—L. Blok. (*Philips Tech. Review*, Aug. 1939, Vol. 4, No. 8, pp. 237–243.) Continuation of the work dealt with in 1443 of 1939.

982. Electric Razors: Emergency Power Supply and Interference.—(*Wireless World*, Jan. 1940, Vol. 46, No. 3, pp. 112–113 and 115.)

983. The Dry Shaving Apparatus "Philishave" [and the Steps taken to prevent Interference, including That due to Capacitive Coupling between Collector & Hand].—A. Horowitz & others. (*Philips Tech. Review*, Dec. 1939, Vol. 4, No. 12, pp. 350–354.)

984. Introduction to VDE-0448 "Guiding Rules for the Testing of Overhead H.T. Insulators in Conditions of Fog and Dirt."—W. Weicker: VDE. (*E.T.Z.*, 28th Sept. 1939, Vol. 60, No. 39, pp. 1135–1136.) The actual proposed rules follow on pp. 1136–1137.

985. Fundamental Electrical and Mechanical Tests on the "Long-Rod" Insulator of Porcelain [and Its Superiority, as regards Broadcast Interference, over Previous Insulators].—F. Obenaus. (*E.T.Z.*, 26th Oct. 1939, Vol. 60, No. 43, p. 1235: summary only.)

986. A New Method for the Measurement of Discharges on Porcelain Insulators [using the "Balanced Discharge Bridge"].—A. N. Arman. (*BEAMA Journ.*, Dec. 1939, Vol. 45, No. 30, pp. 123–125.) *See* Arman & Starr, 3522 of 1936, for this bridge.

987. Noise Disturbance in the Broadcast Audio-Frequency Band [Investigation of Various Types of Noise and Measurement of Most Disturbing Noise Frequency (Same Frequency Band as Programme): Design of Suitable Noise Generator: etc.].—M. Kono. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 119–120: summary only.)

988. The Internal Noise of Receivers and Amplifiers.—Klemt. (*See* 949.)

989. Paper on Parasitic Oscillation as a By-Product of the Mixer Process.—Sargrove. (*See* 971.)

990. Crystal Control of the Mixer Oscillator in a Superheterodyne Receiver [Optimum Performance over Wide Frequency Range (2–7 Mc/s) with Change of Crystal only: Pierce-Circuit Anode Load replaced by Inductance giving Suitable Antiresonant Frequency with Stray Circuit Capacities: Design, Mounting, & Rating of Crystals (including Use of "Sectional" Oscillations): etc.].—J. E. Benson. (*A.W.A. Tech. Review*, No. 3, Vol. 4, 1939, pp. 127–137.) For these "sectional" oscillations at ultra-high-frequencies *see* 2268 of 1938.

991. AVC Developments: Using a Subsidiary RF Automatic Gain Control.—W. T. Cocking. (*Wireless World*, Dec. 1939, Vol. 46, No. 2, pp. 51–55.)

992. Economising in H.T. Consumption: Anode Current dependent on Volume [Brit. Pat. 511 912].—(*Wireless World*, Jan. 1940, Vol. 46, No. 3, p. 91.)

993. SMOOTH REACTION : AVOIDING "PLOPPINESS" AND BACKLASH, *and* REACTION REFINEMENTS : EFFECTS OF THE AERIAL, R.F. AMPLIFIER, AND A.F. LOAD.—(*Wireless World*, Jan. & Feb. 1940, Vol. 46, Nos. 3 & 4, pp. 92–95 & 133–135.)

994. THE VARIATION OF THE SELF-INDUCTANCE OF HIGH-FREQUENCY COILS BY D.C. MAGNETIC BIAS [for the Tuning of Receivers].—G. Maus. (*Funktech. Monatshefte*, Nov./Dec. 1939, No. 11/12, pp. 289–294.)

A theoretical and experimental investigation of the possibilities of this method of near or remote tuning. The papers of von Kramolin (3566 of 1938 & 966 of 1939) and Leithäuser & Boucke (2974 of 1936) are referred to. It is concluded that existing materials, suitably treated mechanically, thermally, & chemically, make the method suitable for the medium- and long-wave bands.

995. THE HYDROGEN-FILLED IRON-WIRE BALLAST LAMP [Barretter : Derivation of Differential Equation of Temperature Distribution : Consequences of the Equation (with Curves)].—R. A. L. Cole & D. P. Dalzell. (*Elec. Communication*, Oct. 1939, Vol. 18, No. 2, pp. 115–119.)

996. THE BETTER UTILISATION OF TRANSFORMERS WITH TAPPING-POINTS [Formulae & Nomogram for Calculation of Apparent Impedances Not Usually given by Manufacturers].—M. Wünsch. (*Funktech. Monatshefte*, Nov./Dec. 1939, No. 11/12, pp. 305–308.)

Thus in a primary with 4 connecting points the only values given by the makers may well be those between 12, 13, & 14, whereas the extra ones between 23, 34, & 24 would be useful if known. It is shown how to calculate these without a knowledge of the number of turns. For previous work *see* 3142 of 1939.

997. SELECTIVITY MEASUREMENT AND SELECTIVITY REQUIREMENTS IN BROADCAST RECEIVERS.—R. Moebes. (*T.F.T.*, Oct. 1939, Vol. 28, No. 10, pp. 375–380.)

Author's summary :—For the measurement of selectivity two methods are commonly employed, which may be called the "single signal-generator method" and the "two signal-generators" method [*anglice*, "one-signal" and "two-signal" methods]. Each has its advantages and disadvantages ; for a single-circuit receiver the one-signal method appears the more suitable. Measured results on the same receiver by the two methods must differ numerically if, in that receiver, the output voltage is connected with the input voltage by a relation other than a linear one. In small receivers the rectification as a rule is markedly a square-law process, so that the two-signal method must give a value in nepers about twice that given by the one-signal method [for a comparison of the two methods, applied to a diode, *see* Williams, 2223 of 1938]. The necessary attenuation of the interfering carrier is given by the requirement that the output voltage due to the interfering modulation should be reduced to about 1/100th of the value of the tuned signal corresponding to "room volume" at 30% modulation [for 400 c/s, taken as 60–70 phons at 1 m from the loudspeaker : the voltage U_a, at the loudspeaker input, corresponding to this volume is measured and used to represent the standard condition of volume]. The values necessary to obtain this result differ for linear and quadratic relations between E [input voltage] and U_a, and are here calculated for the general and special cases [including h.f. wire-broadcasting]. While with the one-signal method the choice of the receiver-output voltage employed for the measurements has no marked influence on the results, it may cause serious discrepancies in the results given by the two-signal method. These theoretical considerations are confirmed by some measurements on "People's" receivers [*see* Figs. 3, 4, 6, 7 : Fig. 5 refers to the "German Small" receiver. Fig. 7 shows the selectivity of the VE 301 measured by the two methods : at low attenuations the one-to-two relation between the two results, mentioned above, holds well (*e.g.* 3 & 6 nepers), whereas at higher attenuations the ratio decreases (*e.g.* 4.5 & 8.2 nepers)].

998. SELECTIVE FADING IN [Short-Range] BROADCAST RECEPTION.—E. Alsleben : Feldtkeller & Mayer. (*T.F.T.*, Oct. 1939, Vol. 28, No. 10, p. 392.)

Prompted by the paper dealt with in 3933 of 1939, Alsleben describes similar occurrences, in the evenings of April & May 1939, as observed in Berlin from the Munich station. Further, the phenomenon previously found with short-wave communication, of periodic changes in the interference conditions, arising from changes in the effective height of the reflecting layer (Mayer, 895 of 1939), were established. They were indicated, in the apparatus used, by oscillations (with a period of about ¼ to ½ second) of the major axis of the recorded ellipse, and simultaneous changes of the eccentricity. The amplitude of these oscillations underwent a strong and more or less regular variation, with a period of about half an hour. On some evenings, particularly at the beginning of April, very strong amplitude and phase differences, varying with complete irregularity, between the two sidebands were observed, causing marked distortion of reception.

999. FADING OF BROADCAST RECEPTION PRODUCED BY MOVING RAILWAY-TRAINS.—Oxenfart. (*See* 927.)

1000. SHORT-WAVE RECEPTION : NEWS-GATHERING CONDITIONS IN PROSPECT AND RETROSPECT.—(*Wireless World*, Feb. 1940, Vol. 46, No. 4, pp. 144–145.)

1001. B.B.C. RECEIVING STATION : SOME RECENT DEVELOPMENTS.—H. V. Griffiths. (*Wireless World*, Dec. 1939, Vol. 46, No. 2, pp. 69–71.)

1002. PUBLIC LISTENING [Obstacles preventing Public Dissemination of News Bulletins & Speeches].—A. A. Gulliland. (*Wireless World*, Jan. 1940, Vol. 46, No. 3, p. 106.)

1003. EMERGENCY RECEIVER [for News Bulletins, etc : without Any Form of Power Supply : New Type (WX1) Westector in place of Crystal].—(*Wireless World*, Dec. 1939, Vol. 46, No. 2, p. 65.)

1004. Sets for Active Service [Correspondence on Demand for Suitable Receivers].—(*Wireless World*, Jan. & Feb. 1940, Vol. 46, Nos. 3 & 4, pp. 105–106 (and 114) & 148–149.)

1005. Design Problems in Automobile Radio Receivers.—G. G. Hall. (*A.W.A. Tech. Review*, No. 3, Vol. 4, 1939, pp. 105–126.)

History & general considerations: aerials & coupling: automatic volume control: sensitivity & power output: reproducer: power supply (for an article on vibrators *see* 508 of 1939 and 886 of February): power-supply interference and (in a long section) ignition interference.

1006. Radio Receiving Sets with Linear-Action Tuning Condensers [Each Set of Plates consists of a Strip wound into Archimedean Spiral: for Press-Button Tuning.]—S. Gradstein. (*Philips Tech. Review*, Oct. 1939, Vol. 4, No. 10, pp. 277–283.)

1007. Radio Sets with Station Dials calibrated for Short Waves [Band Spread with Variable Condenser: with Variable Self-Induction: Constancy of Tuning with Both Systems].—G. Heller. (*Philips Tech. Review*, Oct. 1939, Vol. 4, No. 10, pp. 284–289.)

1008. Single-Dial Band Spread: Short-Wave Reception simplified by New System of Tuning.—(*Wireless World*, Feb. 1940, Vol. 46, No. 4, pp. 129–132.) Constructional details will be given in the March issue.

1009. Test Reports: G.E.C. Model 4010 [with Twin Loudspeakers and 12 Watts Output]: *and* Philips Type 855X [Mechanical Push-Button Tuning].—(*Wireless World*, Dec. 1939, Vol. 46, No. 2, pp. 56–58: pp. 76–77.)

1010. Test Reports: H.M.V. Model 1200 [10-Watt Output Stage with Negative Feedback: Elliptical Diaphragm]: *and* "Mighty Gem" Portable [Superhet. weighing $3\frac{1}{2}$ lb: Dry Cells only].—(*Wireless World*, Jan. 1940, Vol. 46, No. 3, pp. 96–97: p. 116.)

1011. Test Reports: Bush Model PB63 [with Permeability-Tuned Push-Button Circuits and "Teleflic" Dial for Short Waves]: *and* Peto Scott Trophy 6 [Communication-Type Receiver].—(*Wireless World*, Feb. 1940, Vol. 46, No. 4, pp. 136–137: pp. 146–147.)

AERIALS AND AERIAL SYSTEMS

1012. A Study of the Radiation from a Horizontal Dipole mounted above a Reflecting Surface.—N. I. Ashbel & F. A. Chernov. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 9, 1939, pp. 581–586.)

A report on an experimental investigation to check the theory proposed by Strutt (1929 Abstracts, p. 329). The theory is discussed and the apparatus used described. This consists of a horizontal half-wave dipole, mounted at an adjustable height h above a duralumin sheet 150 cm in diameter and 2 mm thick, and fed at $\lambda = 32.5$ cm by a magnetron through a feeder normal to the plate and passing through an aperture in the centre. The power radiated by the dipole is of the order of 1.0–1.5 w. Measurements of the horizontal and vertical polar diagrams, for the cases $h = \lambda/2$, $3\lambda/4$, & $5\lambda/4$, show good agreement with theoretical results for the directions of the maxima of radiation, but a divergence in the numerical values.

1013. Electromagnetic Field of Paraboloid-of-Revolution Reflectors.—B. A. Wwedensky & E. N. Maizels. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 9, Vol. 23, 1939, pp. 908–911: in English.)

Darbord (1932 Abstracts, p. 346: *see* also p. 525) "ignores the fact that every point on the mirror surface has a different phase": in the case considered by him this leads to an exaggeration of the actual gain by 3.2 db. His work includes no calculations of radiation characteristics, and Morita (2866 of 1936) has set himself to fill this gap. "Yet he is using Darbord's expression (10) without correcting it, and therefore his curves lack in accuracy. Therefore the direction characteristics of Morita are much broader than those calculated according to (5) & (6) [of the present paper] and even fail to agree with his own experimental results." Staal's calculations (972 of 1937) "are based on an obviously wrong statement that the component of electric field parallel to the vibrator is not affected by reflection from the mirror . . ."

1014. On the Radiation Resistance of the Hertz Oscillator [Elementary Dipole: Calculation by "Poynting Vector" and "Induced E.M.Fs" Methods: Deductions].—A. Arenberg. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 4, Vol. 23, 1939, pp. 345–349: in French.)

"Thus one sees that the principal difference between this result [induced e.m.fs method] and the one given earlier [Poynting vector method] consists in the fact that when we calculate the power radiated (and consequently the radiation resistance also) by the induced e.m.fs method, we must not confine ourselves to considering only the influence of the vector potential $\bar{A}$, but must necessarily take into equal account the influence of the scalar potential ϕ; important deductions result from this. The reasons which cause this difference, as well as other questions arising in the course of the present study, require further researches, of which a part will soon be completed."

1015. Self-Induction and Capacity of a Hertz Vibrator and Its Equivalence to a Closed Oscillatory Circuit.—A. G. Arenberg. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 9, Vol. 23, 1939, pp. 904–907: in English.)

"In our preceding communication [1014, above] . . . we have shown that for computing the radiation resistance of a Hertz vibrator with the help of the method of 'induced e.m.fs' it is only necessary to take account of the 'active' (watt) components of these e.m.fs, for whose amplitudes the respective formulae were obtained. However, from the general expressions for induced e.m.fs it follows that along with these active components, proportional to sin ωt, there also exist 'reactance' (wattless) components proportional to cos ωt.

Knowledge of these components permits us to determine the self-induction and capacity of an oscillating vibrator and to reduce it to the terms of an equivalent closed oscillatory circuit." In the course of the latter work the writer criticises the 1908 treatment by Rudenberg and his use of an additional term to take radiation into account ("a counterpart of the term of 'radiant brake-effect'").

1016. Radiation Efficiency of Aerial Systems.—F. Babin. (*L'Onde Élec.*, Aug./Sept./Oct. 1939, Vol. 18, No. 212/213/214, pp. 335–360: to be contd.)

Difficulties with the "external" or "radiant vector" (Poynting vector) method: advantages of Brillouin's "internal" method: G. H. Brown's paper (1782 of 1937) giving the equations of the problem for all practical cases, with numerous examples of transmitting & receiving aerials: "being unable to reproduce here the whole of his work, we will lay stress on the methods of calculation and will give formulae calculated by us which are easy to use in practice."

1017. Experimental Comparison of Shunt- and Series-Excitation of a High, Uniform-Cross-Section, Vertical Radiator [and Conclusions regarding Suitability of Shunt-Excitation for High-Power Canadian Broadcasting].—K. A. MacKinnon. (*Canadian Journ. of Res.*, Dec. 1939, Vol. 17, No. 12, Sec. A, pp. 227–236.)

Morrison & Smith (113 of 1937), in developing the shunt-excited aerial, tested a uniform-cross-section tower (of only 0.38λ) for ground-wave efficiency and a double-tapered tower (of 0.58λ) for fading characteristics. The present tests appear to provide the first comparison, as regards fading, of the two kinds of excitation for a tower of uniform cross-section, and the first comparison, also, as regards ground wave, for a high (0.55λ) tower. They lead to the conclusion that though shunt-excitation with a high uniform tower may give a ground wave within 3% of that given by series-excitation (provided that adequate grounding arrangements are made around the tower base), the sky-wave suppression with shunt-excitation is "much less satisfactory" than with series-excitation. Decision was therefore made against the use of shunt-excitation for the purpose under consideration.

1018. Duplex Operation on a Single Aerial [*e.g.* for Use of Best Possible Car Aerial not only for Transmission but also for Reception (particularly for Frequencies 1.5–5 Mc/s): General Basis of Circuit Design, applicable also to Multi-Frequency Transmission & Reception].—G. Builder. (*A.W.A. Tech. Review*, No. 3, Vol. 4, 1939, pp. 93–104.) A special case, for ultra-high-frequency waves, was given by Leeds (3485 of 1938): Green's paper (3368 of 1935) is also referred to.

1019. Hyperbolic Angle of a Feeder for a Short-Wave Antenna, and Its Applications [particularly to the Branching of the Feeder and to Its Sharing between Two (and Three) Aerials].—Y. Kato. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 67–73.)

1020. Receiving Aerials [Factors in designing Aerials to give Low Interference Level: the Shielded Aerial, Equivalent Circuit & Equations: "Philistatic" Aerial Types 7314 & 7323 (10–2000 m, with Shielded Downlead): Types 7320 & 7313 (Short Waves, Dipole with Transmission Line: acts as T Aerial for Waves above 200 m)].—J. van Slooten. (*Philips Tech. Review*, Nov. 1939, Vol. 4, No. 11, pp. 320–324.)

1021. Experiments on the Steerable Antenna [Reception Tests on Simple Form of Array (2×4 Horizontal Elements, with Phase of Upper Group reversible by Switch) show Improved Reception in Certain Conditions].—H. Takeuchi. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 82–83.)

