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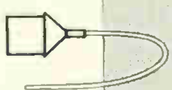

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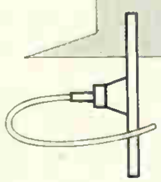

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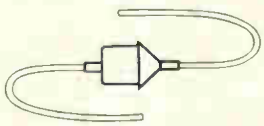

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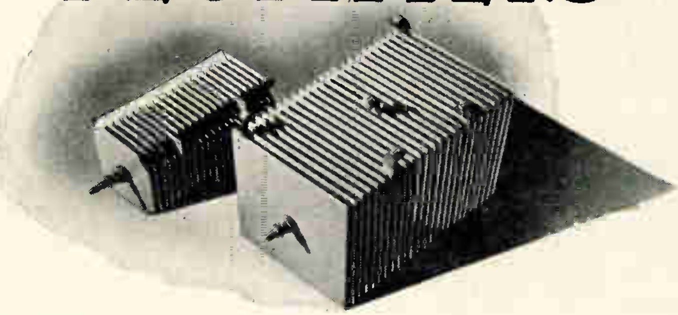

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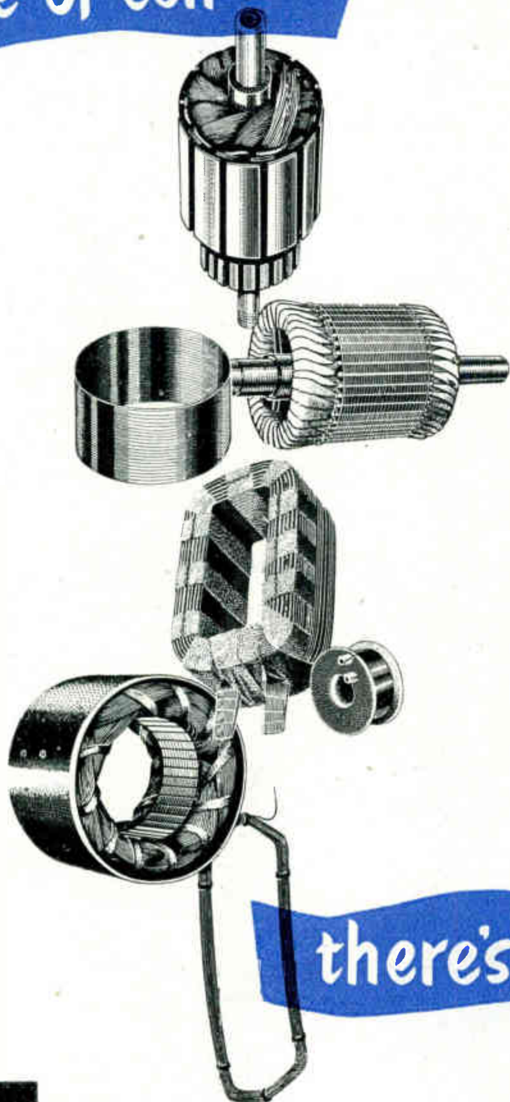

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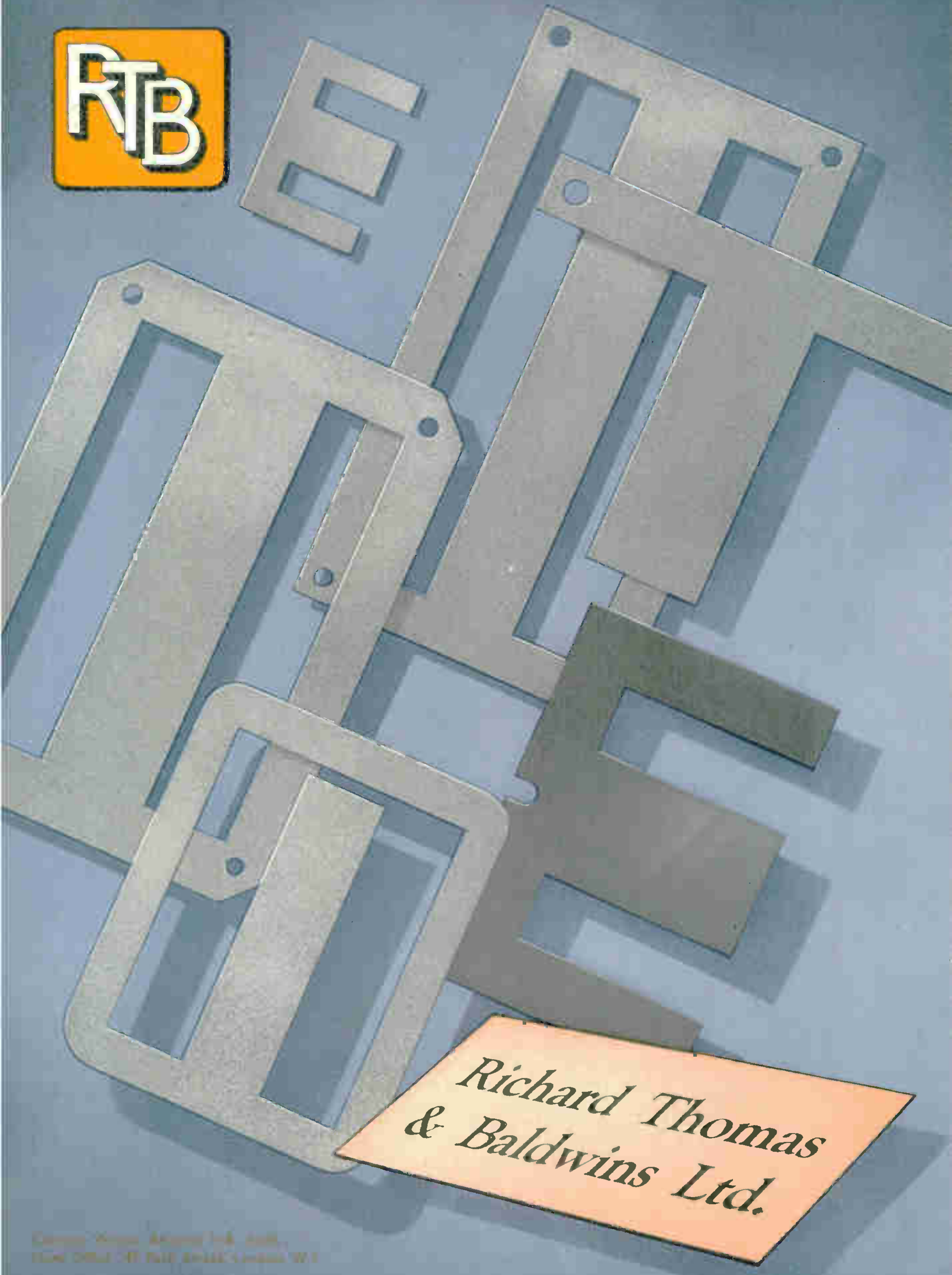
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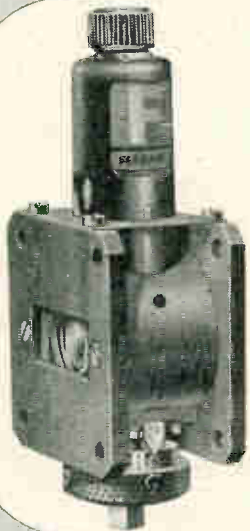

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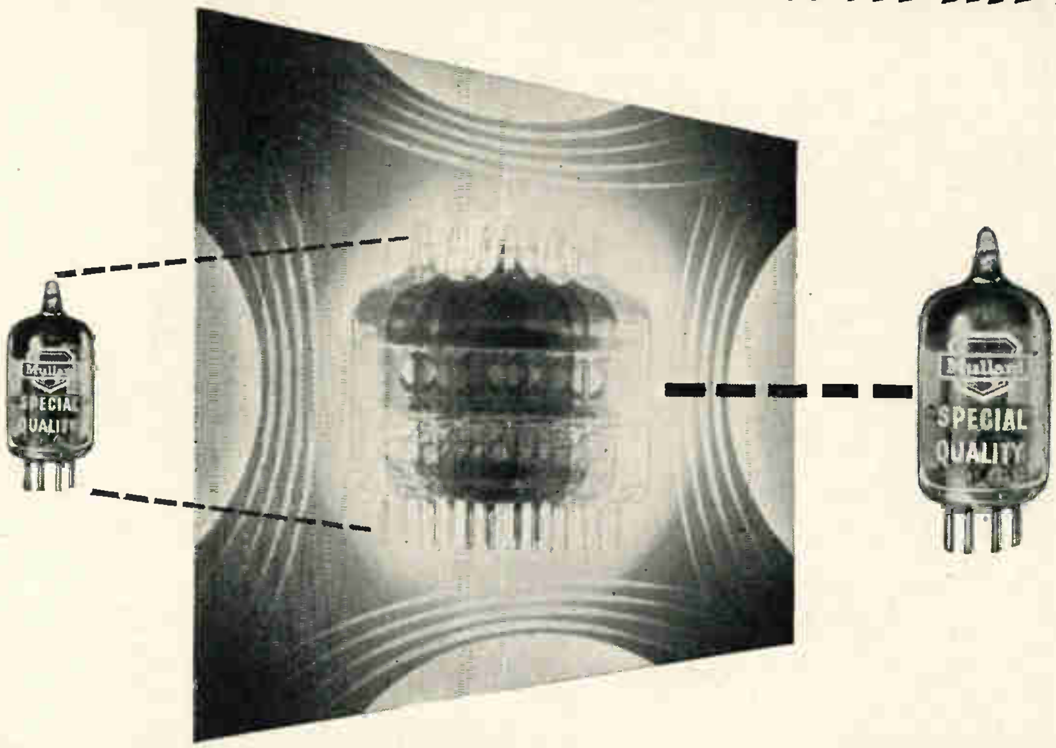

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A Heaviside-Lorentz Network Theorem

"THE decomposition of an arbitrary function into the sum of functions of special types has many fascinations. No student of mathematical physics, if he possesses any soul at all, can fail to recognize the poetry that pervades this branch of mathematics." (Oliver Heaviside Electrical Papers, Vol. II, p. 201.)

In our April Editorial we mentioned that in one of his last papers Lorentz developed a generalization of a little-known theorem of Heaviside. At the I.R.E. Convention in Sydney in August 1952, Professor B. D. H. Tellegen of Delft University, read a paper entitled "A General Network Theorem, with Applications", which was published in *Philips Research Reports*, 1952, p. 259, and also in the *Proc. Instn. Radio Engrs.* of Australia, November 1953. This covers a wider field, but one section is devoted to the Heaviside-Lorentz theorem, which we stated as follows:—Given a constant passive network at rest, if at time $t = 0$ a constant e.m.f. is suddenly applied to the network, in general, transients will occur. After a long time t_1 the transients may be considered to have died down, and only a direct current will, in general, be present in the network. The direct current (if there is any) will cause a Joulean heat dissipation at a constant rate per second. If we call W the pseudo heat dissipation which would have occurred if the constant final current had been present all the time from $t = 0$ to $t = t_1$, then the total amount of energy A supplied exceeds W by twice the excess of the stored electric energy U over the stored magnetic energy T; that is $A - W = 2(U - T)$.

We now propose to illustrate this by a simple example. We shall consider first the circuit of Fig. 1, then the circuit of Fig. 2, and finally the combination, as in Fig. 3.