VALVES AND THERMIONICS

1022. The Theory of Klystron Oscillations.—Webster. (*See* 968.)

1023. Short [and Ultra-Short]- Wave Valves: Advantages of Specialised Types [for Reception of Wavelengths 40–5 m].—F. E. Henderson. (*Wireless World*, Feb. 1940, Vol. 46, No. 4, pp. 120–123.) From the Osram Valve Department of the G.E.C.

1024. On Some Properties of an Electron Gas in a Magnetic Field [by Quantum Theory].—Achieser. (*See* 1250.)

1025. Inconstancy of "Durchgriff" and Cubical Distortions of Single-Grid Valves.—H. Holzwarth. (*E.N.T.*, Sept. 1939, Vol. 16, No. 9, pp. 241–252.)

For previous work on the non-linearity of the characteristics of a single-grid valve *see* 2357 of 1939. In the present paper a review of the deviations of the characteristic field from that of the ideal valve is first given, with an analysis of the reasons for regarding the deviations in the case of modern single-grid valves as due solely to the variation of the "durchgriff" with voltage. In §1 the influence of the cathode on the form of the characteristic field is discussed; this is however neglected in the rest of the work, in which the non-linear distortions are attributed to the Langmuir space-charge law for diodes and the variation of "durchgriff" with voltage. §2 gives the calculation of these distortions, based on the laws of variation of "durchgriff" with voltage given by Jobst (1932 Abstracts, pp. 226–227). The effect on the curvature of the short-circuit characteristic (Fig. 3) is worked out; §3 gives calculations for the cubic "klirr" factor for an arbitrary discharge law, using Feldtkeller's method (1067 of 1935), §4 calculations of the "klirr" factor for normal single-grid valves. The special case of parabolic variation of "durchgriff" (eqn. 7) is worked out in §5; numerical values are given to the parameters to obtain sets of theoretical curves for the cubic "klirr" factor (Figs. 5a, b, c, d; Fig. 6, quadratic "klirr" factors). The inconstancy of "durchgriff" with the smallest cubic distortions is deduced in §6. Measurements with the apparatus described in the previous paper are given in §7 (Figs. 8–12) and demonstrate the validity of

Jobst's assumptions. "It may be generally stated that, as the deviation of the 'durchgriff' from a straight line increases . . . the zero of the cubic distortion moves in the direction of over-matching."

1026. SECONDARY-EMISSION VALVES AS AMPLIFIERS.—F. C. Saic. (*E.T.Z.*, 2nd Nov. 1939, Vol. 60, No. 44, pp. 1245–1248.)

The writer concludes that the special characteristics of such valves, compared with the ordinary type, are: (1) greater steepness of slope combined with comparatively low internal resistance, and consequently larger anode currents; and (2) the formation of two currents opposed in phase. The anode-current/anode-voltage characteristic resembles that of a tetrode, while the same ratio for the auxiliary electrode has a falling characteristic. He refers, however, to Engbert's conclusion that in spite of the greater steepness of slope the valve noise is greater (155 of 1939). These properties make the valves specially useful for the amplification of high frequencies, where the impedance of the anode load will be small compared with the internal resistance. Moreover, in the ultra-high-frequency region (television) the possibilities of amplification are fixed by the ratio S/C, where C is the sum of all the natural and unwanted capacities. With the valves considered the S/C ratio may be 0.53 for a 2 Mc/s band (for a permitted amplification drop of 10%) compared with 0.14 for acorn valves.

Fig. 9 shows such a valve connected for television so that the synchronising voltage may be taken off the auxiliary electrode B while the anode voltage, of opposed phase, supplies the cathode-ray tube. Fig. 10 shows the valve used as a heterodyning valve in a television receiver: the oscillator circuit is completely separated from the input circuit: a disadvantage is that the oscillator circuit is at 150 v above earth potential. The valve is also useful for phase-reversal: it can be introduced directly in the negative-feedback connection.

1027. MEASUREMENTS OF POTENTIAL [and the Plotting of Potential Fields and Electron Paths] BY MEANS OF THE ELECTROLYTIC TANK.—G. Hepp. (*Philips Tech. Review*, Aug. 1939, Vol. 4, No. 8, pp. 223–230.)

1028. THE PROPERTIES OF OXIDE-COATED CATHODES: I [Résumé of Technique: Thermal & Electrical Properties of Alkaline-Earth Oxides]: II [Review: Chemical & Physical Properties of Alkaline-Earth Oxides and Mixtures: Properties of Thin Films on Tungsten: Methods of Detection of Ba or Sr or Ca: Preparation of Oxide-Coated Cathodes: Activation Process: Electrical Properties: Bibliography].—J. P. Blewett. (*Journ. of Applied Phys.*, Oct. & Dec. 1939, Vol. 10, Nos. 10 & 12, pp. 668–679 & 831–848.)

1029. THE OXIDE-COATED CATHODE [Theory, Manufacture, and Investigation with Electron-Microscope].—H. Te Gude & R. Theile. (*Funktech. Monatshefte*, Nov./Dec. 1939, No. 11/12, pp. 311–315.)

1030. CONTRIBUTION TO THE THERMOELECTRONIC STUDY OF THORIATED MOLYBDENUM [Theory & Measurements of A and ϕ: Activation & Deactivation: etc.].—Grauwin. (*Ann. de Physique*, July/Aug. 1939, Series 11, Vol. 12, pp. 88–160.) "It is concluded that the use of thoriated molybdenum is much less interesting than that of thoriated tungsten." A *Comptes Rendus* note was dealt with in 985 of 1938.

DIRECTIONAL WIRELESS

1031. RECORDING RADIOGONIOMETER FOR ATMOSPHERICS [Narrow-Sector Apparatus with Two Receivers ("Recording," with Frame & Vertical Aerial, and "Opposing," with Frame only, at Right Angles to First): Both Frames rotate on Common Vertical Axis, Once in Half-Hour: Moving-Coil Oscillograph: Some Results].—I. Ranzi. (*La Ricerca Scient.*, July/Aug. 1939, Year 10, No. 7/8, pp. 664–674.)

1032. BRITISH STANDARD GLOSSARY OF TERMS USED IN RADIO DIRECTION-FINDING.—British Standards Institution. (*Supplement to B.S.* 205–1936, Section 12, Dec. 1939, 15 pp.)

1033. MEASUREMENTS OF THE PROPAGATION VELOCITY OF ELECTROMAGNETIC WAVES ALONG A TWO-WIRE CIRCUIT IN AN INHOMOGENEOUS MEDIUM.—Malov. (*See* 1127.)

1034. METHOD OF MEASURING THE PHASE DIFFERENCE BETWEEN TWO FREQUENCIES IN SIMPLE NUMERICAL RATIO, PARTICULARLY FOR DISTANCE DETERMINATION BY THE INTERFERENCE METHOD. — Lyubchenko. (*See* 954.)

1035. "DIE SENDER UND SENDEANLAGE DER REICHSFLUGSICHERUNG: TEIL II" [Circuits & Construction of the Ground-Station Transmitters: Book Review].—H. J. Zetzmann. (*T.F.T.*, Nov. 1939, Vol. 28, No. 11, p. 424.) This is Part II of Vol. 3 of a series of handbooks on the German security service for aviation.

ACOUSTICS AND AUDIO-FREQUENCIES

1036. LOUDSPEAKER DESIGN: FREQUENCY CHARACTERISTIC TO COUNTERACT ROOM EFFECT.—W. West & D. McMillan. (*Wireless World*, Feb. 1940, Vol. 46, No. 4, pp. 124–125.) Abstract of a recent I.E.E. paper.

1037. THE TESTING OF LOUDSPEAKERS [Philips Laboratory Methods (including Description of the Logarithmic Potentiometer with Opposed Magnetic Drives, recording on "Philimil" Film: the "Soft" Chamber (imitating Out-of-Doors Conditions) and "Hard" Chamber (comparable to Ulbricht Sphere in Optics): etc.].—R. Vermeulen. (*Philips Tech. Review*, Dec. 1939, Vol. 4, No. 12, pp. 354–363.)

1038. Elastic and Mechanical Properties of Moving-Coil Loudspeaker Cones [Theory: Experimental Apparatus: Recorded Curves for Jenkins, Safar, Phonola, & Geloso Loudspeakers].—A. Manfredi. (*La Ricerca Scient.*, May 1939, Year 10, No. 5, pp. 404–415.) A summary was referred to in 3606 of 1939.

1039. Sound Diffusers in Loudspeakers [High-Note Beam Formation avoided by Truncated-Cone and Vertical-Partition Scattering Devices].—J. de Boer. (*Philips Tech. Review*, May 1939, Vol. 4, No. 5, pp. 144–148.)

1040. The Radiation of Sound [Differential Equations for "Pulsating-Sphere" Air Movement, and Their Solutions: Mechanical Model (equivalent to Idealised Loudspeaker in Large Baffle): Oscillating Rigid Sphere & Its Mechanical Model (Loudspeaker without Baffle): etc.].—Th. van Urk & R. Vermeulen. (*Philips Tech. Review*, Aug. 1939, Vol. 4, No. 8, pp. 213–222.)

1041. The Efficiency of Loudspeakers [Equivalent Circuit and Its Analysis: Estimation of Efficiency in Practical Case: Fundamental Limitations].—J. de Boer. (*Philips Tech. Review*, Oct. 1939, Vol. 4, No. 10, pp. 301–307.)

1042. The Nature of the Anomalies of Some Properties of Rochelle Salt and Its Relation to the Polymorphism [Kerr Effect, Pyro-Effect, "Spontaneous Polarisation," etc.].—R. D. Schulwas [Shulvas]-Sorokina. (*Journ. of Phys.* [of USSR], No. 4, Vol. 1, 1939, pp. 299–307: in English.)

The writer agrees with Kobeko and Kurchatov that dipoles exist in Rochelle salt, but differs from them in believing that these dipoles are not free and cannot turn spontaneously, but only as a result of a displacement deformation.

1043. Symmetrical Extensional Vibration and Symmetrical Torsional Vibration of the Free Circular Plate [with Possible Application to Tourmalin Piezo-Oscillators].—T. Hayasaka. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 118–119: summary only.)

1044. Effect of a Back Chamber to a Clamped Circular Plate [of a Vibrometer].—T. Hayasaka. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, p. 121: summary only.)

1045. The Calculation of Chladni Patterns.—J. K. Stewart & R. C. Colwell. (*Journ. Acoust. Soc. Am.*, July 1939, Vol. 11, No. 1, Part 1, pp. 147–151.)

1046. The Effect of Rotatory and Lateral Inertia on Flexural Vibration of Prismatic Bars.—W. T. Thomson. (*Journ. Acoust. Soc. Am.*, Oct. 1939, Vol. 11, No. 2, pp. 198–204.)

1047. Absolute Calibration of Microphones [Comparison of Four Methods].—W. Ernsthausen. (*Journ. Acoust. Soc. Am.*, July 1939, Vol. 11, No. 1, Part 1, pp. 153–154.) Long summary of the German paper dealt with in 2384 of 1939.

1048. Construction of an Amplifier for Collective Communications [and Conferences].—C. A. Beer & D. G. Tucker. (*Ann. des Postes, T. et T.*, Sept. 1939, Vol. 28, No. 9, pp. 710–720.) Translation of a *Technical Report* of the G.P.O.

1049. The Better Utilisation of Transformers with Tapping Points.—Wünsch. (*See* 996.)

1050. Getting the Best from Records: Part I — The Recording Characteristic. — P. G. A. H. Voigt. (*Wireless World*, Feb. 1940, Vol. 46, No. 4, pp. 141–144.)

1051. A Simple Apparatus for Sound Recording [on Wax or Gelatin on Glass Discs: only A.F. Part of Broadcast Amplifier required: including Discussion of Edge/Centre *versus* Centre/Edge Recording, etc.].—K. de Boer & A. Th. van Urk. (*Philips Tech. Journ.*, April 1939, Vol. 4, No. 4, pp. 106–113.)

1052. An Electrical Megaphone [" Portaphone " Type 2831: Range 5–10 Times Greater than Ordinary Megaphone].—J. de Boer. (*Philips Tech. Review*, Sept. 1939, Vol. 4, No. 9, pp. 271–273.) With little extraneous noise, normal speaking can be understood beyond 300 metres. For a specially efficient ordinary megaphone *see* 3190 of 1939.

1053. On Improving of Defect Hearing [Development of Apparatus, Non-Portable, for Particular Case of Partial Deafness, to satisfy Very High Requirements: Two Microphones in Spherical "Artificial Head," avoiding Defects of Single-Microphone/Two-Earphones Arrangement].—K. de Boer & R. Vermeulen. (*Philips Tech. Review*, Nov. 1939, Vol. 4, No. 11, pp. 316–319.) The phenomenon of rearward location of the sound source, found by Robin (3910 of 1938), is also encountered here.

1054. Instrumental Aids for Defective Hearing.—Phyllis Kerridge. (*Reports on Progress in Physics*, Physical Society, Vol. 5, pub. 1939, pp. 150–163.)

1055. Analysis of World's Fairs' Hearing Tests.—H. C. Montgomery. (*Bell Lab. Record*, Dec. 1939, Vol. 18, No. 4, pp. 98–103.)

1056. Inductive Systems for the Deaf, in Cinemas and Theatres.—G. A. V. Sowter. (*Wireless World*, Dec. 1939, Vol. 46, No. 2, pp. 63–65.)

In an article entitled "Induction: a One-Time Rival to Radio becomes Its Ally." The work is continued in the issue for February, 1940 (Vol. 46, No. 4, pp. 126–128) under the sub-heading "Design of a Practical Electro-Magnetic System." It is mentioned in the summary that the induction method has been applied by the Multitone Company.

1057. Piezoelectric Measurements on the Absolute Auditory Threshold for Bone Conduction.—G. von Békésy. (*Journ. Acoust. Soc. Am.*, Oct. 1939, Vol. 11, No. 2, pp. 259–261.) Long summary of the German paper referred to in 2417 of 1939.

1058. On the Sensitivity of the Standing and Sitting Man to Sinusoidal Vibrations.—G. von Békésy. (*Akust. Zeitschr.*, Nov. 1939, Vol. 4, No. 6, pp. 360–369.)

1059. The Degenerative Sound Analyser [Type 760-A: combining Advantages of Heterodyne & Tuned-Circuit Types without Their Disadvantages].—H. H. Scott. (*Journ. Acoust. Soc. Am.*, Oct. 1939, Vol. 11, No. 2, pp. 225–232.)

1060. A Mechanical Harmonic Synthesiser-Analyser [with Thirty Harmonic Elements operating Simultaneously].—S. L. Brown. (*Journ. Franklin Inst.*, Dec. 1939, Vol. 228, No. 6, pp. 675–694.)

1061. Synthetic Sound [with Prescribed Periodic Wave-Forms represented by Paper Stencils: for Problems in Physiological Acoustics].—J. F. Schouten. (*Philips Tech. Review*, June 1939, Vol. 4, No. 6, pp. 167–173.) The reverse of the analysing process dealt with in 1549 of 1939 (*see* also 1062, below).

1062. An Acoustic Spectroscope [for Demonstration].—J. F. Schouten. (*Philips Tech. Review*, Oct. 1939, Vol. 4, No. 10, pp. 290–291.) Based on the sound-film light-diffraction principle (1549 of 1939).

1063. On the Application of Sound Film to Harmonic Analysis [Curves converted into Photocell Voltages and dealt with by Wave Analyser].—L. W. Pollak. (*Zeitschr. f. Instrumentenkunde*, May 1939, Vol. 59, No. 5, pp. 208–210.)

1064. The Vocoder [including Some Possible Applications (Privacy Systems, etc.)].—H. Dudley. (*Bell Lab. Record*, Dec. 1939, Vol. 18, No. 4, pp. 122–126.) *See* also 655 of February.

1065. A Design for a Keyboard Instrument in Just Intonation [playable also in Equal Temperament].—C. Williamson. (*Journ. Acoust. Soc. Am.*, Oct. 1939, Vol. 11, No. 2, pp. 216–218.)

1066. Acoustical Properties of Especially Fine-Toned Violins.—H. Meinel. (*Journ. Acoust. Soc. Am.*, Oct. 1939, Vol. 11, No. 2, pp. 257–259.) Long summary of the German paper referred to in 2400 of 1939.

1067. Variations in the Quality of a Violin after Repair by an Expert.—(*La Ricerca Scient.*, Nov. 1939, Year 10, No. 11, pp. 1057–1058 and 1056.)

1068. The Rapid and Precise Measurement of Frequency [using the Vecchiacchi "Electronic" Frequency Meter with Galvanometer replaced by Oscillograph or Other Indicator with Low Time Constant].—A. Barone. (*La Ricerca Scient.*, Nov. 1939, Year 10, No. 11, pp. 1055–1057.)

In a report on recent work of the "O.M. Corbino" National Institute. The new method will deal even with short-period sounds such as are produced by the striking of a string. The Vecchiacchi meter (condenser-current principle: 3086 of 1937) requires a filter to eliminate the a.c. component of the current mixture, and Barone's first task was to obtain a filter which would provide the necessary attenuation and yet have a short time constant: a type intermediate between the non-dissipative (inductance-capacity) and dissipative (resistance-inductance or resistance-capacity) was found satisfactory. To reduce the time necessary to obtain a steady reading on the registering instrument, a multivibrator was added, giving a frequency in the neighbourhood of the unknown frequency: by this device it was possible to measure a 440 c/s note over less than a tenth of a second.

1069. Portable Apparatus for the Measurement of the Standard Pitch Note [using a Reed Frequency Meter measuring Beat Note with Fixed 400 c/s Note from Valve-Driven Fork].—A. Barone. (*La Ricerca Scient.*, Nov. 1939, Year 10, No. 11, pp. 1021–1024.)

1070. The Pitch of Musical Instruments and Orchestras.—B. van der Pol & C. C. J. Addink. (*Philips Tech. Review*, July 1939, Vol. 4, No. 7, pp. 205–210.) A short version was dealt with in 2828 of 1939.

1071. "A Table relating Frequency to Cents" [Book Review].—R. W. Young. (*Journ. Acoust. Soc. Am.*, Oct. 1939, Vol. 11, No. 2, p. 255.)

1072. The Sound Spectrum of Explosive Sparks and of Flobert Pistols, with a Section on Application Possibilities in Electro-acoustic Measuring Technique [Microphone Calibration, Electroacoustic Measurements, Measurement of Radiation Resistances: Theoretical & Experimental Investigation].—W. Weber. (*Akust. Zeitschr.*, Nov. 1939, Vol. 4, No. 6, pp. 373–391.)

1073. A Noise Source with Continuous and Uniform Spectrum [based on Thermal Agitation in a Resistance: Avoidance of Irregular Components (due to Valve Noises in Amplification) by deriving the Low Frequencies from the High by Frequency Division].—M. Nuovo. (*La Ricerca Scient.*, Nov. 1939, Year 10, No. 11, p. 1059.) For investigations on the intelligibility of speech in the presence of disturbing noises (*cf.* Elsnits & Goldin, 3776 of 1937.)

1074. Noise Disturbance in the Broadcast Audio-Frequency Band.—Kono. (*See* 987.)

1075. Measuring Lines for Programme Transmission: I—The 19-Type Oscillator: II—The 13A Transmission-Measuring Set.—S. J. Harazim: J. M. Hudack. (*Bell Lab. Record*, Dec. 1939, Vol. 18, No. 4, pp. 108–112.)

1076. AN ACOUSTIC PROBE.—V. N. Fedorovich & S. Ya. Saltykov. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 9, 1939, pp. 737–742.)

In order to measure the sound pressure at a given point of a sound field the measuring microphone is normally fitted with a tube for conducting the sound from that point to the microphone diaphragm. The disadvantage of this method is that owing to the resonance in the conducting tube the frequency characteristic of the system is not uniform. In order to eliminate the resonance phenomena the tube should be loaded by an impedance equal to its own characteristic impedance. Accordingly a system has been developed in which the microphone is connected to the side of the tube, near one of the ends, and a rubber tube containing wool thread (" infinite " load) is slipped on that end (Fig. 6).

From an examination of an equivalent electrical circuit (Fig. 4) the theory of the system is discussed and methods are indicated for the design work. A probe utilising this principle has been constructed having the following characteristics: (1) The maximum deviation of the frequency characteristic does not exceed $\pm$ 2.5 db for a frequency range of 50 to 6000 c/s; (2) the sensitivity of the probe is of the order 1.5–2.5 mv/bar; and (3) the pressure range is 0.35–1000 bars.

1077. USE OF THERMOCOUPLE AND FLUXMETER FOR MEASUREMENT OF AVERAGE POWER OF IRREGULAR WAVES, *and* THE GRASSOT FLUXMETER AS A QUANTITY METER.—H. K. Dunn. (*Review of Scient. Instr.*, Dec. 1939, Vol. 10, No. 12, pp. 362–367 : pp. 368–370.)

1078. ON THE ABSORPTION OF SOUND IN SOLIDS [Dielectrics : Dependence of Absorption Coefficient on Temperature], *and* ON THE ABSORPTION OF SOUND IN METALS.—A. Akhieser. (*Journ. of Phys.* [of USSR], No. 4, Vol. 1, 1939, pp. 277–287 : pp. 289–298 : in English.)

1079. FORM AND PROPAGATION OF SOUND WAVES IN A SPACE LIMITED BY ABSORBING SURFACES [Formation of *S* Waves].—J. Brillouin. (*Journ. de Phys. et le Radium*, Dec. 1939, Series 7, Vol. 10, No. 12, pp. 497–503.) For a critical summary of a previous paper *see* 685 of February.

1080. SUGGESTION FOR THE DEFINITION OF FOOTSTEP-NOISE INSULATION COEFFICIENT [and Objections to the DIN Definition].—P. Haller. (*Akust. Zeitschr.*, Nov. 1939, Vol. 4, No. 6, pp. 370–372.)

1081. " PICTURE OF REFLECTION " AND ITS APPLICATIONS IN ARCHITECTURAL ACOUSTICS [for determining Effect of Shape of Room on Reverberation, Effect of Disposition & Distribution of Absorbing Materials & Openings, Effect of Directional Characteristics of Sound Source, and the Reverberation in Partly Open Rooms].—G. A. Chigrinsky. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 7, Vol. 23, 1939, pp. 631–635 : in English.)

" The path of a ray repeatedly reflected from the faces of a rectangular parallelepiped may be represented by its unfolded image in two or three projections upon planes parallel to the faces of the parallelepiped. In each of the projections the images of the points of reflection of the ray are disposed at the points of intersection of the direction of this ray with the sides of a ' reflection network,' the meshes of this network being equal to that face of the parallelepiped which is parallel to the plane of the respective projection. . . . The image of the ray plotted on a ' reflection network ' will hereinafter be called the ' picture of reflection.' "

1082. A FIXED-PATH ACOUSTIC INTERFEROMETER FOR THE STUDY OF MATTER [and for Measurements of Acoustic Absorption & Reflection Coefficients].—J. C. Hubbard & I. F. Zartman. (*Review of Scient. Instr.*, Dec. 1939, Vol. 10, No. 12, pp. 382–286.)

1083. METHOD OF MEASUREMENT OF REVERBERATION TIME, USING SEVERAL MICROPHONES [reducing the Usual Irregularity of Decrement Curve and improving the Accuracy of Results].—F. Vecchiacchi & M. Nuovo. (*La Ricerca Scient.*, Nov. 1939, Year 10, No. 11, pp. 1018–1020.)

1084. THE EQUIPMENT OF BROADCASTING STUDIOS [A.V.R.O. and K.R.O. Studios at Hilversum].—S. Gradstein. (*Philips Tech. Review*, May 1939, Vol. 4, No. 5, pp. 136–144.)

1085. MODERN BROADCAST REPEATER EQUIPMENTS [with Equalisation, Switching, & Remote-Control Circuits].—R. A. Meers & F. G. Filby. (*Elec. Communication*, Oct. 1939, Vol. 18, No. 2, pp. 168–180.)

1086. THE CALCULATION OF ARTICULATION FOR EFFECTIVE RATING OF TELEPHONE CIRCUITS.—L. C. Pocock. (*Elec. Communication*, Oct. 1939, Vol. 18, No. 2, pp. 120–132.)

1087. ONE METHOD OF EQUALISING THE ATTENUATION IN LONG-DISTANCE TELEPHONE CIRCUITS [Calculation of the Constant-Resistance Ladder-Type Equaliser].—S. Iida & F. Akiyama. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, p. 123 : summary only.)

1088. TRANSMISSION CHARACTERISTICS OF 4800-KILOMETRE CIRCUIT [" Intra-Connected "] USING NON-LOADED CABLE.—N. Shinohara & Y. Hirayama. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 107–110.)

1089. REPORT ON PROGRESS IN SOUND.—E. G. Richardson. (*Reports on Progress in Physics*, Physical Society, Vol. 5, pub. 1939, pp. 121–149.) Free propagation, supersonics : vibrating systems, solids & fluids : acoustic impedance : speech & hearing : technology.

1090. THE PROPAGATION OF SHOCK WAVES IN AIR : I & II.—L. Thompson & N. Riffolt : L. Thompson. (*Journ. Acoust. Soc. Am.*, Oct. 1939, Vol. 11, No. 2, pp. 233–244 : pp. 245–253.)

1091. Propagation of Waves in a Liquid possessing "Maxwell Viscosity."—M. A. Issakovich. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 8, Vol. 23, 1939, pp. 783–787: in English.)

1092. Sound Radiation Pressure in Liquids.—G. Hertz & H. Mende. (*Zeitschr. f. Physik*, No. 5/6, Vol. 114, 1939, pp. 354–367.)

Experiments on sound radiation pressure effects occurring at the passage of a supersonic beam through the boundary between two liquids. Forces arise in such a way as to cause motion in the direction towards the liquid of greater acoustic velocity. Simple theory of sound radiation pressure in elastic fluids obeying Hooke's Law. "True sound radiation pressure does not exist in elastic fluids. The forces causing the phenomena regarded as effects of sound radiation pressure exist solely on the boundary between the supersonic beam and the quiescent fluid." Explanation of origin of these forces. Distinction between two types of definition of sound radiation pressure, Rayleigh's and Langevin's.

1093. On the "Voice of the Sea" [Theoretical Investigation of Shoulejkin's Infrasonic Vibrations (around 10 c/s) from Surface of Sea].—N. N. Andreev. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 7, Vol. 23, 1939, pp. 625–628: in English.)

1094. Infrasonic and Ultrasonic Waves.—M. Adam. (*Génie Civil*, 16th Dec. 1939, Vol. 115, No. 25, pp. 433–435.)

1095. A Method for the Determination of the Reflecting Power of Ground Surfaces [Concrete, Wet & Dry Sand Layers, Gravel, etc: in connection with Aircraft Acoustic Altimeters].—W. Ernsthausen & W. von Wittern. (*Akust. Zeitschr.*, Nov. 1939, Vol. 4, No. 6, pp. 353–359.)

Authors' summary:—A reflection-measuring method was developed having direct indication and small errors for a frequency range of 500–10 000 c/s. The measurements carried out with it gave a high reflecting power for normal ground surfaces (meadows, well consolidated earth). Snow and sand layers of only a few centimetres' thickness produced, on the other hand, a serious falling off of the reflected sound pressure as the frequency was increased.

The marked fluctuations in the curves of reflection factor as a function of frequency are due to interference phenomena. They are without serious importance for echo-sounding, since in a series of soundings there would always be included sufficiently strong secondary pulses.

1096. Supersonic Dispersion in Vapours.—W. Railston. (*Journ. Acoust. Soc. Am.*, July 1939, Vol. 11, No. 1, Part 1, pp. 107–112.)

1097. Sound Velocity and Inter-Molecular Forces [Velocity in Liquid varies Inversely as Ninth Power of Inter-Molecular Distance: etc.].—M. R. Rao. (*Current Science*, Bangalore, Nov. 1939, Vol. 8, No. 11, pp. 510–511.)

1098. "Supersonics: the Science of Inaudible Sounds" [1937 Lectures: Book Review].—R. W. Wood. (*Journ. Acoust. Soc. Am.*, Oct. 1939, Vol. 11, No. 2, p. 256.)

PHOTOTELEGRAPHY AND TELEVISION

1099. On the Practical Construction of Cathode-Ray Storage-Type Projecting Tubes [for Television or Oscillography].—M. von Ardenne. (*T.F.T.*, Nov. 1939, Vol. 28, No. 11, pp. 403–407.)

Following on the papers dealt with in 3633 of 1939 & back reference, the present paper describes practical experiments with sealed-off tubes with zinc-blende-crystal "relay screens," and various optical arrangements for obtaining projected images from them. The experimental tube of Fig. 1 was used in the arrangement of Fig. 2 to investigate the effect of stray fields in the crystal in enlarging the apparent spot size: to make this effect more evident the crystal was originally made 1 mm thick. The observed enlargement agreed with that predicted from consideration of the theoretical representation in Fig. 4. In the first models the conductivity conditions in the relay-screen unit were such as to allow polarising charges to form at the auxiliary-layer/crystal surface (the auxiliary layer was a glass film, on the side of the crystal exposed to the electrons, to provide a surface of low secondary emission): the time required for the dispersal of these charges (and also of the storage charges) was about $\frac{1}{2}$ to $\frac{1}{3}$ second. The electrical conditions which must be fulfilled in order that these polarisation charges may be prevented can be derived from consideration of Fig. 5: one method is to make the auxiliary layer of a conducting material, such as special "Schott" glass, in a very thin film, with the result that leakage through the layer occurs in a fraction of a second without, however, a sideways dispersal of the useful charge taking place. By this or other methods the effects of polarisation charges were completely avoided in subsequent tubes; with ray currents around 10^{-3} A full brightness was obtained at a recording speed of 1 km/sec.

Fig. 6 gives the various optical arrangements examined, those on the left having the cathode ray incident obliquely on the crystal screen, while those on the right have their scanning normal to the surface. Arrangement "A," the simplest, is the only one in which the screen is simply transparent; all the others make use of the reflector principle to give the advantage of a double-length path through the crystal. About the most promising arrangement is "C," in which the reflector is a fine "ladder" grating (having a shallow saw-tooth section) which with oblique scanning projects the light beam normally to the screen surface. In the normal-scanning arrangements on the right, the electron-optical and optical systems are on opposite sides of the crystal screen, with the principal axes of both systems perpendicular to the latter, so that precautions in the deflecting circuits for the avoidance of distortion are superfluous. The reflecting layers in these arrangements must consist of isolated mosaic elements or prisms, as in Fig. 7; the rest of the paper deals with this point.

1100. STEREOSCOPIC TELEVISION RECEPTION WITH THE VON ARDENNE LARGE-SURFACE LIGHT RELAY.—H. Gröttrup: von Ardenne. (*T.F.T.*, Nov. 1939, Vol. 28, No. 11, pp. 407–409.)

Von Ardenne has already shown (1976 of 1939) that the halving of the number of picture elements in each of the two images necessary for stereoscopic television is more than compensated, for nearly all types of subject, by the subjective improvement in quality. He has also described how his zinc-blende or similar "crystal-cell" light relay can be used for plane-of-polarisation modulation (4031 of 1939). The present writer discusses the application of this to stereoscopic television in which both images are projected onto the same single screen (thus avoiding the defects of the side-by-side system) but with planes of polarisation at right angles, so that an observer wearing polarised spectacles obtains the stereoscopic effect (Fig. 3) without having to worry about the position of his head (von Ardenne, 232 of 1937).

1101. THE IMPLOSION OF CATHODE-RAY TUBES [Results of Tests show that Adequate Protection demands Protective Cover of "Armour-Plate" Glass at least ¼ Inch Thick].—C. N. Smyth. (*Elec. Communication*, Oct. 1939, Vol. 18, No. 2, pp. 133–134.)

From the Kolster-Brandes laboratories. "Ordinary plate glass, as well as celluloid and other transparent synthetic materials (partly due to electrostatic effects), proved to be quite unsuitable."

1102. TELEVISION OPTICS.—W. D. Wright. (*Reports on Progress in Physics*, Physical Society, Vol. 5, pub. 1939, pp. 201–209.)

1103. BAND SPECTRA OF CATHODO-LUMINESCENCE [of Sulphide Phosphors: Shape, Position, & Fixity of Emission Bands: Effect of Various Activator Metals: Series of Solid Solutions of CdS in ZnS: Comparisons between Ultra-Violet and Electron Excitation: Origin of Emission Bands].—S. T. Henderson. (*Proc. Roy. Soc.*, Series A, 18th Dec. 1939, Vol. 173, No. 954, pp. 323–338.)

1104. CHARGING AND DECREASE OF CHARGING OF LUMINISCENT MATERIALS AND SEMICONDUCTORS IRRADIATED BY ELECTRONS.—E. Krautz. (*Zeitschr. f. Physik.*, No. 7/8, Vol. 114, 1939, pp. 459–469.)

The luminescent materials investigated are compounds of Ti and Zn; their charging under irradiation by electrons is measured for anode voltages up to 20 kV. It is found that, if these materials are simultaneously subjected to additional irradiation by slow electrons, too strong charging of the luminescent screen can be avoided and a marked increase in light density thus attained. Illustrative photographs and curves are given.

1105. CORRECTION OF AFTER-GLOW IN CATHODE-RAY SCANNING [Fluorescent-Screen Scanning for Television Transmission].—J. J. Müller. (*Hochf:tech. u. Elek:akus.*, Oct. 1939, Vol. 54, No. 4, pp. 111–115.)

The various methods of after-glow correction are first investigated theoretically; the after-glow curve is regarded as a sum of n exponential functions. The case of $n = 1$, *i.e.* a purely exponential after-glow, is discussed in § I (Fig. 1, exponential curve of brightness distribution along the tail of the scanning spot). The current from the transmitting photocell at any moment is calculated; Fig. 2 gives an equivalent electrical circuit for the after-glow, which is found to be equivalent to distortion at an RC circuit in parallel (*see* also Bedford & Puckle, 1934 Abstracts, p. 506). § II discusses the correction of an after-glow which is the sum of n exponential functions; the photocurrent is given by eqn. 4, in which the integrands may be expanded into Fourier series, and the integrals and thence the correcting factors determined. Finite width of the scanning spot (Fig. 3) gives rise to further distortion; it is found that the spot should have special forms and that the quality of the image can be much improved by decreasing the size of the spot. The theory is translated into electrical correcting terms and further distortion terms. A circuit designed to give the appropriate after-glow correction is shown in Fig. 4, which consists of an appropriate combination of resistances and capacities. The limits of the possibility of correction are described in § IV, which discusses theoretically (a) the shot effect limit, for which eqn. 9 gives a limit for the maximum time constant which can be corrected, and (b) a comparison of the correction method here given with the so-called modulation method (Schröter, 4034 of 1939). It is found that the latter needs a much greater light flux.

1106. THE ADSORPTION OF NON-POLAR GASES ON ALKALI HALIDE CRYSTALS [Experimental Results: Comparison with Theoretical Calculations: Maximum in Curve of Heat of Adsorption as Function of Amount Adsorbed marks Completion of First Monolayer, etc.].—W. J. C. Orr. (*Proc. Roy. Soc.*, Series A, 18th Dec. 1939, Vol. 173, No. 954, pp. 349–367.)

1107. REFLECTION AND TRANSMISSION FACTORS OF THIN METAL FILMS [Survey].—P. Rouard. (*Zeitschr. f. Instrumentenkunde*, May 1939, Vol. 59, No. 5, p. 221: summary only.)

1108. EXPLANATION OF THE ANOMALIES OF THE OPTICAL CONSTANTS OF THIN METALLIC FILMS.—David. (*See* 930.)

1109. CONFERENCE ON SECONDARY-ELECTRON EMISSION AND PHOTOEFFECT.—I. Mazover. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 9, 1939, pp. 748–750.)