In Fig. 1, on closing the switch, $V - v = R_1 i + L_1\, di/dt$, putting $i = C\, dv/dt$, $V - v = R_1 C\, dv/dt + L_1 C\, d^2v/dt^2$, and

$$\frac{d^2v}{dt^2} + \frac{R_1}{L_1}\frac{dv}{dt} - \frac{V - v}{L_1 C} = 0$$

The solution of this is $V - v = Me^{m_1 t} + Ne^{m_2 t}$. Since, when $t = 0$, $v = 0$ and $dv/dt = i = 0$

$$M + N = V \text{ and } Mm_1 + Nm_2 = 0$$

$$M = V\frac{m_2}{m_2 - m_1};\quad N = V\frac{m_1}{m_1 - m_2}$$

$$m_1 = -\alpha + j\omega;\ m_2 = -\alpha - j\omega$$

where $$\alpha = \frac{R_1}{2L_1};\quad \omega^2 = \frac{1}{L_1 C} - \left(\frac{R_1}{2L_1}\right)^2;$$

$$\alpha^2 + \omega^2 = \frac{1}{L_1 C}.$$

At any moment

$$v = V\left(1 + \frac{m_2}{m_1 - m_2}e^{m_1 t} - \frac{m_1}{m_1 - m_2}e^{m_2 t}\right)$$

and

$$i = C\frac{dv}{dt} = CV\left(\frac{m_1 m_2}{m_1 - m_2}\right)(e^{m_1 t} - e^{m_2 t})$$

$$= CV\left(\frac{\alpha^2 + \omega^2}{\omega}\right)e^{-\alpha t}\sin\omega t.$$

Since $\int_0^\infty e^{-\alpha t} \sin \omega t \, dt = \frac{\omega}{\alpha^2 + \omega^2}$, $\int_0^\infty i \, dt = CV$

which is, of course, the final charge on the capacitor. For the total amount of energy dissipated in R_1 we could put

$$\int_0^\infty i^2 R_1 \, dt = c^2 V^2 R_1 \frac{(\alpha^2 + \omega^2)^2}{\omega^2} \int_0^\infty e^{-2\alpha t} \sin^2 \omega t \, dt$$

$$= C^2 V^2 R_1 \frac{\alpha^2 + \omega^2}{4\alpha} = C^2 V^2 R_1 \frac{1/L_1 C}{4R_1/2L_1} = CV^2/2$$

but this is unnecessary, since the quantity of electricity CV was all supplied at the voltage V, and the total energy A_1 supplied was therefore CV^2; of this $CV^2/2$ was stored in the capacitor, and the remaining $CV^2/2$ was dissipated in R_1. This shows, as we stated before, that the efficiency of charging the capacitor is 50%, whatever the value of R_1.

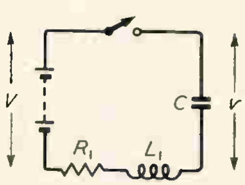

Fig. 1

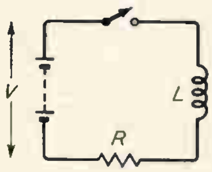

Fig. 2

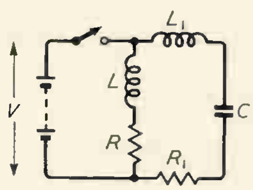

Fig. 3

In the simple case of Fig. 2 $i = \frac{V}{R}\left(1 - e^{-\frac{R}{L}t}\right)$.

The total amount of energy dissipated up to the time t_1 is

$$\int_0^{t_1} i^2 R \, dt = \frac{V^2}{R} \int_0^{t_1} \left(1 - 2e^{-\frac{R}{L}t} + e^{-2\frac{R}{L}t}\right) dt$$

$$= \frac{V^2}{R}\left(t_1 - 2\frac{L}{R} + \frac{L}{2R}\right) = \frac{V^2}{R}\left(t_1 - \frac{3}{2}\frac{L}{R}\right)$$

The first term is the energy that would have been dissipated if the current had jumped at once to its final value V/R. It is what van der Pol calls the pseudo dissipation W. In addition to the dissipated energy, the battery supplies the energy T stored in the magnetic field, viz., $\frac{1}{2}V^2 L/R^2$, so that the total energy supplied is

$$A_2 = V^2\left(\frac{L}{2R^2} + \frac{t_1}{R} - \frac{3L}{2R^2}\right)$$

of which the first term is the stored energy, the second term the pseudo dissipation which is proportional to t_1, and the last term the energy that was saved due to the initial current being smaller than its final value.

Combining Figs. 1 and 2 in the network of Fig. 3 we have for the total energy supplied

$$A = A_1 + A_2 = V^2\left(C - \frac{L}{R^2} + \frac{t_1}{R}\right)$$

Subtracting the pseudo dissipation $W = V^2 t_1/R$ we have $\quad A - W = V^2(C - L/R^2)$

and since $U = \frac{1}{2}V^2 C$ and $T = \frac{1}{2}V^2 L/R^2$

$$A - W = 2(U - T)$$

in accordance with the network theorem.

To illustrate the theorem we have chosen a very simple example. In the publications of Lorentz and in the recent paper by Tellegen much more complicated problems are considered, such as the application of variable and alternating voltages to complex networks. Tellegen states one question as follows. Can anything be said about the distribution of energy that depends only on the admittance matrix of a $2n$-pole network and not on the particular network used for realizing it? He arrives at the following result. If on a linear, constant, passive, gyratorless $2n$-pole at rest, constant voltages are suddenly applied, then, when the final state has been reached, the total energy delivered to the $2n$-pole exceeds the energy representing the loss by dissipation at the final rate, supposed to start at once, by twice the excess of the electric over the magnetic energy. The difference between the magnetic and the electric energy will at any moment depend only on the admittance matrix of the $2n$-pole and not on the particular network used for realizing it. This being true at any moment, it is true for the mean values.

This interesting theorem, which we have illustrated by a simple example, is thus of very wide application.

G. W. O. H.

CATHODE-COUPLED VALVES

Graphical Method of Design

By T. W. Brady, B.Sc.

Electronics Engineering Department, British Thomson-Houston Co., Ltd., Rugby)

Introduction

THIS paper will deal with a graphical method of solving cathode-coupled amplifier problems. By this term, Ross[1] and Lyddiard[2]—previous writers on the subject—meant the circuit shown in Fig. 1, in which one triode section acts as a cathode follower. The method to be described is quite general, however, and is demonstrated, applied to the circuit of Fig. 2.

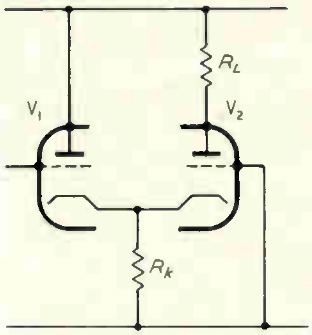

Fig. 1. *Simple cathode-coupled amplifier.*

First, it will be shown how the quiescent conditions of the amplifier in Fig. 2 may be represented on the anode characteristics of the valve. In this case the valve selected is a theoretically perfect Mullard ECC33, its characteristics being identical with published data.

Secondly, it will be shown how the dynamic operating conditions may be deduced, together with some notes on output impedance, and thirdly the design of the amplifier will be considered.

Quiescent Conditions

By a trial and error solution of the amplifier in Fig. 2 using the published data it can be shown that the quiescent conditions are as follows:—

$$E_{HT} = 300\ \text{V}$$
$$I_{a1} = 2{\cdot}1\ \text{mA}$$
$$V_{g1} = -5\ \text{V}$$
$$I_{a2} = 5{\cdot}4\ \text{mA}$$
$$V_{g2} = -3\ \text{V}$$
$$I_{a1} + I_{a2} = 7{\cdot}5\ \text{mA}$$
$$V_k = 15\ \text{V}$$

A copy of the anode characteristics is now taken (Fig. 3). Since 15 V exists across the cathode resistor R_k, this leaves 285 V across each triode section with its associated load resistor. The load lines (for 20 kΩ and 40 kΩ) are drawn in from the 285-V point on the abscissa. These lines are marked "20 kΩ, V_2" and "40 kΩ, V_1" respectively for easy reference.

MS accepted by the Editor, July 1953

A cathode-bias line is now drawn for each triode section. This term designates a line giving the net bias or grid voltage on the section for various currents through the cathode resistor. For example V_1 has a 10-V positive bias applied, so that if 5 mA were to flow through the 2-kΩ cathode resistor the net bias or grid voltage would be zero. Note here that this current may not be due to V_1 alone, but to a combination of currents through V_1 and V_2. Nevertheless the statement still holds true. So on the $V_g = 0$ grid-voltage curve a mark is plotted against 5 mA. Similarly, if 6 mA were to flow through the cathode resistor, the net grid voltage would be − 2 V. Therefore, on the $V_g = -2$-V grid-voltage curve a mark is plotted against 6 mA. Carrying the process further, a line is constructed and marked "V_1 Bias Line", for easy reference.

The whole process is repeated for V_2, giving a line higher than that for V_1 because of the higher applied positive bias. If by design the applied bias were the same for both triode sections, there would be only one bias line.

The next step is to draw composite load lines. These are lines which represent the sums of the anode currents of V_1 and V_2. Just as a normal load line gives the graphical determination of anode current when the grid voltage is known, the composite load line gives the sum of anode

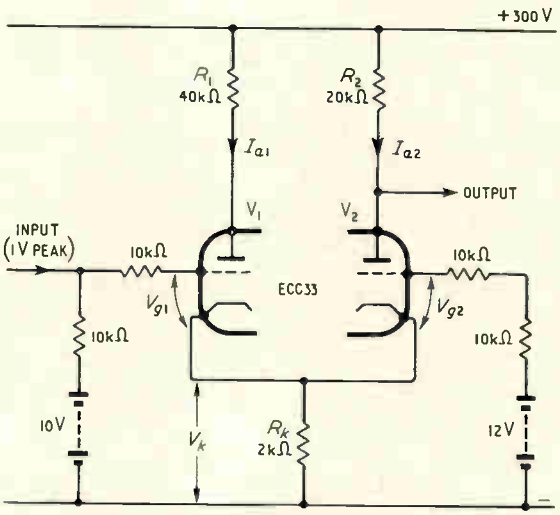

Fig. 2. *Form of amplifier treated in the text.*

currents for both sections when the grid voltages are known. However, since the grid voltages may be different for the two triode sections, these current sums when plotted must be referred to the grid voltage of one section and then to that of the other. The following description should make this clear.

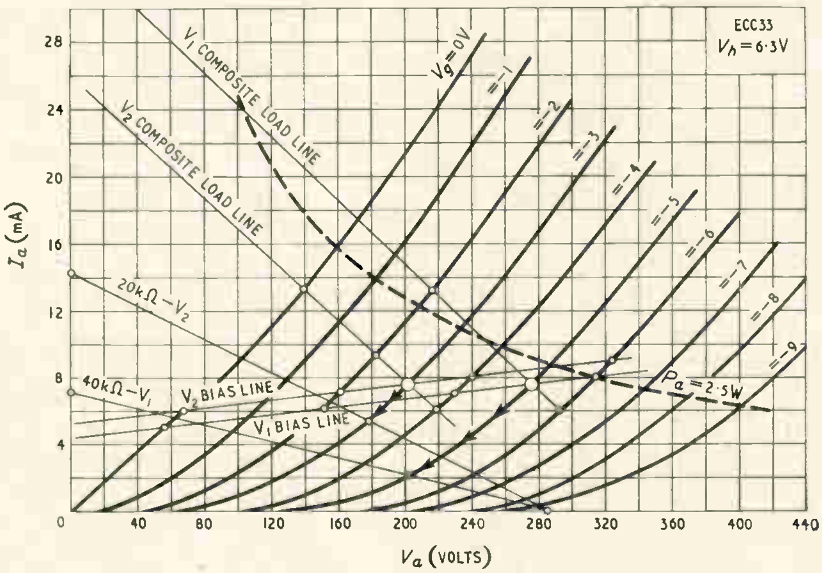

Fig. 3. *Construction for determining the quiescent operating conditions.*

Whatever the net bias or grid voltage of V_1 may be, the grid voltage of V_2 is 2 V greater because of the higher applied positive bias. Therefore the anode currents of V_1 at integral values of its grid volts are measured, and to these are added the anode currents of V_2 at corresponding values of grid volts. For example, the anode current of V_1 at $V_{g1} = -2$ V is 4 mA and the anode current of V_2 at $V_{g2} = 0$ is 9·2 mA. The sum is therefore 13·2 mA and this is plotted on the $V_g = -2$-V grid line, since $V_{g1} = -2$ V for this condition. Proceeding in this manner yields a composite load line for V_1.