1110. ABNORMAL PHENOMENA IN PHOTOCELLS DUE TO SUPERPOSED ULTRA-HIGH-FREQUENCY VOLTAGES [Greatly Increased Sensitivity, explained by Secondary-Electron Multiplication].—T. Seki, T. Nijoh, & K. Matsudaira. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, p. 123: summary only.) It is suggested, as a consequence of this experimental result, that ordinary commercial photocells can be made in this way to act as highly sensitive secondary-electron cells. A 5 m wavelength was used.

1111. CHARACTERISTICS OF PHOTOELECTRIC CELLS WITH THREE ELECTRODES.—T. Franzini. (*La Ricerca Scient.*, Nov. 1939, Year 10, No. 11, pp. 1025–1030: *Nuovo Cimento*, Aug./Sept./Oct. 1939, Vol. 16, No. 8, pp. 399–409.)

Author's summary:—" The research is devoted to the study of the photoelectric behaviour of sodium, potassium, rubidium, and caesium, both in the massive state and in thin films deposited by vaporisation on layers of different metals. It was also desired to determine the influence of gaseous residues left in the cell (particularly H & He) and the effect of the space charge, in a rarefied atmosphere of these gases, on the photoelectric condition. The study of the photocurrent in the cell was carried out with a suitable d.c. amplifier, with particular regard to the influence, on the photocurrent, of a control electrode (grid) interposed between the emitting surface and the collector electrode at a suitable positive potential," the grid being varied in potential from about -20 to $+20$ volts.

The experimental cell is shown in Fig. 1. The photosensitive surface is carried on a semi-cylinder of metal which can be shifted along the tube by an external magnet: in one case the collector electrode and grid were made out of an indirectly heated cathode from a valve. The curves were plotted with the cell under constant illumination: Fig. 3 shows the different curves given by light of varying spectral composition, Fig. 4 a family of curves for various collector voltages from 30 to 150. A typical value for the amplification coefficient was 9, for the internal resistance 1.5×10^7 ohms. The whole behaviour of the cell is changed if traces of photo-sensitive material are allowed to form on the grid and collector surfaces (Fig. 6, where the grid voltage is varied over a much wider range): no negative value of grid voltage will bring the collector current down to zero, the slope of the characteristic is greatly reduced (particularly at high values of collector potential) and when the grid potential exceeds that of the collector the collector current drops precipitously and changes its sign; at such a point the slope reaches a negative value of 10 μA/volt (v_g) compared with around 0.6 μA/volt in the previous cases.

1112. PHOTOCELLS WITH ANTIMONY-CAESIUM PHOTOCATHODES.—N. S. Zaitsev. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 9, 1939, pp. 661–672.)

The properties of photocells with antimony-caesium cathodes (*cf.* Zhukov, 714 of February) are discussed in detail and a number of experimental curves are shown. This is followed by a report on an experimental investigation on the effect of various factors, such as the temperature at which the cathode was prepared, the thickness of the antimony layer, and the quantity of caesium used, on the integral sensitivity of the cell. The following new types of photocell using antimony-caesium cathodes are also described: (a) cells with a large number of leads connected to different points of the cathode (to facilitate replacement of electrons liberated from the cathode); (b) cells with cathodes prepared on a silver base; and (c) cells of very small overall dimensions (4–5 mm diameter).

1113. THE LIMITING SENSITIVITY OF THE ALTERNATING-CURRENT METHOD OF PHOTOCELL-CURRENT AMPLIFICATION [Theoretical & Experimental Treatment: Electrometer-Valve/Caesium-Antimony-Cell Combination can detect 4.5×10^{-15} Watt in 30 Seconds: Data on Various Valves (" Factor of Merit ") and Photocells (Dark Current & Granular Noise): etc.].—E. A. Johnson, W. H. Mock, & R. E. Hopkins. (*Journ. Opt. Soc. Am.*, Dec. 1939, Vol. 29, No. 12, pp. 506–511.)

1114. TIME-LAG PHENOMENA IN GAS-FILLED PHOTOELECTRIC CELLS [Increases with Amplification Factor: for Values below 10, Lag is Insignificant up to 10 kc/s: Extra Lag found at 1–5 kc/s due to Metastable Atoms: etc.].—A. A. Kruithof. (*Philips Tech. Review*, Feb. 1939, Vol. 4, No. 2, pp. 48–55.)

1115. INVESTIGATIONS OF THE SELENIUM PHOTOELEMENT: IV—BEHAVIOUR AT LOW TEMPERATURES.—A. Becker. (*Zeitschr. f. Physik*, No. 5/6, Vol. 114, 1939, pp. 342–353.)

Continuation of the work dealt with in 4065 of 1939. The remarkable effect of temperature previously found (*see* also Goos, 4588 of 1939) is investigated more closely. Certain general properties are found, which are independent of the peculiarities of the particular specimen used; these appear to be characteristic of the behaviour of the selenium photoelement and of importance in understanding its theory.

1116. PHOTOVOLTAGE AT THE ELEMENT METAL/SEMICONDUCTOR/METAL: VI—THE NORMAL PHOTOVOLTAGE OF THE INTERNAL PHOTOELECTRIC EFFECT [Connection with Thermovoltage].—G. Mönch. (*Ann. der Physik*, Series 5, No. 6, Vol. 36, 1939, pp. 557–566.)

Photoelectric observations on cuprite, the natural cuprous oxide, and pure cuprous-oxide crystals produced in the laboratory, gave (§ 1) some contradictory results; to explain these, observations (Tables 1, 2) of the sign of the photo- and thermovoltages were made on various substances. Two classes were distinguished: (1) those in which the sign of the photovoltage is the same as that of the thermovoltage; in these the internal photoelectric phenomena have already been successfully investigated and their photoeffect is termed the " normal photovoltage of the internal photoelectric effect "; (2) those which show more complicated phenomena. Class 1 comprises the pure, insulating crystals, class 2 mineral crystals. A further comparison of photoelectric and thermal effects is given in § 3; a relation for the photovoltage is found in § 4; new questions on the connection between photo- and thermovoltage are tabulated in § 5.

1117. THE INERTIA OF THE KERR EFFECT [New Method of Measurement: Deduction of Relaxation Time of Dipole-Free Molecules].—W. Hanle & O. Maercks. (*Zeitschr. f. Physik*, No. 7/8, Vol. 114, 1939, pp. 407–417.) For previous papers *see* 1605 of 1939.

1118. INVESTIGATIONS ON THE QUESTION OF INERTIA OF THE FARADAY EFFECT [New Method of Inertia Measurement: Measurements on Nitrobenzol & Other Substances: No Appreciable Inertia found: Agreement with Theory].—W. Hanle. (*Zeitschr. f. Physik*, No. 7/8, Vol. 114, 1939, pp. 418–426.)

1119. SECONDARY-EMISSION VALVES AS AMPLIFIERS [particularly in Television].—Saic. (*See* 1026.)

1120. [Ultra-] SHORT-WAVE WIDE-BAND AMPLIFICATION.—M. J. O. Strutt & A. van der Ziel. (*E.N.T.*, Sept. 1939, Vol. 16, No. 9, pp. 229–240.)

The selectivity requirements for the frequency characteristics of a picture and sound receiver are described in § 1 on the basis of the television transmitters in Berlin, Paris, London, and New York, whose frequency schemes are shown in Fig. 1. The case is discussed in which the picture carrier with one side-band is amplified in one stage (picture h.f. stage) and the sound in a separate stage. Cascade amplification is used for the picture carrier and its modulation; the total amplification from the input of the first stage to the rectifier must be of the order of 10^4, modern cathode-ray tubes being used for the television picture. The scheme of such a television circuit, with amplification in three stages is shown in Fig. 2; simple oscillating circuits are used as the coupling elements. The total impedance in the tuned position of a circuit at the input of the apparatus is calculated (eqn. 2); eqn. 3 gives the impedance for a circuit between two valves. The position of the resonance frequency and the question of the band width to be employed are discussed. The amplitude of the audio-frequency carrier reaching the input of the first h.f. valve should be very small; this can be achieved by using a suitable rejector circuit in the input stage of the amplifier (Fig. 5).

A quantitative treatment of cascade amplification with equal and with detuned circuits is given in § 2; it is found that in the first case sufficient selectivity can only be attained by using a circuit such as that shown in Fig. 5. For the second case, examples and calculated frequency and other curves are given which show that the requirements can be satisfied. § 3 deals with amplification regulation and distortions; regulation of the valve working conditions (steepness, attenuation) is found to be of more importance than the use of a potentiometer. The consequent variation of input capacity and resistance is discussed, with practical curves; methods of counteracting this variation are given (Fig. 14). Modulation distortion, cross modulation, and the disturbances in television reception due to these distortion effects are also considered. Noise due to irregular thermal movements of the electrons in the resistances, impedances, and valves is analysed in § 4; the smallest input signals of a television receiver, for disturbance-free reception, are deduced. Fig. 15a, b shows photographs of the experimental wide-band amplifier designed on the principles described in the paper.

1121. THE NIPKOW DISC [Technical Details of Construction and Mounting of Modern Disc].—H. Rinia & L. Leblans. (*Philips Tech. Review*, Feb. 1939, Vol. 4, No. 2, pp. 42–47.) Used in the film-television equipment dealt with in 1597 of 1939.

1122. FRENCH TELEVISION SHOULD ENTER THE PRACTICAL DOMAIN.—S. Mallein. (*Ann. des Postes, T. et T.*, Aug. & Sept. 1939, Vol. 28, Nos. 8 & 9, pp. 587–617 & 675–709.)

The LMT installation at the Paris studio and Eiffel Tower, for comparative tests on Thomson-Houston, Comp. franç. de Television, Soc. Radio-Industrie, & Soc. d'Applications téléphoniques (Grammont) systems: descriptions of these four systems: the tests, leading to the French standardisations of July 1938: discussion of the reasons for the adoption of these various standards: receiving installations, and errors to be avoided: the 1938 Paris Exhibition: medium and large-screen television: the future of television, and the example set by the English service.

1123. TELEVISION RECEIVERS [for London and Paris Transmissions: Previous Design simplified for Mass Production by Use of Secondary-Emission Valves (Slope 13 mA/Volt), "Relay" Valves (Gas-Filled Triodes) in Saw-Toothed Generators, etc.].—G. Heller. (*Philips Tech. Review*, Dec. 1939, Vol. 4, No. 12, pp. 342–350.) For the previous design *see* 3398 of 1937.

1124. THE CIRCUIT OF THE "UNIT" TELEVISION RECEIVER [including a Frequency-Testing Equipment for Mass-Produced Receivers].—A. Köpping. (*Funktech. Monatshefte*, Nov./Dec. 1939, No. 11/12, Supp. pp. 73–77.) Continued from 703 of February.

MEASUREMENTS AND STANDARDS

1125. THE DIELECTRIC CONSTANTS OF AMMONIA, NITROGEN, AND CARBON DIOXIDE AT ULTRA-HIGH FREQUENCY [56 Mc/s: Use of Heterodyne Beat Method: Techniques Customarily Used at Lower Frequencies are Applicable also at Ultra-High Frequencies: Results].—G. W. Fox & A. H. Ryan. (*Phys. Review*, 1st Dec. 1939, Series 2, Vol. 56, No. 11, pp. 1132–1136.)

1126. A NEW METHOD OF CALCULATING THE ABSORPTION WITH THE DRUDE-COOLIDGE MEASURING ARRANGEMENT.—H. Slätis. (*Ann. der Physik*, Series 5, No. 5, Vol. 36, 1939, pp. 397–412.)

"A method is [theoretically] developed, in which the absorption coefficient of the condenser dielectric can be calculated from the ratio of the maximum galvanometer deflections without and with the condenser in the Lecher system. No measurements need be made except those which are required for calculation of the capacity, so that it is not necessary to determine the resonance curve provided that the decrements of the apparatus have been determined once for all.

"The new theory is free from the restricting hypothesis of the old 'method of resonance-curve determination' which assumes the constancy of the so-called Bjerknes intensity factor in the region of the resonance curve. My method requires only the maximum deflections and also takes into account the variation of the intensity factor. Corresponding to the different hypotheses, the two methods give results in agreement only when the experimental arrangement is correct. This gives a valuable test for the validity of the arrangements. The methods are tested on propyl alcohol, among other materials" [wavelengths below 1 m].

1127. MEASUREMENTS OF THE PROPAGATION VELOCITY OF ELECTROMAGNETIC WAVES ALONG A TWO-WIRE CIRCUIT [Lecher Pair] IN AN INHOMOGENEOUS MEDIUM [with Reference to Drude's First Method for Investigation of Liquid Dielectrics: the Effect of Depth below Surface].—N. M. Malov. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 7, Vol. 23, 1939, pp. 629–630: in German.)

At wire-pair depths of 30 mm and over, for wavelengths (in air) around 65 cm, the wavelength in the liquid (water) was independent of the depth (Fig. 1, lower curve). At smaller depths the wavelengths increased as the depth was decreased, the measured points for a 24 mm depth falling outside the curve. This increase, as the depth is decreased still further, is shown in curve I of Fig. 2. The upper curve of Fig. 1 shows how, at small depths, the later maxima may exceed the earlier ones: this is never observed at the greater depths.

Changes in the wire diameter and in the dimensions of the sliding bridge produced no appreciable effect. A much more conductive liquid (salt solution) gave a smaller increase of velocity, the maximum ratio of wavelengths being only 1.28 compared with 1.40 for water. A smaller increase was also given when one wire lay vertically above the other instead of in the same horizontal plane (curve II of Fig. 2). "Since the calculation of the velocity in all these cases is very difficult, these preliminary data may be of importance—for example in electromagnetic methods of measuring distances."

1128. CONDUCTANCE MEASUREMENT USING RECTIFICATION.—L. Rohde & G. Opitz. (*Hochf:tech. u. Elek:akus.*, Oct. 1939, Vol. 54, No. 4, pp. 116–121.)

This resonance method of measuring complex conductance has, it is claimed, the advantage that it can be used for all frequencies for which there is no objection to diode rectification. The method has already been described in a previous paper (245 of 1938). In the present paper a description is first given (§ 2) of the principles underlying resistance transformation by the use of diodes in systems which can oscillate (Fig. 1, diode rectifier and equivalent circuit; Fig. 3, connection between h.f. resistance equivalent to resonance system and rectifier steepness for sinusoidal voltage). The fundamentals of the circuit for conductance measurement using difference substitution are shown in Fig. 5; Fig. 6a gives the real working resistance of the rectifier, Fig. 6b an equivalent circuit for resistances in parallel. The conductance meters for the frequency ranges 0.1 to 10 Mc/s and 10 to 100 Mc/s, based on this principle, are shown in Figs. 7a, b; numerical data are given for their sensitivity and constancy. Measured results are shown in the form of curves of grid input impedance, input capacities, etc. (Figs. 8–14). The principle may be applied above 100 Mc/s by the circuit of Fig. 15, which uses a telescopic-tube system in place of a variable condenser.

1129. BEAT NOTES IN HIGH-FREQUENCY CALIBRATION [Difficulties in the Lissajous Figure Method for Frequencies above 1 Mc/s: the Zero-Beat Method for 1–50 Mc/s].—F. R. Stansel. (*Bell Lab. Record*, Dec. 1939, Vol. 18, No. 4, pp. 116–118.)

1130. RADIO-FREQUENCY HIGH-VOLTAGE PHENOMENA [High Voltage Measurements by the Half-Wave Coupled-Transmission-Line-Section Method, with Inductively Coupled "Shortometer" for measuring Current in the Short Circuit: Phenomena at 60 000 V, 13 Mc/s: Breakdown Tests (and Correlation with 60 c/s Corona): Variable-Air-Condenser Voltage Ratings: Insulator Tests: etc.].—A. Alford & S. Pickles. (*Elec. Communication*, Oct. 1939, Vol. 18, No. 2, pp. 135–149.)

1131. MEASUREMENTS OF ATTENUATION IN CABLES FOR VERY HIGH FREQUENCIES [Usual "Resonance Frequency" Method requires Very Long Lengths for Lower Frequencies: Method applicable to 10-Metre Lengths: Some Results on Frequencies 340 kc/s–5.1 Mc/s].—G. Zin. (*La Ricerca Scient.*, July/Aug. 1939, Year 10, No. 7/8, pp. 742–744.)

1132. AN ALL-WAVE FREQUENCY METER [Combination of "Coarse" Meter (& Signal Generator) 50 c/s–50 Mc/s, "Fine" Meter 2.5–3.75 Mc/s, & Crystal Stage 100 kc/s ± 3 c/s].—A. Habermann. (*E.T.Z.*, 26th Oct. 1939, Vol. 60, No. 43, p. 1237: summary only.)

If f_x, as measured on the "coarse" meter (range covered in 7 steps) within 0.8%, comes in the "fine" range, it is measured directly with an accuracy of 5×10^{-5}. If it comes outside the range, a harmonic of the "fine" meter is superposed on the "coarse" meter oscillation, or *vice versa*; the order of harmonic is determined by the rough frequency ratio, and the accurate frequency is derived from the "fine" meter reading. The exact procedure is described. The mixing of the "coarse," "fine," and unknown frequencies, and the frequency of the standard oscillator stage (for checking purposes), is accomplished by two mixing hexodes in series: a good mixing amplification is obtained, so that only one l.f. stage is necessary. The "fine" meter depends entirely on ceramic insulation. The equipment is mains-driven.

1133. FREQUENCY VARIATIONS IN A SELF-OSCILLATOR DUE TO SPACE-CHARGE, *and* DEVIATION OF THE FREQUENCY OF A VALVE OSCILLATOR FROM THE NATURAL FREQUENCY OF THE LINEAR CIRCUIT.—Sakamoto: Shembel. (*See* 975 & 976.)

1134. SYMMETRICAL EXTENSIONAL VIBRATION AND SYMMETRICAL TORSIONAL VIBRATION OF THE FREE CIRCULAR PLATE [with Possible Application to Tourmalin Piezo-Oscillators].—T. Hayasaka. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 118–119: summary only.)