The composite load line for V_2 follows by plotting the current sums obtained previously, at values of grid voltage 2 V greater than for V_1. This means the current sums are referred to V_2, by transposing them to the left by 2 grid volts on the graph.

Before proceeding further with the construction, a point must be explained in connection with the load lines and composite load lines. It has been assumed throughout that the voltage on the abscissa from which the load lines are drawn is 285 V. This is only true for the combination of anode currents which make a sum of 7·5 mA, so producing a drop of 15 V across the cathode resistor. Any increase in this current should cause the load lines to be drawn from a point on the abscissa to the left of the 285-V mark, while a decrease in current should cause the load lines to be drawn from a point to the right. The composite load lines would therefore move left and right of their present positions.

However, when the voltage drop across the cathode resistor is 15 V, the quiescent conditions must be along the load lines and composite load lines just drawn. In the construction so far, these lines must be regarded as devices to find information and not the loci of valve conditions. These will come later.

Coming back to the construction, the intersections of the composite load lines with the corresponding bias lines give the net grid voltage of each triode section, and also each intersection gives the total current through the cathode resistor, which must be the same in each case. (This is a check on the construction.) Considering each triode section in turn, the grid voltage curve must be followed down from each intersection of composite load and bias lines until the corresponding triode-section load line is encountered. This yields the individual quiescent conditions for the triode section. Thus for V_1 the conditions are 2·1 mA and 84 V across the 40-kΩ anode load resistor, and for V_2 5·4 mA and 108 V across the 20-kΩ load resistor. The net grid voltages are − 5 V and − 3 V respectively.

On reflection, it may now appear that a good deal of this construction is unnecessary. Since the voltage drop across the cathode resistor is known to be 15 V, the net grid voltages are immediately known to be − 5 V for V_1 and − 3 V for V_2. These points could have been plotted on the load lines at once and the rest of the construction ignored. However, composite load lines must be drawn to obtain dynamic operating conditions, and for the initial design of an amplifier.

Dynamic Conditions

Assume for the sake of argument that a positive signal of 1 V peak is injected into the grid of V_1. The instantaneous conditions are required at the limit of grid swing. These could be obtained by starting afresh and completely replotting, and before discussing an easier way it may be as well to describe the essentially new steps.

V_1 has now effectively 11 V positive bias applied, and not 10 V as before. Therefore it needs a new bias line. Moreover, the composite load lines must be redrawn since the net grid voltage on V_1 must be 1 V less than V_2 and not 2 V as before. As an example the anode current of V_1 at $V_{g1} = -2$ V is 4·0 mA, and to this must be added the value of V_2 anode current at $V_{g2} = -1$ V, that is 7·8 mA. The total of 11·8 mA is plotted on the $V_g = -2$-V line for V_1 composite load line, and on the $V_g = -1$-V line for V_2 composite load line.

All of this work is not required, however (Fig. 4). It is known that V_2 bias line will not be changed in position since no signal has been injected on the grid of V_2. Therefore, the first step is to draw the new composite load lines and find where the new composite load line for V_2 meets the old (and still valid) bias line for V_2. This point is the new composite load–bias line intersection for V_2. Moving horizontally to the right until the new composite load line for V_1 is met gives the new intersection for V_1.

A further, or rather alternative, simplification is to draw the new composite load line for V_2 only, find the composite load–bias line intersection for V_2 as before, and then move horizontally to the right by a distance equivalent to 1 grid volt. Both of these methods are shown in Fig. 4.

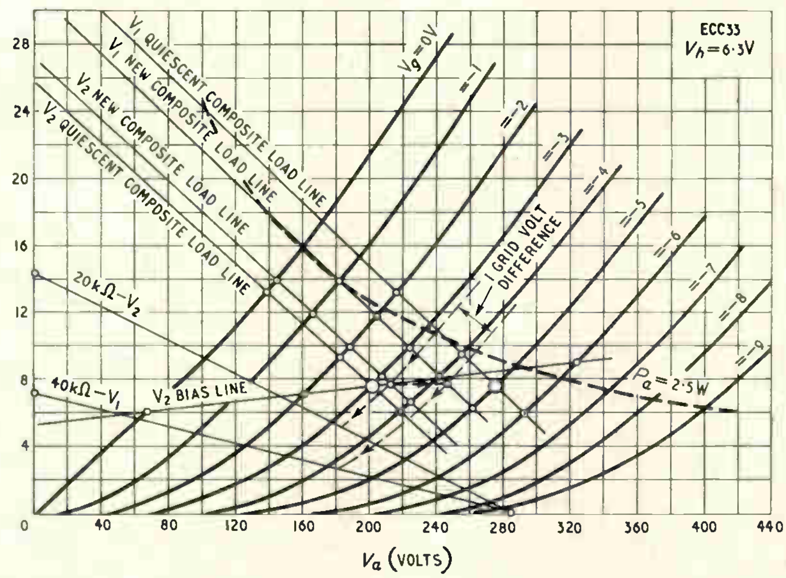

Fig. 4. *Construction for obtaining the dynamic operating conditions.*

Once the intersections are found, the grid voltage curves must be followed down to the load lines as before. The conditions obtained are:—

$$I_{a1} = 2{\cdot}6 \text{ mA}$$
$$V_{g1} = -4{\cdot}2 \text{ V}$$
$$I_{a2} = 5{\cdot}05 \text{ mA}$$
$$V_{g2} = -3{\cdot}2 \text{ V}$$
$$I_{a1} + I_{a2} = 7{\cdot}6 \text{ mA}$$
$$V_k = 15{\cdot}2 \text{ V}$$

Voltage across R_1 = 104 V.

Voltage across R_2 = 101 V.

The voltage gain from V_1 is therefore 20 and from V_2 about 7.

Two things will immediately be noticed about these results. First, I_{a1} and I_{a2} measured separately do not add up to $I_{a1} + I_{a2}$ measured at either (or both) of the composite load–bias line intersections. This is mensuration error. Second, the voltage across the cathode resistor is 15·2 V and not 15 V. Strictly speaking, therefore, the load lines are not based correctly, but since in practice it is very difficult to plot a voltage correct to 0·2 V on the abscissa of the anode characteristics, this fact may be ignored.

The dynamic load lines may not be the same as the steady-state or quiescent load lines as they were in the example. If such a case arises, the composite load–bias lines intersections and quiescent points on the load lines must be obtained first, the dynamic load lines are then drawn through the quiescent points (in the case of resistance loads) or based on the quiescent points for reactive loads. New composite load lines must be constructed for dynamic operation, but the procedure is as before.

An interesting construction follows from this. A vertical line drawn through a triode-section quiescent point represents zero dynamic load resistance. That would be physically a capacitor of infinite capacitance connected between the anode of the section (say V_2) and negative h.t. This, of course, is a dynamic short circuit at any frequency however low, and the construction may now be used to find the output impedance of the circuit if the output is taken from V_2.

To find the output impedance an arbitrary input signal is chosen, and the output voltage is found by the construction demonstrated. The construction is then repeated with zero dynamic load resistance, and from this the increase in V_2 anode current is obtained. By dividing the output voltage by the increase in current the output impedance is calculated. Readers will recognize that an open-circuit and short-circuit test has been carried out (on paper), and this is the recognized way of measuring output impedance.

An analytical solution of the output impedance yields the formula:—

$$Z_{out} = R_2\left(\frac{[(\mu_2 + 1)(r_{a1} + R_1) + (\mu_1 + 1)\,r_{a2}]\,R_k + r_{a2}(R_1 + r_{a1})}{[(\mu_2 + 1)(r_{a1} + R_1) + (\mu_1 + 1)(r_{a2} + R_2)]\,R_k + (R_1 + r_{a1})(R_2 + r_{a2})}\right)$$

To solve this formidable expression numerically, the parameters must be extracted from the valve anode characteristics, so the graphical method just enumerated is very much simpler and quicker.

Design

A problem arises in the application of this method to amplifier design, which is that since the value of voltage across the common cathode resistor is not known initially, the voltage from which to drawn the load lines is not known either. The practical solution is to draw the bias lines in first, since these do not alter with supply voltage, and then to draw the load lines from the value of supply voltage. In the previous construction, this of course was 300 V. One composite load line is now drawn, and this will give the net grid voltage on the triode section selected, usually within a fraction of a volt of its true value. Thus the drop in voltage across the common cathode resistor is known very nearly. As a practical example, a first cast at this problem gave a net grid voltage on V_2 of $-3{\cdot}3$ V; this meant that approximately 15 V existed across the cathode resistor, and this was then subtracted from the supply voltage to give 285 V, from which point the load lines were drawn. If a quick approximate solution is required, it is often possible to estimate the voltage across the common cathode resistor by drawing the load lines and bias lines only, since it is known that the quiescent point for a triode section must lie along its bias line, and also must lie to the right of the load line of smaller anode resistance. This follows, of course, because both composite load lines must lie to the right of the load line of smaller anode resistance.

It may be remembered that when dynamic conditions were obtained for the amplifier in Fig. 2, the change in voltage across the cathode resistor was neglected. This was justified at the time. In general, it is safe to neglect this change unless signals of the order of a few volts (or greater) are injected.

Conclusion

This method gives a solution to all cathode-coupled amplifier problems, without the necessity of drawing separate special curves or resorting to formulae. While it is not possible to refer immediately to a derived set of curves (vide Ross), amplifiers can be designed using this construction, as common RC-coupled amplifiers are designed by drawing simple load lines on the same valve anode characteristics.

Several variations of this scheme are possible, and it is quite easy to use a simpler construction if we are quite familiar with the theory. For example, it is not really necessary in Figs. 3 and 4 to draw the bias line and composite load line for V_1, since when the composite load–bias line intersection for V_2 is found, the corresponding point for V_1 can be found by moving horizontally to the right by the corresponding grid voltage difference.

The method has two disadvantages. First, it requires a trial solution to determine the voltage across the cathode resistor in the quiescent case, and secondly, it is difficult to determine small voltage changes accurately. However, since an actual valve performance is very rarely the same as the published data, small voltage changes deduced from a graph of any sort are only approximate to say the least.

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MEASUREMENT OF WAVEGUIDE IMPEDANCE

Use of Simple T Junction

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SUMMARY.—The two symmetrical limbs of a right-angled T junction are connected to a waveguide section with a sliding-short termination and to the impedance under test respectively. The other limb is connected to the source of oscillations. Voltage is measured by means of a small pick-up probe at a fixed point in the limb connected to the impedance under test. The unknown impedance is found from observations of the voltage resonance which occurs when the sliding-short is adjusted. The apparatus can be used over a wide frequency band.

1. Introduction

WAVEGUIDE impedance is usually measured either by the standing-wave method or by the 'magic T' waveguide bridge. Both these methods, and particularly the standing-wave method, have been so successful that there has been a tendency for other possible methods to be overlooked completely or not considered in detail. The present method, which does not appear to have been previously considered, utilizes a resonance technique which is well known at lower frequencies. Like the standing-wave indicator, the apparatus can be used over a wide frequency band.

The resonance technique involved is that in which a circuit is adjusted to resonance by altering a known standard component. For example, in the Hartshorn and Ward method for the measurement of dielectric constant[1] and in the Q meter, the system is tuned to resonance by adjusting a standard capacitor. In the present adaptation, the standard component takes the form of a section of waveguide with a movable short-circuiting termination. The input reactance or susceptance of this waveguide section can be calculated theoretically from its length and the characteristic impedance of the waveguide. Theoretically, if losses are negligible, it can be made to vary continuously from minus infinity to plus infinity by sliding the short-circuiting termination along the length of the waveguide.

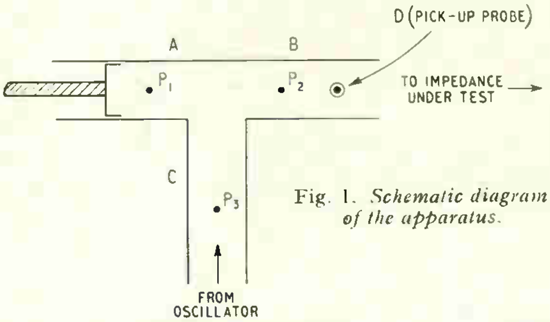

Fig. 1. *Schematic diagram of the apparatus.*

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The arrangement is shown in Fig. 1. The sliding short-circuit moves in one of the symmetrical limbs, A, of a simple right-angled T junction, and the other symmetrical limb, B, is terminated with the impedance under test. Power enters the junction via the third limb, C, and a voltage pick-up probe is placed at a fixed point, D, in the limb B.

2. Theory of the Method

The method depends for its action on the use of *characteristic points*, the idea of which was introduced by Allanson, Cooper and Cowling.[2] Let P_1, P_2 and P_3 be characteristic points in the limbs A, B and C respectively. It is assumed that the waveguides transmit freely only the fundamental mode, and that P_1, P_2 and P_3, as well as the sliding-short, pick-up probe, impedance under test and the oscillator, are sufficiently far away from the junction for the evanescent higher-order modes formed there to have decayed to a negligible amount. It is also assumed that the junction itself contained between the points P_1, P_2 and P_3 is free from loss.

Let the source, as seen from P_3 and looking away from the junction, be equivalent to an ideal voltage source, E, with an internal series impedance, Z_3. Let the impedances in the other two limbs, referred to the points P_1 and P_2, and looking away from the junction, be Z_1 and Z_2 respectively. Then it can be shown that the voltage at either of the points P_1 or P_2 can be written as V where

$$V = \frac{\alpha}{\beta}\frac{E}{Z_3}\Big/\left(\frac{\alpha^2}{\beta^2 Z_3} - \frac{1}{\beta^2} + \frac{1}{Z_1} + \frac{1}{Z_2}\right) \quad \ldots \quad (1)$$

and where for a given frequency of oscillation, α and β are constants, the squares of which are pure reactances. (1) can be written as

$$V = i/(A_s + A_1 + A_2) \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where $i = \frac{\alpha}{\beta}\frac{E}{Z_3}$, $A_s = \frac{\alpha^2}{\beta^2 Z_3} - \frac{1}{\beta^2}$, $A_1 = \frac{1}{Z_1}$ and $A_2 = \frac{1}{Z_2}$.

Now a system comprising a constant-current source, i, with an internal shunt admittance, A_s, further shunted by admittances A_1 and A_2, as shown in Fig. 2, has a voltage, V, across it which can be calculated from an equation identical with (2). The circuit of Fig. 2 is, therefore, an exact equivalent circuit of the waveguide system. A_1 and A_2 are admittances referred to P_1 and P_2 of Fig. 1 respectively, looking away from the junction, and V is the voltage at either P_1 or P_2. If V can be measured, by making A_1 a known variable susceptance, the circuit can be used to measure A_2. Put $A_1 = jY_1$ and $A_2 = G_2 + jY_2$.

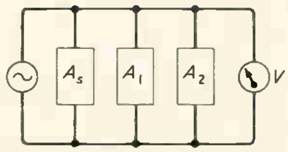

Fig. 2. *Equivalent circuit of Fig. 1—parallel resonance.*

If L_1 is the distance of the sliding-short from P_1, Y_1 can be calculated in terms of L_1. Neglecting losses,

$$Y_1 = -\frac{1}{Z_0}\cot\frac{2\pi}{\lambda_g}L_1$$

where Z_0, the characteristic impedance, and λ_g, the wavelength in the waveguide, can be calculated from its dimensions.

The unknown susceptance can be found as follows. Let Y_1' be the value of Y_1 for which V is a maximum with A_2 present. Let Y_1'' be the value of Y_1 for which V is a maximum with A_2 removed. Then

$$Y_2 = Y_1'' - Y_1' \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

With the waveguide apparatus, to make the measurement with A_2 removed, A_2 is to be replaced by a quarter-wavelength of guide with a short-circuit termination.

To determine the unknown conductance, G_2, three methods are available:

(a) Measure $\Delta Y_1'$ and $\Delta Y_1''$, the changes in Y_1 needed to tune the system between the half-power points with A_2 present and with A_2 removed respectively. Then

$$G_2 = \tfrac{1}{2}(\Delta Y_1' - \Delta Y_1'') \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

(b) Let V' and V'' be the resonant values of V with A_2 present and with A_2 removed respectively. Then

$$\frac{G_s}{G_s + G_2} = \frac{V'}{V''} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

where G_s is the conductive part of A_s. If G_s is known, G_2 can be found by measuring V' and V''.

(c) Having found Y_2, use the apparatus to measure the susceptance Y_2' of A_2 as seen through a quarter-wavelength of guide. Then

$$G_2 = \sqrt{-\frac{Y_2}{Z_0^2 Y_2'} - Y_2^2} \quad \ldots \quad \ldots \quad (6)$$

This method has the advantage that the voltmeter is only required to indicate resonance, and therefore need not be calibrated.

In the above discussion, V is the voltage at the characteristic points P_1 or P_2. Now as far as variation in the position of the sliding-short only is concerned, the voltage at any point not too close to the junction along the limb containing P_2 will be proportional to V. This means that the same values will be obtained for Y_1', Y_1'', $\Delta Y_1'$ and $\Delta Y_1''$ with a pick-up probe placed at any point not too close to the junction along the limb containing P_2. Therefore, as far as these measurements are concerned, the pick-up probe need not be at the characteristic point P_3. This is important, because the positions of the characteristic points vary with frequency, and had it proved necessary to have the pick-up probe exactly at the characteristic point, the apparatus, once the hole had been drilled for the probe, would only be usable at a fixed frequency.

In a similar way, the probe need not be at the characteristic point if method (c) is used to measure G_2. It must, however, be at the characteristic point for method (b).

The hole for the probe and the depth of insertion of the probe should be small, to avoid distortion of the field. Rather more distortion is allowable when the probe is exactly at the characteristic point, because the distortion effectively forms an admittance in parallel with A_s. If the probe is not adjusted during a measurement, this admittance may then be considered to be part of A_s.

The positions of the characteristic points can be calculated theoretically, but they can more easily be found experimentally. Thus the sliding-short will be an integral number of half-wavelengths from P_1 when it is adjusted until there is no voltage at the pick-up probe. The characteristic points along the two symmetrical limbs will, of course, be symmetrically arranged with respect to the centre of the junction.

If the values of E, Z_1, Z_2 and Z_3 are E', Z_1' Z_2' and Z_3' when referred to points P_1', P_2' and P_3' distant $\lambda_g/4$ away from the points P_1, P_2 and P_3 respectively, it can be shown that the current at the point P_2' can be written as i' where

$$i' = -\frac{\alpha}{\beta}E' \bigg/ \left(\frac{\alpha^2}{\beta^2}Z_3' - \frac{Z_0^2}{\beta^2} + Z_1' + Z_2'\right) \quad (7)$$

Equation (7) indicates a *series* resonance method for *impedance* measurement. The equivalent circuit is shown in Fig. 3. Z_1' is a known variable reactance. Since, as far as variation of Z_1' only is concerned, the current i' at P_2' is proportional to the voltage at any point not too close to the junction along the limb containing P_2, it follows that the apparatus can be used for the determination of impedance by a series-resonance method. That is, the same apparatus can be used either for admittance measurements with the circuit of Fig. 2, or for impedance measurements with the circuit of Fig. 3. In the admittance measurements, the admittance under test is to be referred to the characteristic point P_2. In the impedance measurements, the impedance under test is to be referred to the point P_2' distant $\lambda_g/4$ away from P_2.

3. Experimental Work

To test experimentally the efficacy of the method, a T junction was made from rectangular ½-in. by 1-in. brass waveguide. The junction was an H-plane junction; that is, the plane of the T was parallel to the magnetic vector and the long side of the waveguide. The limb of the junction, which was at right angles to the other two limbs, was coupled, via an attenuator to provide "padding", to a CV 129 oscillator. One of the other limbs contained the sliding short-circuit, which was a plunger making mechanical contact with the waveguide wall a distance $\lambda_g/4$ in front of the short. The plunger was driven by means of a micrometer head. The remaining limb was terminated with a coupling flange for connection to the impedance to be tested, and the pick-up probe was inserted through a hole drilled through the centre of the long side of the waveguide at a point along this limb. This hole had a diameter of 0·220 cm and was 6·294 cm from the centre of the junction. This was not a characteristic point for the free-space wavelength of 3·200 cm at which the measurements described below were carried out. The pick-up probe had a diameter of 0·125 cm and was tunable, the energy picked up being fed to a detector unit with a square-law characteristic.

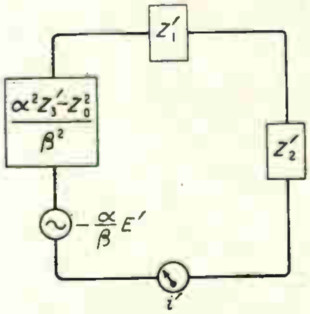

Fig. 3. *Equivalent circuit of Fig. 1—series resonance.*

To test the apparatus as an admittance-measuring device, it was used to measure the susceptance of a length of waveguide with a sliding-short termination similar to the one incorporated in the apparatus. The susceptance measured was then calculated theoretically, and experimental and theoretical results were compared. The positions of the characteristic points in the limbs containing the sliding-shorts were found by the method described in the last section. The short on the waveguide section being measured was then set at an arbitrary point and the other short adjusted until the detecting apparatus indicated resonance. The distances L_1 and L_2 of the shorts from their respective characteristic points were then obtained from the micrometer head settings. At resonance

$$Y_s + Y_1 + Y_2 = 0$$

where Y_s is the susceptance part of A_s.

$$\text{i.e.,}\quad Y_s - \frac{1}{Z_0}\left(\cot\frac{2\pi}{\lambda_g}L_1 + \cot\frac{2\pi}{\lambda_g}L_2\right) = 0 \qquad (8)$$

For most of the experiments, the pick-up probe was not actually inserted into the waveguide, but was withdrawn so that the tip of the probe was approximately level with the waveguide wall.

Fig. 4 shows a graph of cot $2\pi L_1/\lambda_g$ plotted against cot $2\pi L_2/\lambda_g$. That is, the normalized susceptance Z_0Y_1 is plotted against the normalized susceptance Z_0Y_2. The graph shows a straight line of slope -1 as required according to equation (8). The intercepts give a normalized susceptance Z_0Y_s equal to $-0{\cdot}24$. The table below gives some results for numerically-large normalized susceptance values.