1135. THE NATURE OF THE ANOMALIES OF SOME PROPERTIES OF ROCHELLE SALT AND ITS RELATION TO THE POLYMORPHISM.—Schulwas-Sorokina. (*See* 1042.)

1136. METHOD OF MEASURING THE PHASE DIFFERENCE BETWEEN TWO FREQUENCIES IN SIMPLE NUMERICAL RATIO, PARTICULARLY FOR DISTANCE DETERMINATION BY THE INTERFERENCE METHOD.—Lyubchenko. (*See* 954.)

1137. THE MEASUREMENT OF THE SELECTIVITY OF BROADCAST RECEIVERS.—Moebes. (*See* 997.)

1138. THE SCIENCE OF BALANCING AN IMPEDANCE BRIDGE [Analysis of Balancing, based on Locus Diagrams: Measure of Rapidity of Attaining Balance: Shifting Balances, Trivial Balances, Choice and Initial Setting of Adjustments, etc.].—G. B. Hoadley. (*Journ. Franklin Inst.*, Dec. 1939, Vol. 228, No. 6, pp. 733–754.)

1139. A DUO-TRIODE BRIDGE VOLTMETER [Advantages of the Bridge Type of Valve Voltmeter with Two Triodes retained, with Gain in Simplicity & Compactness].—R. E. Vollrath. (*Review of Scient. Instr.*, Dec. 1939, Vol. 10, No. 12, pp. 361–362.)

1140. PROBE VALVE VOLTMETER [with Rectifying Valve built into Electric-Torch Case at end of Multiple Flexible Lead: Constructional Details].—H. Andrewes & F. A. Lowe. (*Wireless World*, Jan. 1940, Vol. 46, No. 3, pp. 83–86.)

1141. CAPACITY MEASUREMENT WITH THE STRING ELECTROMETER: II [Theory].—J. Tagger. (*Physik. Zeitschr.*, 15th Nov. 1939, Vol. 40, No. 22, p. 695.) For I *see* 3691 of 1939.

1142. THE LIMITING SENSITIVITY OF THE ALTERNATING-CURRENT METHOD OF PHOTOCELL-CURRENT AMPLIFICATION.—Johnson & others. (*See* 1113.)

1143. USE OF THERMOCOUPLE AND FLUXMETER FOR MEASUREMENT OF AVERAGE POWER OF IRREGULAR WAVES, *and* THE GRASSOT FLUXMETER AS A QUANTITY METER.—H. K. Dunn. (*Review of Scient. Instr.*, Dec. 1939, Vol. 10, No. 12, pp. 362–367: pp. 368–370.)

1144. AN AMPLIFIER-WATTMETER COMBINATION FOR THE ACCURATE MEASUREMENT OF WATTS AND VARS [and of Current in Complex or Polar Form: primarily in connection with the MIT Network Analyser].—G. S. Brown & E. F. Cahoon. (*Elec. Engineering*, Nov. 1939, Vol. 58, No. 11, Transactions pp. 593–598.)

1145. A NEW METHOD OF DETERMINING PER CENT. HARMONICS [by Use of Voltmeter & Ammeter, for Waves containing Not More than Three Components].—W. T. Thomson. (*Elec. Engineering*, Nov. 1939, Vol. 58, No. 11, p. 488.)

1146. ON THE QUESTION OF THE WAVE-FORM ERROR OF RECTIFIER METERS.—W. Pfannenmüller. (*E.T.Z.*, 28th Sept. 1939, Vol. 60, No. 39, pp. 1125–1129.)

Author's summary:—The effective value and the absolute mean value given by linear rectification are compared. It is pointed out that the generally employed effective-value calibration is justified even with rectifier meters, although the instruments may thus appear dependent on wave form. The advantages and disadvantages of the two main types of rectification, represented by the ideal linear and the ideal square-law rectification, are mentioned. The comparison shows why the non-quadratic type is frequently preferred even if it is dependent on wave form. Methods of reducing the wave-form error or correcting for it are mentioned and discussed. The limited practical values of the wave-form errors calculated for certain definite wave forms are pointed out, and some generally applicable approximate formulae for small harmonic amplitudes are discussed. A too favourable judgment of rectifier instruments is deprecated, and an adverse opinion given of the use of bias for increasing the over-all accuracy. It is recommended whenever possible to use a biased dynamometer rather than a biased rectifier instrument.

1147. A VECTOR-TYPE IMPEDANCE ANALYSER [1 Ohm to 1 Megohm, 30 to 16 000 c/s, 0.01 to 50 Volts: for obtaining Transmission-Line, Amplifier, Transformer, & Scanning-Coil Characteristics, Power Factors of Dielectrics, etc.].—S. Godet & H. R. Meahl. (*Gen. Elec. Review*, Dec. 1939, Vol. 42, No. 12, pp. 548–551.)

1148. A NEW TYPE OF COIL TESTER [Short-Circuited Turns or Insulation Faults in H.T. Coils detected by introducing End of Long Core of H.F. Iron with Magnetising Winding (supplied by Oscillator) & Two Opposed Secondary Windings supplying Indicator].—T. M. Dickinson. (*E.T.Z.*, 26th Oct. 1939, Vol. 60, No. 43, pp. 1236–1237: summary only.) *Cf.* Brailsford, *Met.-Vick. Gazette*, Feb. 1940, pp. 334–336.

1149. A NEW METHOD FOR THE MEASUREMENT OF DISCHARGES ON PORCELAIN INSULATORS [using the "Balanced Discharge Bridge"].—A. N. Arman. (*BEAMA Journ.*, Dec. 1939, Vol. 45, No. 30, pp. 123–125.) *See* Arman & Starr, 3522 of 1936, for this bridge.

1150. COMPARING RESISTANCES OF FOUR-TERMINAL RESISTORS.—D. C. Gall. (*Nature*, 9th Dec. 1939, Vol. 144, p. 982.) Remarks on letters referred to in 270 of January and 749 of February.

1151. ELECTRICAL SHORT-TIME METERS OF HIGH PRECISION [for testing Relays, Electricity Meters, etc: Advantages of the Small Synchronous Motor over Ordinary Stop-Watches, Chronometers, etc: a Special Valve-Driven Tuning-Fork Circuit for providing the Necessary Synchronised Frequency when Time-Controlled Mains are Not Available].—E. Tritschler. (*E.T.Z.*, 28th Sept. 1939, Vol. 60, No. 39, pp. 1133–1134.)

1152. A NEW RADIATION PYROMETER [using Narrow Band of Infra-Red Wavelengths around 8.8μ (Residual-Ray Band of Quartz): primarily for Temperatures -100 to $+100°$C].—J. Strong. (*Journ. Opt. Soc. Am.*, Dec. 1939, Vol. 29, No. 12, pp. 520–530.) Other residual-ray bands may be used for certain investigations: *e.g.* that of apophyllite for ozone temperatures.

1153. POTENTIOMETER CIRCUIT FOR PORTABLE OPTICAL PYROMETER [Elimination of Several Elements from Conventional Potentiometer gives Increased Portability & Simplicity in Operation for Measurement of Small Currents (*e.g.* Pyrometer Filament Current)].—R. C. Machler. (*Review of Scient. Instr.*, Dec. 1939, Vol. 10, No. 12, pp. 386–388.)

1154. AN OPTICAL PYROMETER FOR GENERAL USE [Employment of Two Diaphragms instead of One permits Use of Much Larger Aperture].—J. G. Hagedoorn. (*Physica*, Dec. 1939, Vol. 6, No. 10, pp. 1126–1128: in English.)

1155. ABSOLUTE ELECTRICAL MEASUREMENTS.—L. Hartshorn. (*Reports on Progress in Physics*, Physical Society, Vol. 5, pub. 1939, pp. 302–333.)

1156. THE NATURAL UNIT OF RESISTANCE AND THE ABSOLUTE DEFINITION OF THE OHM.—Laboccetta. (*La Ricerca Scient.*, Nov. 1939, Year 10, No. 11, pp. 1043–1044.)

1157. THE NATIONAL STANDARDS OF MEASUREMENT.—L. J. Briggs. (*Reviews of Mod. Physics*, April 1939, Vol. 11, No. 2, pp. 111–120.)

1158. A SUBSTITUTE FOR "SUSCEPTANCE."—A. A. Nims. (*Elec. Engineering*, Oct. 1939, Vol. 58, No. 10, pp. 440–441.) Long letter prompted by the "Proposed American Standard Definitions of Electrical Terms."

SUBSIDIARY APPARATUS AND MATERIALS

1159. OBSERVATIONS AND INVESTIGATIONS ON CRYSTAL DETECTORS [for Frequencies 10^1–10^{11} c/s, Output Currents up to 5 mA].—Klumb. (*See* 978.)

1160. A PIEZO-QUARTZ OSCILLOGRAPH.—Kazanski. (*Journ. Techn. Phys.* [in Russian], No. 8, Vol. 9, 1939, pp. 673–679.)

Developed in Russia for recording voltages of the order of 12 to 15 kv. The current consumption at 10 kv eff. and a frequency of 50 c/s is 71.2 μA only. The sensitivity expressed in volts/mm at a working voltage of 12 kv and an optical magnification of 2000 times is 256 v/mm. The amplitude characteristic is linear throughout the working range (Fig. 1, for a frequency of 50 c/s). The frequency characteristic is also linear up to 7 kc/s approximately, and the linear portion greatly exceeds that obtained with an electromagnetic oscillograph (Fig. 9). The instrument is described in detail and it is pointed out that its construction incorporates a number of improvements over existing models. The theory is also discussed. For a piezo-quartz dynamometer *see* 1294, below.

1161. AN ELECTRON SWITCH [Type GM 4196, for Simultaneous Dual Recording with C-R Oscillograph: Two-Pentode Circuit with Switching Voltages provided by Multivibrator Circuit: applicable also to Study of D.C. Component (usually Ignored) of Pulsating D.C. Voltage].—Dorsman & de Bruin. (*Philips Tech. Review*, Sept. 1939, Vol. 4, No. 9, pp. 267–271.)

1162. A CATHODE-RAY OSCILLOGRAPH [Type GM 3152: General-Purpose Portable Equipment: Photographic Recording Speed around 2.5 km/sec: Visual, 1.5 km/sec.].—Veegens. (*Philips Tech. Review*, July 1939, Vol. 4, No. 7, pp. 198–204.)

1163. ON THE PRACTICAL CONSTRUCTION OF CATHODE-RAY STORAGE-TYPE PROJECTING TUBES.—von Ardenne. (*See* 1099.)

1164. THE IMPLOSION OF CATHODE-RAY TUBES.—Smyth. (*See* 1101.)

1165. NEW INVESTIGATIONS ON CATHODE-RAY OSCILLOGRAPHS: V—THE ULTRADYNAMIC TRANSVERSE CONTROL OF A CATHODE RAY IN MULTIPHASE FIELDS [Derivation of Ultradynamic Correction Factor and Comparison with Experimental Inversion Spectrum].—Thoma. (*Funktech. Monatshefte*, Nov./Dec. 1939, No. 11/12, pp. 294–297.)

For previous parts *see* 4644 of 1939. *See* also Hollmann, 1128 & 2611 of 1939. "It is a common property of all these inversion functions [*see* the previous parts] that they quickly fall as the transit-time angle increases, which involves a decrease of the cathode-ray-tube sensitivity . . . . In the present part it will be shown how it is possible to prevent this decrease of sensitivity by dividing the total deflecting field into several component fields connected in phase opposition."

1166. THE USE OF A CATHODE-RAY OSCILLOGRAPH AS AN ALGEBRAIC CURVE TRACER [by Use of Discharge Transients of Resistance-Capacitance Circuits to produce Deflections on Long-Persistence Screen].—Tanaka & Nagai. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 87–91.)

1167. THE TESTING OF ELECTRIC FUSES WITH THE CATHODE-RAY OSCILLOGRAPH [Melting Time as Function of Short-Circuit Current].—van Liempt & de Vriend. (*Philips Tech. Review*, April 1939, Vol. 4, No. 4, pp. 118–120.)

1168. On the Electron-Optical Image Errors of the Third Order [and Their Elimination].—Voit. (*Zeitschr. f. Instrumentenkunde*, Feb. 1939, Vol. 59, No. 2, pp. 71–82.)

1169. Electron Work Function and Mean Scattering Time [Calculation of Hitherto Undetermined Constant in Scattering Equation using Work Function of Electrons from Cold Metallic Cathode]. — Müller-Strobel. (*Arch. f. Elektrot.*, 10th Nov. 1939, Vol. 33, No. 11, pp. 717–721.) For previous work *see* 917 of 1939.

1170. A Report on the Development of the Electron Super-Microscope at Toronto.—Burton, Hillier, & Prebus. (*Phys. Review*, 1st Dec. 1939, Series 2, Vol. 56, No. 11, pp. 1171–1172.) Refinements to magnetic electron microscope dealt with in 3718 of 1939.

1171. The Theoretically Attainable Resolving Power of the Electron Microscope [Estimate of Limit of Resolving Power set by Diffraction and Aperture Errors: Same Order of Magnitude for All Types of Electron Microscope: Theoretical Limit for Present Methods is Object Points 100 Electron Wavelengths Apart].—Scherzer. (*Zeitschr. f. Physik*, No. 7/8, Vol. 114, 1939, pp. 427–434.)

1172. The Resolving Power of Photographic Films for Electron Radiation.—von Ardenne. (*Zeitschr. f. Physik*, No. 5/6, Vol. 114, 1939, pp. 379–388.)

Importance of resolving power of photographic film used for recording with electron microscopes and micro-oscillographs. Theoretical estimate of its magnitude. Superiority of very thin sensitised layers, free from binding material. Experimental determination of magnitude of resolving power, for various types of film and different electron velocities, from micro-photographs of trace of probe and microtome sections of the film, using an electron probe of sub-microscopic fineness. Phenomena of spatial electron scattering in the film. Resolving power of about 3×10^{-3} mm for Schumann films and 50 kv accelerating voltage.

1173. Number of Quanta required to form the Photographic Latent Image, as determined from Mathematical Analysis of the H & D Curve.—Selwyn: Webb. (*Journ. Opt. Soc. Am.*, Dec. 1939, Vol. 29, No. 12, p. 518.) Prompted by Webb's paper (4664 of 1939).

1174. Luminescence and Absorption of Zinc Sulphide, Cadmium Sulphide, and Their Solid Solutions, *and* Luminescence and Absorption of Solid Solutions in the Ternary System ZnS-CdS-MnS.—Kröger. (*Physica*, Jan. 1940, Vol. 7, No. 1, pp. 1–12: pp. 92–100: in English.)

1175. Band Spectra of Cathodo-Luminescence [of Sulphide Phosphors], *and* Charging and Decrease of Charging of Luminescent Materials and Semiconductors irradiated by Electrons.—Henderson: Krautz. (*See* 1103 & 1104.)

1176. The Possibility of interpreting Phenomena of Polarised Luminescence using Linear Oscillator Model: VII.—Lewschin. (*Journ. of Phys.* [of USSR], No. 4, Vol. 1, 1939, pp. 265–275: in English.) Sequel to work published in 1935.

1177. [Seals for] Electrodes in Metal Vacuum Systems.—Hemmendinger. (*Review of Scient. Instr.*, Dec. 1939, Vol. 10, No. 12, p. 389.)

1178. Sealed Glass Bushings for Electrical Apparatus [Materials Available: Casting Large Bushings: Small Bushings: Testing].—Hull, Moore, & Doll. (*Gen. Elec. Review*, Dec. 1939, Vol. 42, No. 12, pp. 525–528.)

1179. Vacuum Leak Testing [in a Metal Vacuum System: Ion-Gauge Indications vary Widely with Different Liquids: Investigation].—Manley & others. (*Review of Scient. Instr.*, Dec. 1939, Vol. 10, No. 12, pp. 389–390.)

1180. Influence of Spark Type (Length) and Electrode Material on the Increase of Striking Distance due to Ultra-Violet Irradiation with the "Impact" Spark.—Arnold. (*Physik. Zeitschr.*, 15th Nov. 1939, Vol. 40, No. 22, pp. 687–695.) Continuation of work referred to in 2270 (*see* also 2271) of 1939.

1181. Effect of Weak Magnetic Field upon Plasma [Experimental Investigation and Conclusions].—Fataliev. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 9, Vol. 23, 1939, pp. 891–895: in English.)

Among various points discussed are whether the magnetic field lowers or raises the electron temperature, and the idea (erroneous in the studied range of pressures) that a longitudinal field concentrates the discharge about the tube axis at the expense of decreasing the electron density near the walls: it is the *average* concentration which is increased.

1182. The Influence of a Magnetic Field on Mercury-Discharge Radiation.—Rokhlin. (*Journ. of Phys.* [of USSR], No. 4, Vol. 1, 1939, pp. 347–358: in English.)

1183. Spectral Distribution [over Range 2200–26 000 A.U.] of Radiation from Lamps of Various Types.—Barnes & others. (*Gen. Elec. Review*, Dec. 1939, Vol. 42, No. 12, pp. 540–543.)

1184. Explanation of the Electrical Properties of the Alternating-Current High-Pressure Discharge from the Phenomena at the Electrodes [Importance of Dark Spaces occurring before Electrodes when Current passes through Zero].—Kern. (*Zeitschr. f. Physik*, No. 9/10, Vol. 114, 1939, pp. 552–563.)

1185. Diffusion of Ions in a Discharge and the Initial Rate of Gas Deionisation: I and II [Results useful in Practical Computations].—Granovsky. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 9, Vol. 23, 1939, pp. 882–887 & 888–890: in English.) For previous work *see* 2963 of 1939.

1186. Reaction by Metastable Atoms and Breakdown Depression in the Rare Gases.—Rogowski. (*Naturwiss.*, 10th Nov. 1939, Vol. 27, No. 45, pp. 755–756.)