TABLE

$Z_0Y_1 \cot\frac{2\pi}{\lambda_g}L_1$	4·74	3·75	14·6	23·9	−19·8	−5.22
$Z_0Y_2 \cot\frac{2\pi}{\lambda_g}L_2$	−5·24	−3·92	−16·8	−27·3	18·2	4·74

There is increasing uncertainty regarding the susceptance values as the numerical value of the normalized susceptance increases. This limitation arises because the short circuits are then very close to the characteristic points. The percentage errors in the measurement of L_1 and L_2 are then great, and also for these very high susceptance values, the effects of the finite conductivity of the waveguide wall become important. Thus a waveguide section an integral number of half wavelengths long can never form an exact short circuit. Losses due to the finite conductivity of the waveguide wall have been ignored in the theory, but they are not peculiar to this particular method.

As an example of the measurement of a

conductance, results are given below for the measurement of the input admittance of a section of waveguide containing a variable vane-type attenuator adjusted to a nominal value of

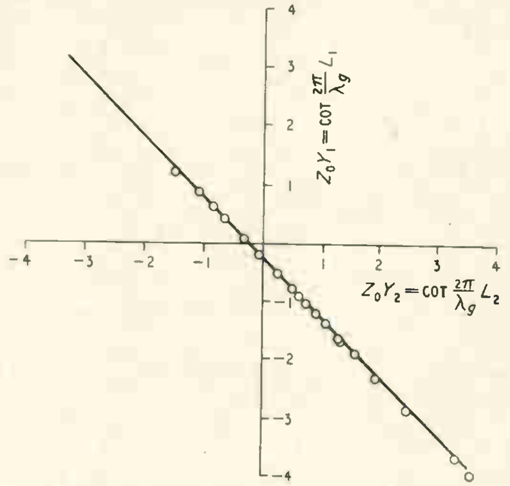

Fig. 4. *Graph of normalized susceptance in arm A plotted against normalized susceptance in arm B.*

25 db. The conductance measurement was made by the half-power method. The values obtained were as follows:—

$$Z_0 G_s = 0{\cdot}66 \qquad Z_0 Y_s = -0{\cdot}24$$
$$Z_0(G_s + G_2) = 1{\cdot}82 \qquad Z_0(Y_s + Y_2) = -0{\cdot}36$$

From these equations, $Z_0G_2 = 1{\cdot}16$ and $Z_0Y_2 = -0{\cdot}12$. Hence $Z_0A_2 = Z_0(G_2 + jY_2) = 1{\cdot}16 - 0{\cdot}12j$, from which it can be seen that the attenuator, as adjusted, formed a load which was approximately matched to the waveguide.

The results obtained seem to indicate that the accuracy of the method compares quite favourably with that of other methods at these wavelengths. The apparatus is easy to make, and the simplicity of the operating technique possibly offers scope for its use in industry.

Acknowledgments

Thanks are due to Professor L. S. Palmer for his interest and for providing the research facilities. D. P. Saville is indebted to the Council of the University College of Hull for the award of a Research Studentship.

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HARMONIC DISTORTION AND NEGATIVE FEEDBACK

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THE effect of negative feedback on distortion has lately been the subject of a good deal of attention.* It has been known for many years that the use of negative feedback gives an improvement in distortion which is not accurately expressed by the factor $(1 + A\beta)$. This fact is to be expected since the gain A is not clearly defined in non-linear conditions. In addition, negative feedback reduces harmonics generated by the amplifier but produces new harmonics, so that even the term 'distortion' cannot be clearly defined.

In his article R. O. Rowlands gives a quantitative expression for the improvement of distortion by feedback. His most important conclusion is given in the statement that distortion due to a flat part of the V_o/V_i curve is not improved by negative feedback. While this is true in the case discussed by Rowlands, it is not generally true.

In the following, a detailed treatment is given of many possible cases and the effect of negative feedback is analysed for each.

At the start it is important to define the gain of an amplifier. When conditions are linear there is no ambiguity in the normal definition. In plotting the graph of output voltage against input voltage we can take the ratio of instantaneous output voltage to instantaneous input voltage, or we can take, for an assumed sinusoidal input, the ratio of the amplitudes of signal frequency. Both definitions give the same value of gain.

When the amplifier is non-linear the conditions are no longer so simple. The ratio of instantaneous output voltage V_o to instantaneous input voltage V_i depends now on the magnitude of the input voltage and can, therefore, be defined only for a given input voltage. But, for a sinusoidal input, the ratio V_o/V_i for maximum V_i is usually not the same as the ratio of the amplitudes of the fundamental frequency.

*R. O. Rowlands, "Harmonic Distortion and Negative Feedback", *Wireless Engineer*, June 1953; correspondence *Wireless Engineer*, September, October, November 1953.

MS accepted by the Editor, January 1954

Referring to Fig. 1, curve 1, assume that $V_o = aV_i - cV_i^3$ and $V_i = E \sin \omega t$, then for $V_i = E$, we have $V_o/V_i = a - cE^2$ but, since $\sin^3 \alpha = \frac{3}{4} \sin \alpha - \frac{1}{4} \sin 3\alpha$, it follows that the ratio of the amplitudes of angular frequency ω is $a - \frac{3}{4} cE^2$; this shows that one has to be careful when defining gain in a non-linear amplifier.

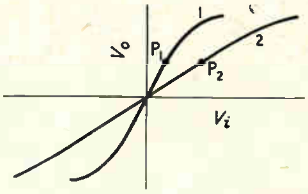

Fig. 1. *Curves representing amplifier characteristics* (1) *without feedback and* (2) *with feedback.*

The two definitions of gain give, however, the same result, if we apply them to the incremental gain dV_o/dV_i, at any point of the V_o/V_i curve. Assume, for instance, that in Fig. 1, the curves 1 and 2 give the relation between V_o and V_i without and with feedback respectively. Then for points on the curves with identical output (P_1 and P_2) the amplifier itself works under the same conditions; hence the incremental gain

$$\frac{dV_o}{dV_i} \text{ (at } P_2) = \frac{dV_o}{dV_i} \text{ (at } P_1)/(1 + A\beta),$$

A being the incremental gain at P_1. If, in curve 1, we express V_i as a function of V_o

$$\left(\text{i.e., if } V_i = F(V_o) \text{ and if } \frac{dV_i}{dV_o} = \frac{1}{A}\right)$$

we may write

$$V_i = \int_0^{V_o} \frac{1}{A} \, dV_o$$

where A may now be considered to be a function of V_o. Then, in curve, 2,

$$V_i = \int_0^{V_o} \frac{1 + A\beta}{A} \, dV_o = F(V_o) + \beta V_o.$$

The result, naturally, follows from the definition of feedback and shows clearly the relation between the two curves. If the input required for a given V_o is V_i in curve 1 and V_i' in curve 2, the above formula gives

$$\frac{V_i'}{V_i} = \frac{V_i + \beta V_o}{V_i} = 1 + \beta \frac{V_o}{V_i}.$$

Now V_o/V_i is the average slope A_{av} of curve 1. Thus it is seen that the average slope A_{av} of a V_o/V_i curve is reduced by feedback in the ratio $1 + A_{av}\beta$. (The fact is stated by F. G. Kerr in his letter in *Wireless Engineer*, September 1953.) It is, therefore, reasonable to use the average slope to define the gain of a non-linear amplifier, although this slope does not give the ratio of the amplitudes of fundamental frequency. In practice this fact should not matter, because only in cases of excessive distortion will the latter ratio differ appreciably from A_{av}.

It is easy graphically to construct the V_o/V_i curve with feedback when the curve without feedback is given. Of several methods the following is particularly suitable.

Let us assume that we draw from the origin a straight line of some convenient slope A; for a given output V_o the required input may be written $V_i = F(V_o) = \frac{V_o}{A} + \delta V_i$. Then δV_i is the horizontal distance of the V_o/V_i curve from the straight line $V_o = AV_i$; i.e., δV_i is the amount by which the actual input required for an output V_o differs from that of the ideal amplifier which obeys the relation $V_o = AV_i$. With feedback we have

$$V_i' = F(V_o) + \beta V_o = V_o \frac{1 + A\beta}{A} + \delta V_i;$$

this shows that the horizontal distance of the new V_o/V_i curve with feedback is the same as before when measured from the straight line of slope $\frac{A}{1 + A\beta}$.* Hence if we reduce the V_i-scale by the factor $1 + A\beta$, the line given by $V_o = \frac{AV_i}{1 + A\beta}$ stays as before, while the new V_o/V_i curve may be obtained directly by reducing the horizontal distances from the straight line by the factor $1 + A\beta$. This is done in Fig. 2. The slope of the straight line is chosen to be equal to the average slope of the V_o/V_i curve (this is particularly convenient) and the value $1 + A_{av}\beta$ is assumed to be equal to 2.

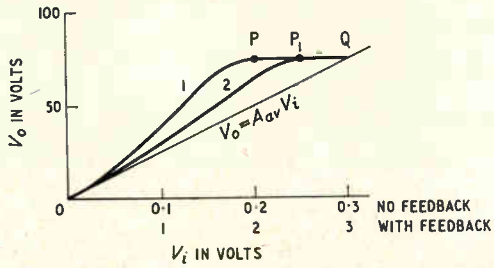

Fig. 2. *Amplifier characteristics so drawn that the initial slopes without* (1) *and with* (2) *feedback equal the average slope.*

For the curve 1 without feedback the initial slope, at $V_i = 0$, and the average slope are identical; hence they are also identical for the curve 2 with feedback. Point P on the old curve becomes P_1 on the new; Q stays at its place. It is easily seen that the reduction of distortion is marked even for the flat part of the curve.

The point is brought out more forcefully in the example shown in Fig. 3(a). This type of V_o/V_i

*Compare p. 132 of Mr. Rowlands's article.

curve may be obtained by two valves working in class C push-pull. The amplifier is to be so driven that the effective input voltage, with or without feedback, does not exceed ± 1V. Then the distortion is caused only by the flat part between $-0{\cdot}5$ V and $+0{\cdot}5$ V.

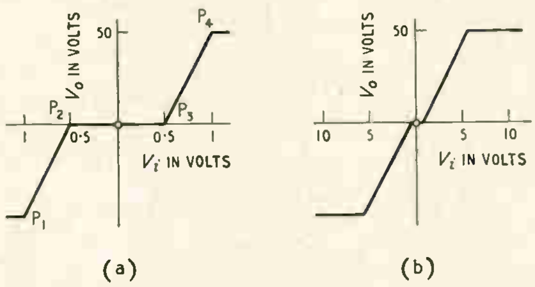

Fig. 3. *Characteristic of push-pull class C amplifier without feedback (a) and with feedback (b);* $1 + A\beta = 10$.

Let us assume that negative feedback is applied of magnitude $1 + A\beta = 10$ where A refers to the incremental gain on the steep part of the curve. In order to reach the cut-off point P_3 the required input voltage is $0{\cdot}5$ V as before, since feedback is not yet effective. To reach point P_4 an additional input of 5 V is required. The curve with feedback hence looks as shown in Fig. 3(b), the V_i-scale being contracted by the factor 10. It is seen that feedback cannot alter the flatness of the curve between P_2 and P_3, but for small angles of no-current flow it reduces by a factor approaching $1 + A\beta$ the fraction of the cycle during which the flat part is operative. Thus feedback tends to change class C into class B amplification. Fourier analysis shows that in the graph of Fig. 3(b) the magnitude of the 3rd harmonic is approximately proportional to the fraction of the cycle during which no-current flows, so that the improvement is of the order of $1 + A\beta$.