1187. The Atomphysical Interpretation of Lichtenberg Figures and Their Application to the Study of Gas Discharge Phenomena.—Merrill & von Hippel. (*Journ. of Applied Phys.*, Dec. 1939, Vol. 10, No. 12, pp. 873–887.)

1188. Electron Concentration and Temperature in the Mercury High Pressure Column and Their Determination by the Broadening of Spectral Lines due to Electron Collisions.—Schulz. (*Zeitschr. f. Physik*, No. 7/8, Vol. 114, 1939, pp. 435–447.)

1189. The Continuous Spectrum of the Carbon Arc.—Maecker. (*See* 917.)

1190. The Bearing of Three-Body Collisions [Two Electrons collide near Neutral Atom] on the Energy Relations in Gaseous Discharges [Wave-Mechanical Theory].—Rebsch. (*Zeitschr. f. Physik*, No. 9/10, Vol. 114, 1939, pp. 620–635.)

1191. Investigations on Gaseous Discharges, with Attention to Their Dynamic Properties and Their Stability.—van Geel. (*Physica*, Aug. 1939, Vol. 6, No. 8, pp. 806–816: in German.)

1192. The Lack of "Sucking" Action by the Cathode Blast of Mercury Vapour in a Pool Rectifier, *and* Does the "Sucking Effect" in Mercury Rectifiers exist?—Tonks: Poletaev. (*Journ. of Applied Phys.*, Sept. 1939, Vol. 10, No. 9, pp. 654–658: *Journ. of Phys.* [of USSR], No. 4, Vol. 1, 1939, pp. 359–361: in English.)

1193. Voltage Control of Mercury-Arc Rectifiers.—McDonald. (*Elec. Engineering*, Nov. 1939, Vol. 58, No. 11, Transactions pp. 563–568.)

1194. Effect of Gas Pressure on Rectifying Action of Needle-Point Discharge.—Kumagai & others. (*Electrot. Journ.*, Tokyo, Sept. 1939, Vol. 3, No. 9, p. 212.)

1195. Some Features of an Electrostatic Generator and Ion Source for High Voltage Research.—Getting, Fisk, & Vogt. (*Phys. Review*, 1st Dec. 1939, Series 2, Vol. 56, No. 11, pp. 1098–1104.)

1196. Spectrum of the Torch Discharge [at Very High Frequencies].—Asami & Hori. (*Nature*, 9th Dec. 1939, Vol. 144, pp. 981–982.)

For this discharge *see* Rohde & Schwarz, 1934 Abstracts, p. 54. The spectrum is essentially the same as that of the high-tension d.c. arc (*see* Thoma & Heer, 1933 Abstracts, p. 112).

1197. Radio-Frequency High-Voltage Phenomena [Phenomena at 60 000 V, 13 Mc/s].—Alford & Pickles. (*See* 1130.)

1198. Discharge Delay in Solid Insulating Materials [Systematic Investigation by the "Time Transformer": Very Different Types of Material show Similarity of Behaviour to Each Other and to Air & Liquid Dielectrics: etc.].—Strigel. (*E.T.Z.*, 26th Oct. 1939, Vol. 60, No. 43, p. 1240: summary only.) For the "time transformer" *see* Steenbeck & Strigel, 1933 Abstracts, p. 225.

1199. On the Crystals of Quartz Glass, *and* On the Mosaic Blocks of Crystalline Quartz [Results indicating Mosaic Structure of Quartz].—Shishakov. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 8, Vol. 23, 1939, pp. 788–791: pp. 792–793: in English.)

1200. Dielectric Losses due to Relaxation in Glass at High Frequencies.—Skavani. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 9, 1939, pp. 612–623.)

Relaxation losses in glass at high frequencies are due to the presence of metal ions in the glass. A metal ion located in a glass pore polarises the surrounding glass atoms, and the negative charge induced by the ion in its turn produces forces which affect the ion. Methods are indicated for calculating these forces. The movement of the ion within the pore and its collisions with the glass atoms are then considered, and a formula (16) is derived determining the relaxation time τ. Another formula (17) for determining $\tan\delta$ is quoted, and a method is suggested for calculating the dielectric constant of glass for given temperature and frequency. Thus $\tan\delta$ can be completely determined, starting from two assumed values only—the radius of the pore and the sum of radii of the ion and of the glass atom. In conclusion a comparison is made between the calculated and experimental results, confirming the accuracy of the theory put forward.

1201. Styroflex and Its Rôle in the Construction of Cables.—Fischer & Müller. (*Ann. des Postes, T. et T.*, Aug. 1939, Vol. 28, No. 8, pp. 625–637.) Extracts from the German paper, a summary of which was referred to in 4041 of 1938.

1202. New Investigations on Phenoplastics [Preliminary Report on Extended Researches on Chemical, Mechanical, & Dielectric Properties].—Stäger, Sänger, & Siegfried. (*Helvetica Phys. Acta*, Fasc. 7, Vol. 12, 1939, pp. 561–580: in German.)

It is deduced from these researches that the dielectric losses are caused (apart from the conductive influence of the condensation medium) by the phenolhydroxyl group which is readily oriented in the molecule: cresol resins have better dielectric properties, for some reason which cannot at present be given definitely. By suitable modification of the molecular construction of the phenoplastic molecule it is possible to suppress the orienting power of the phenolhydroxyl group in such a way that no frequency dependence, and only an extremely small temperature dependence, is to be found.

1203. Developments in Insulating Materials [with Literature References].—Gillies. (*Journ. I.E.E.*, Jan. 1940, Vol. 86, No. 517, pp. 66–70.)

1204. Cation Exchange in Cellulosic Materials [particularly Kraft & Linen Condenser Tissues].—McLean & Wooten. (*Bell Tel. System Tech. Pub.*, Monograph B-1177, 13 pp.)

1205. Tuning Condensers with Linear [Push/Pull] Action.—Philips Company. (*See* 1006.)

1206. Pressure Condensers [Reactive Power per Unit Volume of Oil-Impregnated Paper Condensers increased by applying Pressure to the Oil: Theory & Practical Construction].—de Lange. (*Philips Tech. Review*, Sept. 1939, Vol. 4, No. 9, pp. 254–259.)

1207. Fluid Filling-Media for Electrical Apparatus [Transformers, Condensers, etc: including Attempts to use Non-Inflammable Chlorinated Compounds].—Meyer. (*BEAMA Journ.*, Dec. 1939, Vol. 45, No. 30, pp. 129–132: *Nature*, 6th Jan. 1940, Vol. 145, p. 40.)

1208. The Electrical Properties of Kerosene.—Hochberg & Glikina. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 9, 1939, pp. 730–736.)

1209. Oxidation of Oils due to Light Rays and Electric Discharge.—Kumagai & Yoh. (*Electrot. Journ.*, Tokyo, Sept. 1939, Vol. 3, No. 9, pp. 212–213.)

1210. Molecular Interactions in Solutions: their Effects on the Rotation of Dipoles in an Alternating Field [Curves of Dispersion and Absorption in Wavelength Range 4–300 cm for Organic Substances].—Girard & Abadie. (*Comptes Rendus*, 11th Dec. 1939, Vol. 209, No. 24, pp. 874–877.) The curves resemble those calculated by Yager (1175 of 1937) on the hypothesis of several relaxation times per dipole.

1211. On the Theory of Dielectric Polarisation in Liquids [Criticism of Onsager's Theory].—Zakrzewski & Piekara. (*Nature*, 5th Aug. 1939, Vol. 144, p. 250.) *See* also Falkenhagen, 1714 of 1939.

1212. A Method for Improving the Uniformity of the Central Magnetic Field in a Thick Solenoid [Criticism of Various Proposed Methods, leading to Adoption of the Reversed Correcting Coil of Bühl & Coeterier (1933 Abstracts, p. 52)].—McKeehan. (*Review of Scient. Instr.*, Dec. 1939, Vol. 10, No. 12, pp. 371–373.)

1213. The Design of Powerful Electro-Magnets: Part IV—The New Magnet Laboratory at M.I.T.—Bitter. (*Review of Scient. Instr.*, Dec. 1939, Vol. 10, No. 12, pp. 373–381.)

1214. The Variation of the Self-Inductance of H.F. Coils by D.C. Magnetic Bias.—Maus. (*See* 994.)

1215. Heat Treatment of Ferromagnetic Polycrystals in a Magnetic Field.—Shur. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 5, Vol. 23, 1939, pp. 455–459: in English.)

For previous work *see* 2981 of 1939. The results now given show that "in order to obtain optimum magnetic properties, it is necessary to be very strict in selecting both the magnitude of the outer field and the rate of passage of various temperature fields. In particular, in order to obtain considerable initial permeability it is necessary to cool the ferromagnetic substance in a weak field, whereas to obtain the highest possible permeability the cooling has to be effected in a strong field. The highest effect in the sense of improving magnetic properties may apparently be obtained in the case where, on cooling the substance, the application of the magnetic field is varied so that the spontaneous regions all the time remain oriented in the directions needed."

1216. The Course of Orientated Displacement of Magnetite by Iron.—Frank-Kameneckij. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 6, Vol. 23, 1939, pp. 561–564: in English.)

1217. Measurement of the Gyromagnetic Effect in the Alloys Manganese/Antimony and Iron/Selenium.—Galavics. (*Helvetica Phys. Acta*, Fasc. 7, Vol. 12, 1939, pp. 581–608: in German.)

1218. Magnetisation and Eddy Current Loss in Thin Iron Sheets [Calculations of Eddy Current Loss at Low Frequencies including Effect of Barkhausen Jumps on Surface increase Its Value as compared with That given by Thomson's Theory: Better Agreement with Experiment].—Panczakiewicz. (*Arch. f. Elektrot.*, 10th Aug. 1939, Vol. 33, No. 8, pp. 554–560.)

1219. Rotational and Alternating Hysteresis Losses in Electrical Sheet Steel [Results: More Complicated Relationship than That found by Brailsford].—Tarasov. (*Phys. Review*, 1st Dec. 1939, Series 2, Vol. 56, No. 11, p. 1170.) *See* 2543 (also *cf.* 776 & 1738) of 1939.

1220. Reversible Phenomena in Magnetic Materials with Small Internal Tensions [Theory].—Döring. (*Zeitschr. f. Physik*, No. 9/10, Vol. 114, 1939, pp. 579–601.)

1221. Investigations of Ferromagnetic Impurities, *and* Surface Effects in Testing for Ferromagnetic Impurities [and the Measurement of Very Small Permanent Magnetic Moments].—Constant & Formwalt. (*Phys. Review*, 15th Aug. 1939, Series 2, Vol. 56, No. 4, pp. 373–377: 15th Oct., No. 8, p. 846—abstract only.)

1222. Curie Constant and Curie Temperature of Nickel Alloys.—Niessen. (*Physica*, Oct. 1939, Vol. 6, No. 9, pp. 1011–1033: in German.)

1223. The Magnetic Susceptibility of Nickel Chloride [in Aqueous Solution: Measurements].—Nettleton & Sugden. (*Proc. Roy. Soc.*, 18th Dec. 1939, Vol. 173, No. 954, pp. 313–323.)

1224. THE PARAMAGNETIC SUSCEPTIBILITY OF COPPER/NICKEL AND ZINC/NICKEL ALLOYS [Measurements : Discussion based on Heisenberg and Bloch Models].—Wheeler. (*Phys. Review*, 1st Dec. 1939, Series 2, Vol. 56, No. 11, pp. 1137–1145.)

1225. PARAMAGNETIC DISPERSION IN IRON AMMONIUM ALUM.—Teunissen & Gorter. (*Physica*, Dec. 1939, Vol. 6, No. 10, pp. 1113–1122 : in English.)

1226. THEORY OF PARAMAGNETIC RELAXATION [Connection between Thermodynamic Theory and Kronig's Ideas].—Dänzer. (*Physik. Zeitschr.*, 1st Sept. 1939, Vol. 40, No. 17, pp. 557–559.)

1227. THE MAGNETIC SUSCEPTIBILITIES OF SOME CUPRIC SALTS [Measurements down to 1.6° K : Comparison with Jordahl's Theory]. —Reekie. (*Proc. Roy. Soc.*, Series A, 18th Dec. 1939, Vol. 173, No. 954, pp. 367–378.)

1228. THE PREPARATION OF METALS IN A COMPACT FORM BY PRESSING AND SINTERING [Ductile Tungsten, Molybdenum, & Tantalum : Hard Cemented Carbides : Special Uses for Porous Properties of Sintered Products].—Fast. (*Philips Tech. Review*, Nov. 1939, Vol. 4, No. 11, pp. 309–316.)

1229. STRAIGHTENING THIN TUNGSTEN WIRES [*e.g.* for G-M Counters].—Morgan. (*Review of Scient. Instr.*, Sept. 1939, Vol. 10, No. 9, p. 271.)

1230. ELECTRICAL WELDING OF ALUMINIUM.—Klaptsov. (*Izvestiya Elektroprom. Slab. Toka*, No. 7/8, 1939, pp. 70–74.)

1231. THE PRODUCTION OF VERY FINE QUARTZ FIBRES [Diameters down to 0.1 μ].—Holbourn. (*Journ. of Scient. Instr.*, Oct. 1939, Vol. 16, No. 10, pp. 331–334.)

1232. REFLECTION AND TRANSMISSION FACTORS OF THIN METAL FILMS [Survey].—Rouard. (*Zeitschr. f. Instrumentenkunde*, May 1939, Vol. 59, No. 5, p. 221 : summary only.)

1233. PAPERS ON THE DISTRIBUTION OF INDUCTION CURRENTS IN METAL PLATES AND CYLINDERS. —Shilov. (*See* 1297.)

1234. THE FREE BENDING OF BIMETALLIC STRIPS OF ARBITRARY FORM [Derivation of Equations, leading to Approximate Graphical Determination for Any Temperature Distribution : Calculation of Temperature Distribution for Straight Directly-Heated Strip].—Laig-Hörstebrock. (*E.T.Z.*, 26th Oct. 1939, Vol. 60, No. 43, pp. 1126–1129.)

1235. CATHODE-CIRCUIT PROTECTION [Bimetallic Delay Switch, having Lag at Opening as well as at Closing, may cause the Damage it is intended to Avoid : a Remedy].—(*Wireless World*, Feb. 1940, Vol. 46, No. 4, p. 151.)

1236. THE HYDROGEN-FILLED IRON-WIRE BALLAST LAMP [Barretter].—Cole & Dalzell. (*See* 995.)

1237. THE ELECTRICAL RESISTANCE OF METAL CONTACTS [Convergence & Transition Resistances: Covering-Layers of High-Conductivity Soft Materials : Heating : Oxidised Contacts : Lubrication].—Went. (*Philips Tech. Review*, Nov. 1939, Vol. 4, No. 11, pp. 332–335.) The work of Holm is specially mentioned : *see* 1929 Abstracts, p. 588.

1238. A 120 000-EXPOSURE-PER-SECOND CAMERA [Pinhole Type].—Prince & Rankin. (*Gen. Elec. Review*, Sept. 1939, Vol. 42, No. 9, pp. 391–393.)

1239. A MECHANICAL HARMONIC SYNTHESISER-ANALYSER [with Thirty Harmonic Elements operating simultaneously].—Brown. (*Journ. Franklin Inst.*, Dec. 1939, Vol. 228, No. 6, pp. 675–694.)

1240. SOME RECENT AMERICAN ADVANCES IN APPARATUS AND IN THE TECHNIQUE OF EXPERIMENTAL PHYSICS [with Literature References].—Overbeck. (*Journ. of Scient. Instr.*, Jan. 1940, Vol. 17, No. 1, pp. 1–17.)

1241. "PROCEDURES IN EXPERIMENTAL PHYSICS" [Book Review].—Strong. (*Journ. of Scient. Instr.*, Jan. 1940, Vol. 17, No. 1, p. 16.) An enthusiastic notice in the paper referred to in 1240, above.

1242. "TECHNISCHE KUNSTGRIFFE BEI PHYSIKALISCHE UNTERSUCHUNGEN" [4th Edition : Book Review].—von Angerer. (*Physikalische Berichte*, 15th Nov. 1939, Vol. 20, No. 22, p. 2457.) An enthusiastic review of the first edition was referred to in 4258 of 1936. The new edition contains many new methods, materials, and "tips."

STATIONS, DESIGN AND OPERATION

1243. FREQUENCY MODULATION : SUCCESS OF TRIPLE RELAY EXPERIMENT.—Warner. (*Wireless World*, Feb. 1940, Vol. 46, No. 4, p. 138.) "I thought it just technically unbelievable with three relays, yet the programme was still better by far than the present conventional system at its best."

1244. ON A CERTAIN METHOD FOR INCREASING THE EFFECTIVENESS OF WIRELESS COMMUNICATION [by Simultaneous Modulation of Amplitude and Phase].—Tetelbaum. (*Journ. of Phys.* [of USSR], No. 4, Vol. 1, 1939, pp. 325–333 : in English.)

"Proof is given of the fact that by means of the simultaneous modulation of amplitude and phase of h.f. current, wireless telephonic communication occupying a band of frequencies one-half that of ordinary amplitude modulation can be realised, non-distorted reception being fully obtainable with the help of ordinary receivers and amplitude detection ; all this without increasing the capacity of the carrying frequency . . ." The advantages of this "optimum amplitude-phase modulation" should be very important for medium- and long-wave broadcasting, as well as for television. The system also lends itself to the introduction of new methods for enhancing the efficiency of transmitting stations (*cf.* same writer, 1370 of 1938).

1245. SCINTILLATION [Rapid Fluctuation of Carrier Frequency produced by Amplitude Modulation in Broadcasting Transmitters (Fourth CCIR Meeting): Unsatisfactory Stipulation of "Less than One Cycle" Scintillation: Phenomenon is due to Phase Shift of Carrier: Proposed Stipulation].—Koike. (*Nippon Elec. Comm. Eng.*, Oct. 1939, No. 18, pp. 92–94.)

1246. DUPLEX OPERATION ON A SINGLE AERIAL [Circuit Design, applicable also to Multi-Frequency Transmission & Reception].—Builder. (*See* 1018.)