If, as shown in Fig. 4(a), the slope between $-0{\cdot}5$ V and $+0{\cdot}5$ V is not zero, but still much smaller than that of the other parts, negative feedback acts in two ways. First, it reduces the ratio of the two slopes, secondly it reduces the fraction of time during which the smaller slope is operative; both effects tend to reduce distortion. The V_o/V_i curve with feedback is shown in Fig. 4(b); $1 + A\beta$ is 10 on the steep part of Fig. 4(a). With a sinusoidal input, the shape of the output curve, with and without feedback, may be seen from Fig. 5. In (a) $\theta = \sin^{-1} 0{\cdot}5 = \frac{\pi}{6}$; in (b) $\theta = \sin^{-1} \frac{1}{6} = 0{\cdot}17$. The magnitude of the output of fundamental frequency in Fig. 5(b) is approximately 20% larger than in (a); this may be verified by Fourier analysis, which also shows that the ratio of 3rd harmonic to fundamental in Fig. 5(a) is $0{\cdot}27$ and $0{\cdot}036$ in Fig. 5(b). The improvement is not much less than $1 + A\beta$, A referring to the steep part. As will be seen from the examples, the factor $1 + A_{av}\beta$, gives a reasonable approximation throughout.

In all the previous cases it has been assumed that the V_o/V_i curve is symmetrical about the origin and that the effective input, and hence the maximum output, are the same with or without feedback.

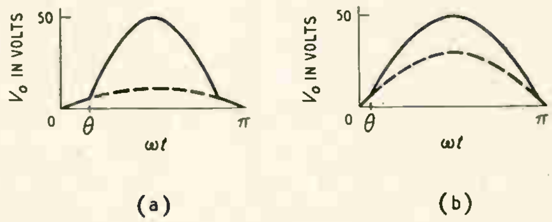

Fig. 5. *Effect of amplifier of Fig. 4. on a sine wave; (a) without and (b) with feedback.*

In Fig. 6 the case is different. Negative feedback will reduce the slope for positive input voltage while the slope for negative voltage remains zero. With a sinusoidal input the output is a sine curve with the negative portion cut-off; hence negative feedback brings no improvement.

In Fig. 7 the V_o/V_i curve is also asymmetrical about the origin, but now negative feedback gives a definite improvement. The gain for positive input voltage is assumed to be A_1, that for negative voltage A_2, where $A_2 < A_1$. The output consists of a positive and a negative half-sine curve; the ratio of the amplitudes is A_1/A_2. The distortion may be measured by the ratio of the difference in amplitudes to the larger amplitude. Hence without feedback the distortion is $\frac{A_1 - A_2}{A_1} = \frac{\delta A}{A_1}$. With feedback the distortion is

$$\left[\frac{A_1}{1 + A_1\beta} - \frac{A_2}{1 + A_2\beta}\right] \Big/ \left(\frac{A_1}{1 + A_1\beta}\right) = \frac{\delta A}{A_1}\,\frac{1}{1 + A_2\beta}$$

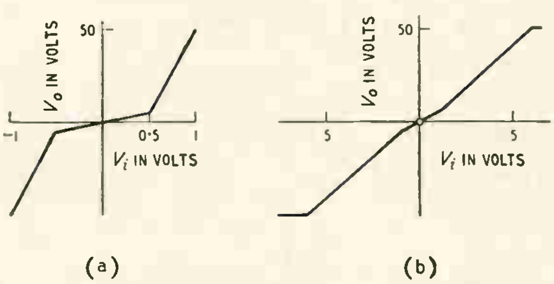

Fig. 4. *Amplifier characteristic having two parts of different slopes (a) and with feedback (b);* $1 + A\,\beta = 10$.

The positive output is the same with and without feedback, the negative is given by curves 1 and 2 respectively (Fig. 8).

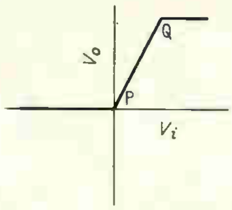

Fig. 6. *Discontinuous characteristic of a single-sided amplifier.*

The last two cases, which may be compared with that dealt with by Rowlands, differ essentially from those described in Figs. 1–4. The cause of this difference must be seen in the fact that in Figs. 6 and 7 the drive is not the same with and without feedback. Let us, for example, suppose that in Fig. 7 the effective positive drive is 1 V with and without feedback, and that with feedback an input of 5 V is required for the purpose.

This means that $A\beta = 4$ for positive input while $A\beta = 2$ for negative input, the slope being half that in the positive region. Hence with feedback the effective negative drive becomes $\frac{5}{3}$V, which is $\frac{2}{3}$V more than without feedback. The output of fundamental frequency, which is equal to the arithmetic means of the positive and negative amplitudes, is increased by 22%. This should be taken into account when assessing the improvement caused by feedback.

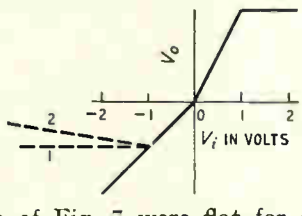

Fig. 7. *Single-sided amplifier characteristic having two portions of different slopes.*

If the V_o/V_i curve of Fig. 7 were flat for a negative drive exceeding 1 V (dotted line 1) the result would be quite different. With feedback the positive output is given by curve 1 as before; but the negative flat part is reached when the instantaneous input voltage is -3 V. Hence the amplifier is driven another 2 V into the negative flat part, and the total negative drive becomes 3 V. The shape of the negative part of the output curve is given initially by 2 and then by 3 of Fig. 8. Even without applying Fourier analysis one can see that negative feedback cannot be expected to bring about much improvement and may even make things worse.

A large increase in distortion would be caused by negative feedback if the slope of the V_o/V_i curve were negative for a negative drive exceeding 1V (dotted line 2). The negative part of the output curve would then be given in Fig. 8 by a combination of lines 2 and 4, the effective negative drive being about 4·2 V.

From the various cases discussed the following conclusions can be drawn:—

1. V_o/V_i Curve Symmetrical about the Origin

The effective drive can be considered to be the same with and without feedback. The improvement in distortion is then, with reasonable accuracy, given by the factor $1 + A_{av}\beta$.

2. V_o/V_i Curve Asymmetrical about the Origin

(*a*) *The average gain the same for the positive and negative parts* (*Fig.* 9). From what has been said on page 119 it is clear that the effective drive and hence the maximum positive and negative output will be the same with and without feedback. Feedback will, therefore, again give an improvement similar to that with symmetrical V_o/V_i curves.

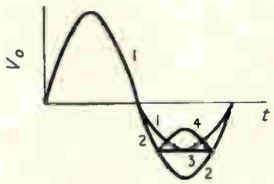

Fig. 8. *Waveforms obtained with the different forms of amplifier characteristic of Fig.* 7.

(*b*) *The average gain different for the positive and negative parts.* The effective drive with feedback will usually be the same for the part having the larger average gain, but it will be larger for the part with the smaller gain. The effect of feedback on distortion depends then on that part of the V_o/V_i curve which, lying on the side with the lower average gain, extends beyond the point to which the amplifier is driven in the absence of feedback. This means that, if the V_o/V_i characteristic is expressed as a power series, the effect of feedback will sometimes be determined by the terms of high powers.

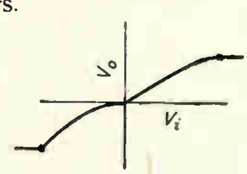

Fig. 9. *Characteristic having the same average gain for its positive and negative parts.*

The way in which distortion should be assessed seems to be largely a matter of taste. For curves of similar type the deviation from a straight line will give a fair indication. Often the V_o/V_i curve may not contain a clearly defined straight part, and in this case it is probably best to draw a straight line through the origin and the maximum V_o on the side having the larger average gain, and to use this line for reference. If this is done in Figs. 5 and 6 the improvement thus found approximates to that calculated for the 3rd harmonic.

AUTOMATIC TUNING FOR PRIMARY RADAR

By S. Ratcliffe, B.Sc.

Introduction

THIS article summarizes the results of a period of research into the basic techniques of automatic frequency correction (a.f.c.) for primary radar, particularly the problems arising in airborne microwave systems. Basic principles of good a.f.c. design are emphasized, and no attempt is made to give a catalogue of circuits. Some of these principles, such as the need to use 'designable' circuits, have already been stated very explicitly elsewhere,[1] but the importance of this point still does not seem to be sufficiently appreciated.

An obvious problem in the design of a microwave radar is that set by the very high ratio of the transmitted frequency to the receiver bandwidth. For example, 4 Mc/s is a typical bandwidth for a 10,000-Mc/s radar, the equivalent of a broadcast receiver bandwidth of, say, 400 c/s in 1 Mc/s. For this reason, the need for some form of a.f.c. was recognized very early in the history of microwave radar. This was a major factor influencing the choice of the reflex klystron[2] for development as the receiver local oscillator.

Initially, it was usual to provide a receiver bandwidth considerably greater than the optimum, in order to allow for possible imperfections in the a.f.c. system, but with increasing demands on radar performance arising from higher speeds of aircraft, the subsequent loss in overall efficiency becomes intolerable. Efforts have accordingly been made to improve the design to the point where it is possible to use a receiver bandwidth not far from the theoretical optimum.

It is essential to notice a fundamental difference between the applications of a.f.c. to broadcast and radar equipments. In the broadcast problem there are many receivers to one transmitter, and it is economical to employ an elaborate arrangement to maintain the transmitted frequency constant. In a primary radar there is one transmitter to each receiver, and it is normally sufficient to control the frequency of either the transmitter or the receiver local oscillator so as to maintain the desired intermediate frequency, the absolute frequency being of less importance. In practice the receiver frequency is controlled, because of the relative ease with which this can be done. Because of this choice between complicating the transmitter or the receiver, their designs and that of the a.f.c. system are inter-related.

The frequency variations with which the radar a.f.c. may have to deal can be divided into two categories. First, there are the long-term variations, such as those due to changes in ambient temperature and pressure. Secondly, there are the variations in magnetron frequency due to changes in the matching during rotation of the scanner, and similar effects. It will be shown that the phase of the reflection from the radome, for example, varies so rapidly that the magnetron frequency may change by a megacycle or so between one pulse and the next. The speed with which the frequency varies from these causes is considerably greater than that of the long-term fluctuations previously mentioned, and an a.f.c. technique which is otherwise adequate may require drastic modification if these short-term effects are important.

There is a further difference between broadcast a.f.c. and the corresponding control in a radar receiver. The former has error information continuously available from the discriminator, so that the a.f.c. system can be designed by the technique developed for negative-feedback amplifiers. In a radar a.f.c. system, however, information about the tuning error is only available while the transmitter is firing (i.e., for a small fraction of the operating time) so that conventional negative-feedback theory must not be too hastily applied to such a system.

Earlier radar a.f.c. systems have a reputation for unreliability. One of the reasons for this is that fault-finding is difficult; since, when the a.f.c. is faulty, the signal on which it should operate is often also missing in consequence. The difficulties are increased by the fact that the setting-up may involve as many as five preset adjustments which interact with each other and are mostly frequency dependent. It was necessary to provide many of these adjustments because much of the design was arrived at empirically, without time to establish the effect on performance of production tolerances on components. The result is that equipments were often so designed that an acceptable performance could only be obtained by selecting a local-oscillator valve to suit a particular set. The maintenance and production problems can be greatly simplified by the use of 'designable' a.f.c. circuits, in which the effect of production

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tolerances can be predicted and minimized and in which the need for preset adjustments can be greatly reduced, as can the necessity for much of the routine 'testing' of this apparatus. Such tests as are necessary can usually be made without the need for special test gear, such as pulsed-signal generators, which are needed for the correct maintenance of many earlier a.f.c. systems.