1247. BROADCASTING IN GERMANY: NEWS FROM OUR FORMER BERLIN CORRESPONDENT.—(*Wireless World*, Dec. 1939, Vol. 46, No. 2, p. 50.)

1248. MODERN BROADCAST REPEATER EQUIPMENTS [with Equalisation, Switching, & Remote-Control Circuits].—Meers & Filby. (*Elec. Communication*, Oct. 1939, Vol. 18, No. 2, pp. 168–180.)

1249. THE PRESENT POSITION OF BAUDOT TELEGRAPHY ON SHORT WAVES.—Prieur. (*Ann. des Postes, T. et T.*, Aug. 1939, Vol. 28, No. 8, pp. 618–624.)

GENERAL PHYSICAL ARTICLES

1250. ON SOME PROPERTIES OF AN ELECTRON GAS IN A MAGNETIC FIELD [by Quantum Theory].—Achieser. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 9, Vol. 23, 1939, pp. 874–878: in German.)

It is known that a gas composed of free electrons, subjected to the effect of a magnetic field, displays a diamagnetic moment which for weak fields $\mu H \ll kT$ ($\mu = eh/me$) is equal to one third of the paramagnetic moment due to the spin: the same reason leads to a change in the resistance of a metal in a magnetic field. It is therefore of interest to examine the effect at low temperatures, when the above inequality is not fulfilled. The results are shown on p. 876: "thus for low temperatures the magnetic moment is a complicated and rapidly changing function of the field. The amplitude of the 'periodic' component of the moment is proportional to $\eta^{2/1}$; that is, it is larger than the linear term [$\eta = \mu H/\epsilon_0$, where ϵ_0 is the chemical potential]; for not too small values of η the periodic component is more important than the linear." The rest of the paper deals with the change of resistance of metals in a magnetic field, extending the work of Titeica (2471 of 1935).

1251. ON QUANTUM ELECTRODYNAMICS: I AND II.—Ginsburg. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, Nos. 8 & 9, Vol. 23, 1939, pp. 774–778 & 899–903: in English.)

1252. SOME DIFFICULTIES AND DEVELOPMENTS IN QUANTUM MECHANICS.—Flint. (*Reports on Progress in Physics*, Physical Society, Vol. 5, pub. 1939, pp. 402–421.)

1253. THE STATE EQUATION OF REAL GASES.—Vukalovich & Novikov. (*Comptes Rendus (Doklady) de l'Acad. des Sci. de l'URSS*, No. 8, Vol. 23, 1939, pp. 768–773: in English.)

"The aim of the present paper is to find a rational form of characteristic equation for gases . . . and to examine the influence of the association and dissociation processes on the parameters characterising the gaseous state."

1254. THE PROBABILITY OF REVERSAL OF ELECTRON SPIN IN COLLISIONS IN NO GAS [Acoustic Measurements show No Influence of Relaxation in Absorption Curve: Reversal of Electron Spin takes place in Relatively Short Time].—Kneser. (*Physik. Zeitschr.*, 15th Nov. 1939, Vol. 40, No. 22, p. 681: abstract only.)

1255. ELASTIC ELECTRON SCATTERING IN GASES.—McMillen. (*Reviews of Mod. Physics*, April 1939, Vol. 11, No. 2, pp. 84–110.)

1256. ON THE GENERAL THEORY OF THE ELEMENTARY CORPUSCLES AND THE THEORY OF THE PHOTON.—Petiau. (*Journ. de Phys. et le Radium*, Dec. 1939, Series 7, Vol. 10, No. 12, pp. 487–494.)

1257. THE ATOMIC CONSTANTS: A REVALUATION AND AN ANALYSIS OF THE DISCREPANCY.—Dunnington. (*Reviews of Mod. Physics*, April 1939, Vol. 11, No. 2, pp. 65–83.)

1258. BROWNIAN MOTION.—Brown. (*Reports on Progress in Physics*, Physical Society, Vol. 5, pub. 1939, pp. 9–11.)

1259. THERMODYNAMICS OF ELECTROMAGNETIC PHENOMENA [Precise Formulation of Thermodynamical Phenomena yields Two Equations which connect up with Electrodynamics].—Kneissler-Maixdorf. (*Arch. f. Elektrot.*, 10th Nov. 1939, Vol. 33, No. 11, pp. 721–732.)

1260. "THE FUNDAMENTALS OF ELECTROMAGNETISM": A REPLY TO PROF. HOWE.—Cullwick: Howe. (*Electrician*, 29th Dec. 1939, Vol. 123, pp. 553–554.) *See* 4763 & 4764 of 1939.

1261. DISCUSSION ON "AN EXPERIMENT OF ELECTROMAGNETIC INDUCTION BY LINEAR MOTION" [and the Cramp/Howe Controversy].—Cullwick. (*Journ. I.E.E.*, Jan. 1940, Vol. 86, No. 517, pp. 96–97.) *See* 4250 of 1939.

MISCELLANEOUS

1262. MATRIX THEORY OF OSCILLATORY NETWORKS.—Pipes. (*Journ. of Applied Physics*, Dec. 1939, Vol. 10, No. 12, pp. 849–860.)

1263. "DETERMINANTS AND MATRICES," "INTEGRATION," "INTEGRATION OF ORDINARY DIFFERENTIAL EQUATIONS," AND "VECTOR METHODS" [Book Reviews].—Aitken & others. (*BEAMA Journ.*, Dec. 1939, Vol. 45, No. 30, p. 135.) In a new series of monographs.

1264. ON THE NATURAL FREQUENCIES OF VIBRATING SYSTEMS [Imposition of Lower Limits: Extension of "Relaxation" Technique: Continuous Systems governed by Differential Equations].—Southwell. (*Proc. Roy. Soc.*, 18th Dec. 1939, Vol. 173, No. 954, p. S 131: abstract only.)

1265. "NEUERE RECHENVERFAHREN DER TECHNIK" [Part I: The Solution of Applied Differential Equations by means of the Laplace Transformation: Book Review].—Droste. (*T.F.T.*, Nov. 1939, Vol. 28, No. 11, p. 424.) *See* also 2705 of 1939. The present volume of 30 pages is the first of a series, edited by the writer, under the title "New Methods of Calculation in Technics." Part II, also by Droste, will deal with matrices and their application.

1266. MECHANICAL INTEGRATION OF DIFFERENTIAL EQUATIONS [Description of Bush Machine in Astrophysical Institute of Oslo University, with 12 Integrators].—Rosseland. (*Naturwiss.*, 3rd Nov. 1939, Vol. 27, No. 44, pp. 729–735.)

1267. INVESTIGATION OF AN INTEGRIMETER AFTER A. OTT.—Werkmeister. (*Zeitschr. f. Instrumentenkunde*, April 1939, Vol. 59, No. 4, pp. 168–172.)

1268. THE USE OF A CATHODE-RAY OSCILLOGRAPH AS AN ALGEBRAIC CURVE TRACER.—Tanaka & Nagai. (*See* 1166.)

1269. SYMBOLIC REPRESENTATION OF THE SCALES OF THE LOGARITHMIC SLIDE RULE.—Schendell. (*Zeitschr. f. Instrumentenkunde*, March 1939, Vol. 59, No. 3, pp. 124–134.)

1270. "FUNKTECHNISCHE FORMELSAMMLUNG" [Radio-Engineering Formulae: Book Review].—Schmid & Leithiger. (*Funktech. Monatshefte*, Nov./Dec. 1939, No. 11/12, p. 320.)

1271. ON THE APPLICATION OF SOUND FILM TO HARMONIC ANALYSIS [Curves converted into Photocell Voltages and dealt with by Wave Analyser].—Pollak. (*Zeitschr. f. Instrumentenkunde*, May 1939, Vol. 59, No. 5, pp. 208–210.)

1272. RADIATION MEASUREMENTS IN THE SHORT-WAVE ULTRA-VIOLET WITH THE SELENIUM BARRIER-LAYER PHOTOCELL [including the Advantages of Quartz Cover-Glass instead of Varnishing, and the Use of a Differential Technique].—Rössler. (*Zeitschr. f. tech. Phys.*, No. 10, Vol. 20, 1939, pp. 290–293.)

1273. ON THE USE OF THE FILTER METHOD IN OBJECTIVE HETEROCHROME PHOTOMETRY [with Selenium Photocells of Various Commercial Types].—König. (*Helvetica Phys. Acta*, Fasc. 4, Vol. 12, 1939, pp. 313–329.)

1274. LINEARITY OF WIDE-RANGE GALVANOMETER RESPONSE IN A PHOTOELECTRIC SPECTROPHOTOMETER UTILISING A BALANCED AMPLIFIER CIRCUIT.—Bosch & Brown. (*Phys. Review*, 15th Oct. 1939, Series 2, Vol. 56, No. 8, pp. 846–847: abstract only.)

1275. WIDE-RANGE INTENSITY MEASUREMENTS IN PHOTOELECTRIC SPECTROPHOTOMETRY.—Bosch & Brown. (*Journ. Opt. Soc. Am.*, Nov. 1939, Vol. 29, No. 11, pp. 466–469.)

1276. PHYSICAL PHOTOMETRY [and the Philips Photometer with Integrating Sphere].—Voogd. (*Philips Tech. Review*, Sept. 1939, Vol. 4, No. 9, pp. 260–266.)

1277. A PUSH-PULL PHOTOELECTRIC PHOTODENSITOMETER FOR DETERMINING FINE STRUCTURE IN ULTRA-VIOLET ABSORPTION SPECTRA.—Loofbourow. (*Journ. Opt. Soc. Am.*, Dec. 1939, Vol. 29, No. 12, pp. 535–537.)

1278. THE CALIBRATION OF ELECTRICAL PHOTOGRAPHIC EXPOSURE METERS.—Nidetzky. (*Zeitschr. f. Instrumentenkunde*, May 1939, Vol. 59, No. 5, pp. 212–213: summary only.)

1279. THE PENETRATION OF RAYS THROUGH THE SKIN, AND RADIANT ENERGY FOR THE TREATMENT OF WOUNDS.—Hill. (*Journ. Roy. Soc. of Arts*, 8th Dec. 1939, Vol. 88, No. 4542, pp. 88–99.)

1280. ON THE EXISTENCE AND THE CHARACTER OF THE ABSORBABLE IONISING RADIATIONS EMITTED BY ORDINARY METALS [Results easily explained as Effect of Cosmic Rays].—Reboul. (*Journ. de Phys. et le Radium*, Nov. 1939, Series 7, Vol. 10, No. 11, pp. 470–476.)

1281. ELECTRICITY AIDS IN THE SEARCH FOR OIL [Review of Geophysical Prospecting Methods].—Silverman. (*Elec. Engineering*, Nov. 1939, Vol. 58, No. 11, pp. 455–462.)

1282. RADIESTHESIS AND ELECTRICITY: I—AFFINITIES WITH ELECTRICAL RADIATION ["Wave Sensing" applied to Qualitative Laboratory Analysis and to Detection of Small Electrical Forces: the College of Radiesthesis for Medical Students].—Macbeth. (*Electrician*, 29th Dec. 1939, Vol. 123, pp. 556 and 558.) For previous work *see* 2616 of 1939. For II see *ibid.*, 5th Jan. 1940, Vol. 124, pp. 7 and 9.

1283. "THE PHYSICS OF THE DIVINING ROD" [Book Review].—Maby & Franklin. (*Journ. of Scient. Instr.*, Jan. 1940, Vol. 17, No. 1, p. 23.)

Written by a physiologist and a mathematical physicist: the first part gives a general historical introduction, the second describes the writers' own experimental observations, and the third represents these in terms of a coherent mathematico-physical theory. "Physical recording instruments of several types confirm the expert dowser's findings, and important problems in such subjects as terrestrial magnetism, cosmic rays, radio transmission, and atomic physics are seen to be implicated. . . ." For a critical review by G. W. O. H. *see* an editorial in *Wireless Engineer*, Feb. 1940, Vol. 17, No. 197, pp. 51–53. For a recent German paper on divining *see* 897 of February.

1284. RADIO THERAPY IN MEDICINE [Long-Wave Diathermy, "Short-Wave" (3–30 m) Therapy (and the Specific, Athermic Action): Inductothermy].—Dalton. (*Journ. of British I.R.E.*, Dec. 1939, Vol. 1, No. 1, pp. 7–16.)

1285. IONISATION SURFACES AND THEIR MODE OF ACTION IN THE ELECTRICAL PURIFICATION OF GASES.—Brion. (*E.T.Z.*, 21st Sept. 1939, Vol. 60, No. 38, pp. 1113–1115.)

1286. INSTANTANEOUS ELECTROCONVECTIVE EDDIES IN A STRATUM OF AIR CHARGED WITH TOBACCO SMOKE.—Avsec. (*Comptes Rendus*, 11th Dec. 1939, Vol. 209, No. 24, pp. 869–871.) *See* 902 of February.

1287. AN IMPROVED METHOD OF MAKING PERMANENT ELECTRETS, AND FACTORS WHICH AFFECT THEIR BEHAVIOUR.—Good & Stranathan. (*Phys. Review*, 15th Oct. 1939, Series 2, Vol. 56, No. 8, pp. 810–813.) For previous references to electrets *see*, for example, 831, 4291 of 1936; 791, 792, 3974 of 1937; and 2648 of 1938.

1288. RESEARCHES ON HIGH-FREQUENCY ["Electrodeless"] DISCHARGES AND THEIR APPLICATION TO MOLECULAR SPECTROSCOPY.—Mesnage. (*Ann. de Physique*, July/Aug. 1939, Series 11, Vol. 12, pp. 5–87.)

1289. RAPID CHEMICAL ANALYSIS WITH THE MERCURY DROPPING ELECTRODE AND AN OSCILLOGRAPH OR MEASURING BRIDGE [with Electron-Ray Tuning Indicator] AS INDICATOR.—Boeke & van Suchtelen. (*Philips Tech. Review*, Aug. 1939, Vol. 4, No. 8, pp. 231–236.)

1290. THE "RADIO NURSE" [One-Way Short-Wave Radio Transmitter for Hospital or Home Use].—(*Electrician*, 8th Dec. 1939, Vol. 123, p. 508.) In an article on American use of plastic materials. *See* also 4188 of 1938.

1291. AN ELECTRO-MAGNETIC INDICATOR AND KNOCK METER [for Aircraft Engines, etc.].—Ratzke. (*E.T.Z.*, 14th Sept. 1939, Vol. 60, No. 37, pp. 1097–1098: summary only.)

1292. VARIED APPLICATIONS OF THICKNESS GAUGES FOR THIN NON-MAGNETIC LAYERS.—Rusher. (*Gen. Elec. Review*, Nov. 1939, Vol. 42, No. 11, pp. 486–487.)

1293. THE MEASUREMENT OF PRESSURE, MOVEMENT, ACCELERATION, AND OTHER MECHANICAL QUANTITIES, BY ELECTROSTATIC [Capacity-Change] SYSTEMS.—Brookes-Smith & Colls. (*Journ. of Scient. Instr.*, Dec. 1939, Vol. 16, No. 12, pp. 361–366.) From the Southern Instruments Company: *see* also 1785, 2195, & 2944 of 1939.

1294. A PIEZO-QUARTZ DYNAMOMETER FOR MEASURING IMPACT STRESSES.—Andreevski. (*Journ. of Tech. Phys.* [in Russian], No. 8, Vol. 9, 1939, pp. 680–686.)

A description of a dynamometer developed for obtaining the load/time diagram when a sample of material is disrupted by impact. The stress in the sample is transmitted to two crystal rings separated by a steel washer for collecting the piezoelectric charge (Fig. 1). This charge is proportional to the stress in the sample and is measured by a valve voltmeter. A load of 15.63 kg falling from a maximum height of 2.5 m is used in these measurements. For a piezo-quartz oscillograph *see* 1160, above.

1295. PIEZOELECTRIC *versus* MECHANICAL SPRING PRESSURE GAUGE [Piezoelectric possibly less good in Approach to Instantaneous Action than Mechanical Gauge].—Webster. (*Journ. of Applied Phys.*, Dec. 1939, Vol. 10, No. 12, pp. 890–891.)

1296. A DIRECT-READING VIBRATING-RIBBON TENSIOMETER [for Measurement of Elongations of Loaded Structures: Survey of Previous Devices and Description of Steel-Tape Instrument driven Electro-Magnetically, Analysis of Optimum Values of Frequency, Length of Vibrating Element, etc., with Experimental Confirmation].—Egidi. (*Alta Frequenza*, Aug./Sept. 1939, Vol. 8, No. 8/9, pp. 516–536.)

1297. PAPERS ON THE DISTRIBUTION OF INDUCTION CURRENTS IN METAL PLATES AND CYLINDERS [in connection with Magnetic Detection of Flaws, etc.].—Shilov. (*Journ. of Tech. Phys.* [in Russian], No. 7, Vol. 9, 1939, pp. 624–632 & 633–643.)

Approximate formulae are derived for the distribution of the induction currents and the resultant magnetic field. Methods are also indicated for determining the "distortion coefficient," *i.e.* the distortion of the magnetic field caused by a crack or non-uniformity in the material. Experiments at 50 and 300/370 c/s confirm the theoretical results, and show that the higher frequencies should preferably be used in such "defectoscopy."

1298. ELECTRO-MAGNETIC GRAIN CLEANER [based on Observation that Steel Dust adheres to Rougher Surface of Wild Seeds, etc., More than to Good Seeds].—(*Current Science*, Bangalore, Nov. 1939, Vol. 8, No. 11, pp. 536–537.)

1299. A NEW TYPE OF COIL TESTER [for Short-Circuited Turns or Insulation Faults in H.T. Coils].—Dickinson. (*See* 1148.)

1300. OUR NEW BIBLIOGRAPHICAL SERVICE ON INDEX CARDS.—David. (*L'Onde Élec.*, Aug./Sept./Oct. 1939, Vol. 18, No. 212/213/214, Supp. pp. 1–4.)

The proposal described in 2625 of 1939 received enough support to enable the service to be started, on 1st July 1939: it deals with articles appearing since 1st Jan. 1939. Reasons are given for the development of the special variants of "Decimal Classification" which have been adopted, at any rate until the appearance of an improved new edition of the "C.D.U."

Wireless Patents

A Summary of Recently Accepted Specifications

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

ACOUSTICS AND AUDIO-FREQUENCY CIRCUITS AND APPARATUS

514 331.—Negative feed-back coupling used on the low-frequency side of a wireless receiver for volume control.

Philco Radio and Television Corpn. (assignees of J. F. Crowley). Convention date (U.S.A.) 8th May, 1937.

514 729.—Transformer arrangement for the negative feed-back circuit of an amplifier, particularly for low frequencies.

C. G. Mayo; H. D. McD. Ellis; and R. H. Tanner. Application date 6th May, 1938.

515 070.—Tone-control filter for eliminating needle-scratch, "mush," and surface-noise in audio-frequency amplification.

A. E. Barrett; C. G. Mayo; and H. Davies. Application date 23rd May, 1938.

515 090.—Moving-coil loud speaker with a laminated core and polarising coil designed to allow rapid magnetisation and de-magnetisation, without the formation of excessive eddy-currents.

H. Hughes & Son; D. O. Sproule; and A. J. Hughes. Application date 4th May, 1938.

515 348.—Automatic gain control system, based on the use of an auxiliary current, particularly applicable to low-frequency signal-mixing amplifiers fed from several sources.

A. D. Blumlein. Application date 30th March, 1938.

515 636.—Casing and resilient mounting for a piezo-electric crystal, particularly for use in a loud speaker or deaf-aid.

The British Thomson-Houston Co.; L. B. Ault; and W. A. Bocock. Application date 8th June, 1938.

AERIALS AND AERIAL SYSTEMS

513 961.—Compact design of frame aerial in the form of an edge-wound coil.

Pye and W. A. St. C. Smith. Application date 23rd April, 1938.

514 179.—Construction and assembly of the windings of a frame aerial of the enclosed or rigid type, suitable for use on aeroplanes or other moving craft.

F. J. Cleveland (Bendix Aviation Corpn.). Application date 28th April, 1938.

DIRECTIONAL WIRELESS

514 080.—Mobile system of blind-landing radio beacons for the various runways of an aerodrome.

G. L. Davies and G. H. Wintermute. Application date 20th February, 1939.

514 390.—Directive aerial of the "travelling wave" type in which the energy normally dissipated in the terminating impedance is fed back in phase with the arriving signals.

Telefunken Co. Convention date (U.S.A.) 4th May, 1937.

516 149.—Means for coupling and keying the two aerials of a directional transmitter of the over-lapping-beam type.

Marconi's W.T. Co. and B. J. Witt. Application date 21st June, 1938.

RECEIVING CIRCUITS AND APPARATUS

(See also under Television)

514 319.—Electric oscillation-generator of the Hartley type particularly for use in a band-spread system for tuning a multi-range wireless receiver.

Marconi's W.T. Co. (assignees of J. D. Reid). Convention date (U.S.A.) 30th April, 1937.

514 332.—Resilient support or mounting for the tuning coils of a multi-band wireless receiver.

Philco Radio and Television Corpn. (assignees of G. J. Barry). Convention date (U.S.A.) 25th May, 1937.

514 399.—Wire-and-pulley gearing for the tuning indicator of a wireless set, in which a jockey pulley is arranged to take up any lateral movement of the control spindle.

The General Electric Co. and S. G. Hunter. Application date 4th May, 1938.

514 439.—Highly-selective receiver in which an auxiliary channel of low selectivity is utilised to de-tune the H.F. circuits against "static" interference (addition to 467 263).

Electric and Musical Industries and W. S. Percival. Application date 5th May, 1938.

514 481.—Epicyclic gearing designed to allow a single tuning knob to drive the condenser spindle at two different rates, fast and slow.

E. K. Cole and A. Shackell. Application dates 8th April and 7th June, 1938.

514 486.—Detector circuit for deriving A.V.C. voltages which are operative as soon as the receiver is tuned to a given station and before the signal is heard in the loud speaker.

Philco Radio and Television Corpn. Convention date (U.S.A.) 8th May, 1937.

514 640.—Rejector and acceptor network, with a common magnetic core, for cutting-out "image" frequencies in a superhet receiver.

Johnson Laboratories Inc. (assignees of W. A. Schaper). Convention date (U.S.A.) 17th May, 1937.

514 641.—Wide-band aerial input circuit, with variable-permeability tuning, giving a constant ratio of inductance to resistance.

Johnson Laboratories Inc. (assignees of F. N. Jacob). Convention date (U.S.A.) 17th May, 1937.

514 685.—Negative-resistance circuit comprising a two-pentode combination and a quarter-wave transmission line particularly for use as a frequency-stabiliser.

Marconi's W.T. Co.; N. M. Rust; and J. D. Brailsford. Application date 14th April, 1938.

514 713.—Amplifier with negative feed-back and an output impedance which is maintained constant over a wide range of frequencies.

Standard Telephones and Cables; A. H. Roche; and S. J. Goullie. Application date 13th May, 1938.

514 723.—Frequency-changing network for automatic tuning control in a receiver of the superhet type.

Marconi's W.T. Co. (assignees of D. E. Foster). Convention date (U.S.A.) 13th March, 1937.

515 194.—High-frequency coupling circuit in which a movable powdered-iron core compensates for the increased ratio of inductance to resistance of the individual coils.

Johnson Laboratories Inc. (assignees of W. J. Polydoroff). Convention date (U.S.A.) 3rd June, 1937.

515 271.—Multi-stage amplifier with negative feed-back to prevent distortion and reduce the production of second and third harmonics.

Standard Telephones and Cables; D. H. Black; and A. H. Roche. Application date 27th May, 1938.

515 292.—Push-button receiver with means for making a clear-cut break in the motor-circuit at the precise tuning point.

E. K. Cole and A. W. Martin. Application date 17th June, 1938.

515 569.—Combination of a wireless set and loud speaker with an electric lamp of the plug-in or bayonet-joint type.

F. J. G. Van den Bosch. Application date 2nd June, 1938.

515 583.—Aerial input circuit which reduces interference " whistles " and cross-modulation by using negative feed-back on the longer waves.

Telefunken Co. Convention date (Germany) 5th June, 1937.

515 584.—Wireless set with delayed A.V.C. and a tuning indicator which responds to signals of a strength below the threshold value as well as to those above.

Telefunken Co. Convention date (Germany) 4th June, 1937.

515 597.—Wireless receiver in which the component parts of successive stages are carried on separate, detachable, screened panels.

Standard Telephones and Cables (communicated by R. F. L. d'Andriesens). Application date 17th June, 1938.

515 640.—Frequency-selective or band-pass circuit comprising parallel branches fitted with piezo-electric crystals and means for modifying their response to frequency shifts.

J. Robinson. Application date 8th June, 1938.

515 739.—Band-pass filter in which two or more unwanted frequencies can be given substantially infinite attenuation.

J. Robinson (addition to 509 040). *Application date 9th May,* 1938.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

514 155.—Television system in which the scanning-beam changes the point-to-point refracture index of an " image " screen in a cathode-ray tube.

Scophony and A. H. Rosenthal. Application date 18th March, 1938.

514 170.—Construction of a magnetic deflecting-coil for a cathode-ray tube designed to produce a more-uniform field.

The British Thomson-Houston Co. and D. J. Mynall. Application date 27th April, 1938.

514 271.—Separating synchronising impulses of given duration from those of a shorter duration, in television, by means of an artificial transmission line.

Baird Television and T. C. Nuttall. Application date 29th April, 1938.

514 297.—Electron multiplier used to give 100 per cent. modulation, particularly for transmitting television signals.

G. W. Walton. Application date 10th December, 1937.

514 304.—Inter-valve coupling network designed to give a uniform response over a wide frequency range, particularly suitable for handling television signals.

Marconi's W. T. Co. and N. M. Rust. Application date 14th April, 1938.

514 401.—Negative feed-back circuit for modifying the " contrast " range of a television receiver.

Baird Television and T. C. Nuttall. Application date 4th May, 1938.

514 509.—Circuit for separating the two sets of synchronising-impulses from the picture signals in television.

Marconi's W.T. Co. and D. J. Fewings. Application date 4th March, 1938.

514 554.—Separating the line and frame synchronising impulses used in television, particularly for interlaced scanning.

Baird Television and T. C. Nuttall. Application date 10th May, 1938.

514 643.—Television system in which one set of synchronising signals sent out on the picture channel, and the other set of synchronising signals on the sound channel.

Baird Television and P. W. Willans. Application date 11th May, 1938.

514 650.—Method of reversing the polarity of the signals in a television system using an intermediate film-record.

Fernseh Akt. Convention date (Germany) 12th May, 1937.

514 762.—Means for varying the mutual conductance of a valve amplifier utilising secondary emission, for instance in a television receiver.

Ferranti and G. M. Tomlin. Application date 3rd June, 1938.

514 776.—Television system in which coloured images are produced on two or more separate transparent screens and are then combined.

Scophony and A. H. Rosenthal. Application date 12th April, 1938.

514 807.—Separating the line and frame synchronising impulses in television systems using interlaced scanning.

The General Electric Co.; E. C. Cherry; G. W. Edwards; and B. J. O'Kane. Application date 3rd June, 1938.

514 825.—Protective device, particularly for the deflecting-coils of a cathode-ray television receiver.

E. L. C. White and A. D. Blumlein. Application date 13th April, 1938.

514 880.—Television system in which all the picture points are transmitted simultaneously, instead of in sequence.

H. J. Krusemeijer (void). Convention dates (Holland) 18th February, 1937, *and 26th January,* 1938.

514 940.—Cross-coupled valve or "multivibrator" circuit for generating the synchronising impulses used in television.

E. L. C. White. Application date 7th March, 1938.

515 158.—Negative feed-back circuit in which the effective output impedance of a "cathode-follower" valve approximates to that of the load. Utilised for feeding television signals to a low-impedance transmission line.

A. R. A. Rendall. Application date 25th May, 1938.

515 209.—Method of securing automatic gain-control in a television system in which the transmitted wave includes both whiter-than-white and blacker-than-black impulses.

Electric and Musical Industries and E. L. C. White (addition to 476 935). *Application date 18th May,* 1938.

515 210.—Circuit arrangements for separating signal impulses of different duration, particularly suitable for preventing the effect of "spark" interference on the reception of television signals.

E. L. C. White (addition to 491 728). *Application date 19th May,* 1938.

515 264.—Picture-image electron-multiplier for television with means for preventing de-focusing of the electron stream and consequent distortion of the picture.

H. G. Lubszynski. Application date 27th May, 1938.

515 301.—Photo-sensitive surface capable of producing a composite stream of electrons representing a picture image.

H. G. Lubszynski and L. Klatzow. Application date 29th March, 1938.

515 302.—Separating the frame and line synchronising impulses from the picture signals in a television receiver.

Pye; W. Jones; and B. J. Edwards. Application date 22nd April, 1938.

515 304.—Television receiver in which a series of evacuated tubes, forming a receiving-screen, are rendered luminous in proper sequence by an electron-beam commutator device.

Scophony and F. Okolicsanyi. Application date 29th April, 1938.

515 363.—Thermionic-valve switching-arrangement particularly suitable for supervising or testing the A.V.C. and other circuit conditions in a television amplifier.

J. Hardwick. Application date 30th May, 1938.

515 426.—Television receiver in which means are provided to prevent changes in the overall gain of the circuits from converting black signals into grey.

Ferranti; M. K. Taylor; and H. Wood. Application date 30th May, 1938.

515 427.—Circuit for separating the synchronising impulses from the picture signals in a television receiver, and for avoiding the effects of valve and other stray capacitances.

C. L. Faudell. Application date 31st May, 1938.

515 474.—Television system in which the basic frequency of the carrier-wave is shifted from one value for the picture signals to another value for the synchronising impulses.

W. A. Beatty. Application date 4th May, 1938.

515 853.—Impedance transformer for coupling a transmission line to a dipole aerial, and for minimising static interference with television signals.

Kolster-Brandes and P. K. Chatterjea. Application date 14th June, 1938.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

514 778.—Selective arrangement for a short-wave combined transmitter and receiver, such as is used on police patrol cars.

The British Thomson-Houston Co. Convention date (U.S.A.) 7th May, 1937.

515 047.—Modulating circuit in which separate stages handle the positive and negative half-waves, and power is taken in parallel during "peak" periods.

Marconi's W.T. Co. and N. H. Clough. Application date 22nd April, 1938.

515 101.—Means for reducing the emission of undesired electrons from the grid and anode of a short-wave oscillation-generator.

Marconi's W.T. Co. (assignees of C. W. Hansell). Convention date (U.S.A.) 21st May, 1937.

515 106.—Bridge circuit for producing a modulated signal in which all or part of the carrier-wave is suppressed.

Marconi's W.T. Co. (assignees of G. L. Usselman). Convention date (U.S.A.) 26th June, 1937.

515 241.—Transmission system in which a doubly-modulated carrier-wave is utilised to reduce the effect of atmospheric interference at the receiving end.

M. G. Fernandez and E. O. Figueroa. Application date 20th July, 1938.

515 546.—High-frequency amplifier of the Class-B type for a radio transmitter, in which means are provided to compensate for grid-current distortion.

Marconi's W.T. Co. and G. N. Coop. Application date 3rd June, 1938.

515 940.—Frequency-modulating system of the kind in which the carrier-frequency oscillator is controlled by changes in the plate impedance of an associated valve.

Standard Telephones and Cables (assignees of O. E. de Lange). Convention date (U.S.A.) 9th July, 1937.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

514 686.—Electrode arrangement of a valve, particularly for use as a "mixer" in a superhet receiver.

Marconi's W.T. Co. (assignees of E. W. Herald). Convention date (U.S.A.) 28th April, 1937.

514 854.—Preventing surface oxidation in the manufacture of oxide-coated cathodes for thermionic valves.

Standard Telephones and Cables and H. Wolfson. Application date 17th May, 1938.

514 967.—Construction of electron-discharge tube of the gas-filled, grid-controlled type.

The British Thomson-Houston Co. Convention date (Germany) 22nd May, 1937.

515 068.—Short-wave oscillation-generator in which a sharply-defined beam of electrons is made to pass in succession through the apertures of an electrode system.

Marconi's W.T. Co. and N. Levin. Application date 23rd May, 1938.

515 097.—Electron-multiplier with means for deflecting free ions out of the main path of the electron stream.

Farnsworth Television Inc. Convention date (U.S.A.) 5th June, 1937.

515 125.—Mounting and supporting under tension the cathodes of thermionic valves.

J. M. Dodds and Metropolitan-Vickers Electrical Co. Application date 8th June, 1938.

515 190.—Method of coating indirectly-heated cathodes in order to prevent "poisoning" of the active surface.

Marconi's W.T. Co. (assignees of E. A. Lederer). Convention date (U.S.A.) 27th May, 1937.

515 297.—Electron-multiplier arranged to give amplification first at a low ratio and subsequently at a high ratio.

Farnsworth Television Inc. Convention date (U.S.A.) 22nd March, 1937.

515 525.—Electron-multiplier with a low-temperature or "tepid" cathode for amplifying a wide frequency-band.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon). Convention date (France) 23rd June, 1937.

515 586.—Electron-discharge device in which the electrodes are arranged to facilitate dissipation of the heat generated.

Standard Telephones and Cables ; A. I. Vangeen ; and J. H. Whatling. Application date 7th June, 1938.

SUBSIDIARY APPARATUS AND MATERIALS

513 652.—Grid-controlled discharge tube using a low anode voltage, but in which a small applied input releases a large output of power.

Marconi's W.T. Co. (assignees of W. L. Meier). Application date (U.S.A.) 27th March, 1937.

513 970.—Oscillation "storage" circuit, with substantially no external field, for ultra-short waves.

Marconi's W.T. Co. (assignees of C. H. Brown). Convention date (U.S.A.) 23rd April, 1937.

514 066.—Power-control system utilising thermionic relays of the gas-filled type.

The British Thomson-Houston Co. Convention date (U.S.A.) 24th April, 1937.

514 469.—Circuit for converting or transposing frequencies, and for forming and selecting certain combination frequencies.

F. H. Stieltjes. Application date 19th January, 1938.

514 547.—Stabilising the high-voltage supply for high-frequency generators, particularly for induction furnaces.

H. Kikuchi. Convention date (Japan) 22nd November, 1937.

514 578.—Means for preventing "arcing" between the contacts of electromagnetically-operated switches.

J. A. Crabtree & Co. (communicated by Schiele Industriewerke). Application date 1st June, 1938.

515 027.—Variable-impedance bridge circuit for use with a cathode-ray oscilloscope or indicator.

Philips Lamp Co. Convention date (Holland) 24th May, 1937.

515 044.—Cathode-ray tube arrangement for giving the instantaneous value of alternating currents or voltages, either amplitude or phase, by direct reading.

A. D. Blumlein ; J. Hardwick ; and C. O. Browne. Application dates 23rd March and 19th August, 1938.

515 261.—Voltage "prod-indicator" designed to discriminate between the two possibilities (a) that the conductor under test is alive, or (b) that the circuit is defective.

A. Reynolle & Co. ; J. A. Harle ; H. Leyburn ; and M. Waters. Application date 27th May, 1938.

515 545.—Inductance coil with a "gapped" toroidal ferro-magnetic core, particularly for smoothing in a wireless H.T. supply unit.

Marconi's W.T. Co. ; F. M. G. Murphy ; and C. D. Colchester. Application date 3rd June, 1938.

516 034.—Rectifying circuit for supplying operating voltages to the electrodes of an electron multiplier.

The General Electric Co. ; W. H. Aldous ; and D. C. Espley. Application date 8th July, 1938.

516 137.—Preparation of the electrode surfaces used in dry-contact rectifiers and photo-electric cells.

Philips Lamp Co. Convention date (Germany) 24th June, 1937.