One major contribution to the problem of eliminating preset adjustments is the use of a broad-band a.f.c. system in which frequency sensitive adjustments are avoided. This involves some departure from the earlier a.f.c. techniques, in which the local-oscillator frequency was controlled only by variation of the voltage applied to one of its electrodes. The range over which the frequency can be controlled by such means is limited, and it is also necessary to provide a preset tuning adjustment with which long-term corrections are made. Apart from the disadvantage of adding to the number of adjustments, this method lowers the receiver efficiency. Unless the electronic-tuning range is more than adequate to cope with all the long-term frequency drifts, a.f.c. will often fail, but increasing the electronic-tuning range brings a number of difficulties. This technique tends to be particularly unsatisfactory at higher frequencies where the electronic-tuning range may well be inadequate even to cope with frequency drifts in the local oscillator itself. To avoid limitations of this kind, it is necessary to introduce a mechanical servo which can control the frequency by variation of the physical dimensions of the resonator of the oscillator. A variety of suitable techniques is now available.

In the design of a magnetron it is necessary to strike a compromise between a high power output and a low 'pulling figure'. As this pulling figure increases, the receiver bandwidth must be increased to allow for the effects of scanner pulling. This increase in bandwidth results in a deterioration in the receiver sensitivity and the design must aim at a suitable compromise. The use of an a.f.c. system having a sufficiently rapid response to deal with scanner pulling will make possible a magnetron design having a higher pulling figure, with a consequent increase in efficiency, or a receiver having a narrower bandwidth and increased sensitivity. In the next section is discussed the relation between these design parameters, and the conditions under which it may be economical to use a fast a.f.c. system.

A.f.c. should be regarded and designed as an integral part of the radar system, and not simply as an addition to an existing collection of components which is used to deal with the problems left unsolved by the designers of the scanner, magnetron, local oscillator, etc.

Scanner Pulling and Design of Radar Systems

Reference has already been made to the fact that the frequency of a magnetron depends, to some extent, on the impedance into which it is working. Before discussing the behaviour of the magnetron in more detail, it will be of interest to consider some of the relevant properties of the scanner.

In the sense used here, this consists of a waveguide run, with one or more bends, one or more rotating joints, the aerial proper, and, usually, a radome which protects the aerial from the elements. Mechanical tolerances on the components set a limit to the accuracy of impedance matching that can be achieved, and on the X-band, for example, a voltage standing-wave ratio (v.s.w.r.) of 0·85 to 0·9 is probably the best that can be guaranteed in production. For the present purposes we are not so much concerned with this mismatch as with the way in which it varies as the aerial rotates, since it is this variation which influences the a.f.c. problem.

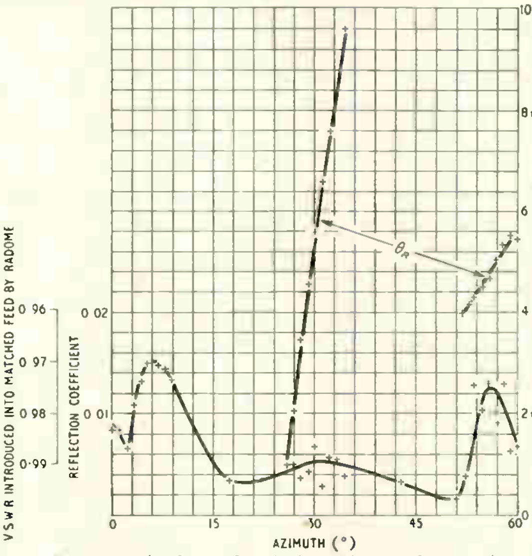


Fig. 1. *Amplitude and relative phase of reflection coefficient due to radome (at S-band);* $|e_R|\theta_R$ *versus azimuth. Radome = 1/12-in. glass-fibre laminate.*

Fig. 1 shows the variation in the reflection from a typical aircraft radome as a function of the direction of the beam. It will be noted that the phase of the reflection varies at a remarkably high speed with change of azimuth. This is because the radome is large compared with the wavelength, and hence a small percentage change in the path length can be responsible for a large shift in the phase of the reflection.

The variation in the reflection from a rotating joint will arise from eccentricity or asymmetry of the rotating section, and although no precise data is available, it does not appear likely that any rapid change in phase will occur during rotation. For this reason, it is probably justifiable to neglect the variation in the frequency pulling due to a well-designed rotating joint.

The output power of a magnetron is extracted by means of a coupling to the resonant cavity. Consequently, the frequency at which a magnetron oscillates depends on the impedance presented to it by the external load. The relationship between this impedance and the magnetron frequency and power output is commonly shown on a Rieke diagram,[3] such as Fig. 2, which shows lines of constant frequency and of constant power output on a circle diagram. Additional lines may be sketched, if necessary, by interpolation. The peak-to-peak variation in frequency as the operating point is taken round the circle for the reflection coefficient $K = 0{\cdot}2$ (v.s.w.r. $= 0{\cdot}67$) is termed the 'pulling figure' of the magnetron. To a first approximation, the effect of a small mismatch can be predicted by assuming the pulling to be directly proportional to the reflection coefficient. Pulling figures of the order of 0·2% of the transmitter frequency are usual. To keep down the pulling figure it is usual to undercouple the load, sacrificing some of the output power in the process. This has happened in Fig. 2, for example.

The Rieke diagram gives the magnetron fre-

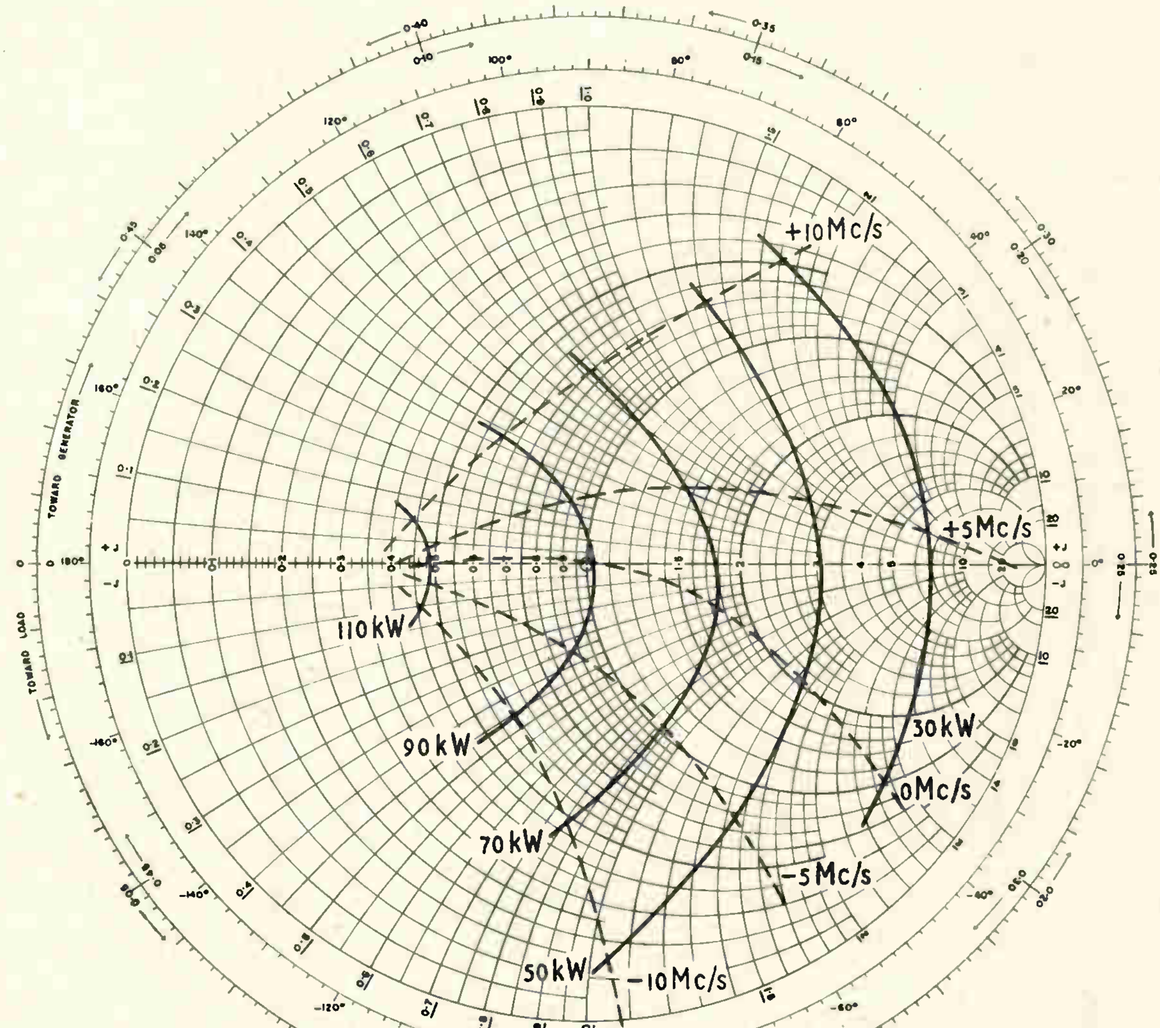


Fig. 2. *Rieke diagram of 4J50 magnetron (6300 gauss, 10 A), showing lines of constant frequency and power.*

quency as a function of the impedance presented to the magnetron by the load. The aerial is usually separated from the magnetron by a guide many wavelengths long, and the intervening length of waveguide will modify the characteristics of the system. This usually has only a second-order effect on the scanner pulling and need not concern us here.

The diagram of Fig. 2 gives the steady-state frequency only. At the beginning of a pulse there is no energy from the scanner returning to the magnetron which, therefore, behaves as though it were feeding a matched load. The determination of the transient variations in frequency of the magnetron is difficult but, for airborne installations at least, the waveguide is usually sufficiently short to make it possible to assume that the magnetron spectrum is centred about the steady-state frequency.

The efficiency of a magnetron is generally limited by the need to restrict the pulling figure. Before discussing the factors influencing the choice of this figure, we require to know the relationship between pulling figure and power output. The pulling figure is controlled by the ratio of the transformer between the output line and the magnetron cavity. Within limits the effect of any such change can be deduced from the Rieke diagram, such as Fig. 2, by multiplying all the impedances by the appropriate factor and re-drawing the diagram. From the modified Rieke diagrams we can determine the way in which the efficiency of a magnetron of this type would vary if the pulling figure were changed. The results are summarized in Fig. 3.

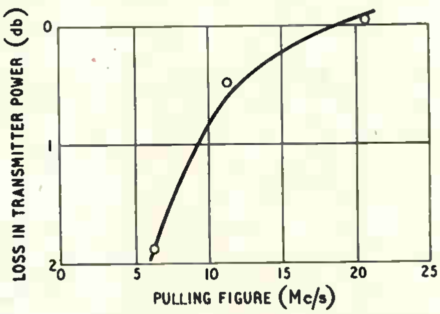


Fig. 3. *Output power of magnetron versus pulling figure.*

Failing a perfect scanner, a certain amount of frequency pulling must occur during the scanner rotation, and the design of the whole equipment should take account of this fact. If the receiver bandwidth is increased in order to reduce the sensitivity of the receiver to changes in the frequency of the received signals, this will affect the overall performance for, as the bandwidth of a radar receiver is increased, the fraction of the transmitted energy spectrum which the receiver can accept will increase steadily, but eventually the noise in the receiver will be increasing at a greater rate. Thus the signal-noise ratio will suffer. The effect of varying receiver bandwidth on the visibility of small signals on a c.r.t. display has been investigated by Haeff,[4] for an A-scope and by Payne-Scott[5] for a P.P.I. Broadly speaking, these writers agree that the optimum i.f. bandwidth is given by the reciprocal of the pulse width, and that for a bandwidth y times this, the sensitivity is reduced by a factor $4y\ (1+y)^{-2}$. This is plotted in Fig. 4. The second-order effect of i.f. bandwidth on the receiver noise factor is neglected.

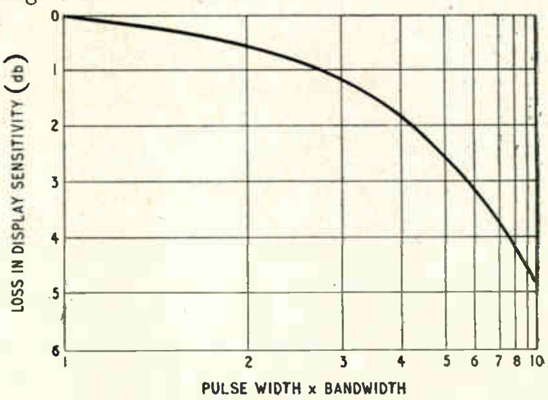


Fig. 4. *Display sensitivity as a function of receiver bandwidth.*

We also require to know the effect on the response of a receiver of given bandwidth of any change in the received frequency. It is assumed, for the present purposes, that we are dealing with an ideal rectangular pulse, that the receiver response curve is also rectangular, and that the sensitivity of the equipment is directly proportional to the received energy. Then, if the receiver is correctly tuned, the output power will be given by

$$cP_0 = \int_{-x}^{+x} \frac{\sin^2 \pi u}{\pi^2 u^2}\, du = 2 \int_{0}^{x} \frac{\sin^2 \pi u}{\pi^2 u^2}\, du = 2I_x, \text{ say,}$$

where c is a constant, and x is equal to half the product of receiver bandwidth and the pulse width. If m denotes the product of a tuning error with the pulse width, then the output power, for this tuning error, will be given by

$$cP = I(x+m) + I(x-m)$$

and the loss in signal power will be given by

$$\frac{P}{P_0} = 1 - \frac{I(x+m) + I(x-m)}{2I_x}$$

A graph of I_x is given in Fig. 5 and a graph of P/P_0 as a function of m for $x = 1, 2, 3,$ and 4, is given in Fig. 6, and from either of these the effect of a given amount of mistuning can be determined.

Hence it is possible to choose the correct receiver bandwidth to handle a pulse having a known amount of frequency modulation due to pulling.

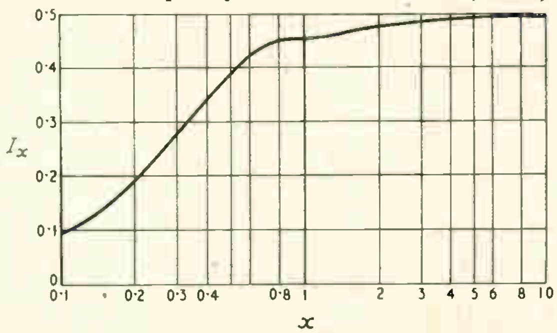


Fig. 5. *Value of I_x as a function of $x = \frac{1}{2}$ bandwidth × pulse width.*

In the presence of any appreciable amount of frequency modulation, some amplitude modulation of the receiver output must ensue, particularly as a practical i.f. amplifier will not have a perfectly flat-topped response, as assumed in Fig. 6. The designer must decide what amount of such amplitude modulation he is prepared to tolerate, bearing in mind that this modulation can only be reduced by lowering the performance of the whole equipment in other respects. The choice may be influenced by factors such as the following:—

(a) It may be known that the mismatch due to the radome will be worst in some special direction. This often happens in an airborne installation when the shape of the radome is determined by aerodynamic considerations. The requirements for the system may be such that it is not essential to maintain the peak performance in this direction.

(b) A signal-comparison technique is often used to give a sensitive indication of the bearing of a target. Fig. 1 shows that a small change in the direction of the beam from an aerial may produce a considerable change in the phase of the reflection, and hence produce a significant change in the magnetron frequency. The resulting amplitude modulation of the receiver output will introduce an error in the apparent bearing of the target, and it will therefore be necessary to choose a receiver bandwidth which will keep this error down to a tolerable amount.

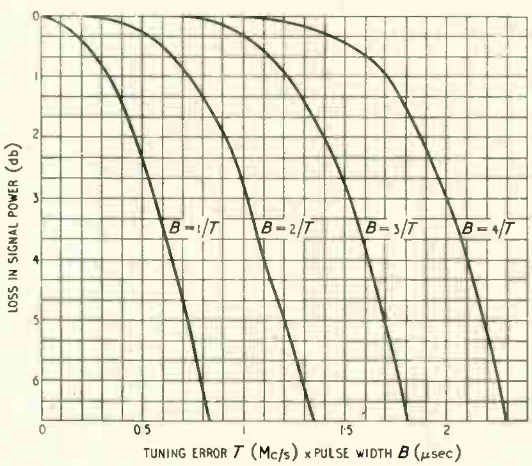


Fig. 6. *Loss of signal on mistuning.*

From an estimate of the probable variation of the scanner impedance during rotation, it is possible to predict the resultant scanner pulling for a given magnetron-pulling figure. It can be assumed, for small reflections, that this is given by

Scanner pulling = (Variable component of reflection coefficient) × (Magnetron-pulling figure) × 5

(This assumes that the pulling varies linearly with the reflection coefficient and that the pulling figure is measured for a reflection coefficient of 0·2).

From the various relations given above, it is possible to deduce the receiver bandwidth required for any given magnetron-pulling figure, and to determine the optimum combination of bandwidth and pulling figure.

Suppose it is desired to design a system using a magnetron of the 4J50 type, and a radome having properties similar to those plotted in Fig. 1. Suppose the pulse width is to be 1·0 μsec, and that one can tolerate a loss in performance of 2 db due to mistuning of the receiver at the positions of the scanner producing the worst mismatch, which will be taken as corresponding to a reflection coefficient of 0·015 (v.s.w.r. = 0·97). The pulling due to this effect will be ($F \times 0{\cdot}075$ Mc/s) where F is the magnetron-pulling figure.

Table 1 shows, for various pulling figures,

(1) the receiver bandwidth required,
(2) the loss in display sensitivity which results,
(3) the loss in transmitter power due to under-coupling,
(4) the sum of items (2) and (3).

TABLE 1

Pulling Figure (Mc/s)	(1) Bandwidth (Mc/s)	(2) Loss in Receiver (db)	(3) Loss in Magnetron (db)	(4) Overall loss in Efficiency (db)
5	1	0	2·5 approx.	2·5
10	1·5	0·2	1	1·2
15	2·4	0·8	0·5	1·3
20	3·2	1·3	0	1·3

There is little point in considering the use of a pulling figure appreciably greater than 20 Mc/s, since the operating point is rapidly moving into the region where magnetron operation is uncertain and, unless the radar has a very short waveguide run, trouble will be experienced from the 'long-line' effect.[6]

For this example, at least, if the receiver bandwidth is correctly chosen to suit the magnetron-pulling figure, the value of the latter is not critical. The value given in column (4) for the overall loss in efficiency, 1·3 db for the existing magnetron, represents the loss in performance due to the imperfection of the radome. This loss would be considerably reduced if the pulse were narrower and vice versa, since it is the ratio of the scanner pulling to the width of the magnetron spectrum that determines the loss in receiver performance due to the fall in the limiting sensitivity of the display.

If the pulse-width is reduced, the mean power output of the transmitter must, of course, be kept constant to avoid loss in performance due to the necessary increase in receiver bandwidth.

The above discussion has omitted any reference to the a.f.c. system. If this were capable of following instantaneously the variations in magnetron frequency due to the radome, the loss in performance due to the latter could be avoided. The difficulty is that even for the 10-cm aerial shown in Fig. 1, the rate-of-change of phase of the reflection is about π radians per degree azimuth. Now a change of π radians in the phase of the reflection may change the magnetron frequency by the whole amount of the pulling, and if the beamwidth is, say, 6° and the radar p.r.f. has been chosen to put six pulses on the target at each sweep, we have one pulse per degree of azimuth, and the a.f.c. must follow a transmitter which may jump in frequency by the whole amount of the pulling between one pulse and the next. We will discuss later the possibility of designing an a.f.c. system which, when faced with this situation, can make possible a significant reduction in the receiver bandwidth.

Source of Control Information

A schematic diagram of a cm-wave radar a.f.c. system is shown in Fig. 7. The requirement is to maintain a constant separation between the frequency of the transmitter and that of the local oscillator, this difference being the intermediate frequency of the receiver. To this end, samples of the output of the transmitter and of the oscillator are applied to a mixer. The resulting difference signal is amplified and applied to a discriminator. The output of the discriminator is proportional in magnitude and sense to any departure of the difference frequency from the desired value and can thus be used to actuate a control system which reduces the tuning error.

For various reasons[7] it is now general practice to derive the a.f.c. discriminator input from a mixer and i.f. amplifier distinct from those used to handle the incoming radar signals.

The design of this mixer need not be discussed at great length, since most of the problems are common to the design of signal mixers. The main difference in emphasis arises because of the importance of maintaining close tolerances on the gain round the a.f.c. loop, and therefore on the output of the a.f.c. mixer, even at the expense of the mixer sensitivity.

Care must also be taken with the method of extracting a sample of the transmitter power, to ensure that a small percentage harmonic content of the transmitter output does not become the dominant signal at the a.f.c. mixer.[7]

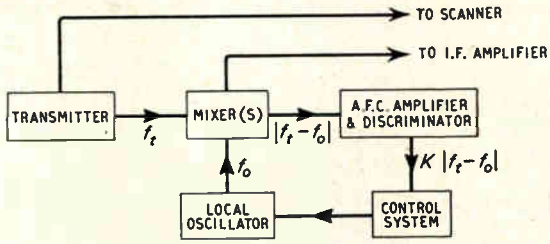


Fig. 7. *A.F.C. system.*

In many a.f.c. systems difficulty is experienced from the harmonics of the i.f. which are generated by the crystal mixer. Thus, if the local-oscillator frequency differs from that of the transmitter by half the desired i.f., the second harmonic produced by the crystal may be sufficient to actuate the a.f.c. circuits, which will then hold the receiver tuned to the wrong frequency. To minimize this trouble, it is necessary to choose with some care the operating conditions of the a.f.c. mixer. The even harmonics generated in the mixer (and spurious signals due to transmitter pulse currents) can be greatly reduced by the use of a balanced a.f.c. mixer.

The level of local oscillator and transmitter power at the mixer will probably be of the order of 2 mW and ½ mW for satisfactory harmonic performance, giving an i.f. output of about 0·1 V. There are a number of arguments influencing the decision as to which of the two signals should be made the larger.

(a) It may be difficult to obtain 2 mW from the local oscillator, or to keep down leakage from the transmitter to a level low compared with ½ mW.

(b) The r.f. impedance of the crystal will be mainly determined by the larger of the two signals. If this signal is the c.w. from the local oscillator, the impedance presented to the waveguide will be substantially the same during the transmitter pulses as during the intervals between them. If the transmitter drive is the larger, the crystal impedance will change during the pulse, and this may complicate the problem of designing the 'plumbing' so as to keep down interaction between the a.f.c. and signal mixers. This change of impedance also complicates the problem of ensuring that the a.f.c. gets the desired level of l.o. power during the transmitter pulse.

(c) Troubles due to the video components of the mixer current will be reduced by keeping the pulsed-signal low.

(d) It is important to maintain close tolerances on the gain round the a.f.c. loop. The output from the a.f.c. mixer will depend mainly on the smaller of the two input signals, and it is desirable, therefore, to choose as the greater of the two signals that likely to vary most widely. The argument is further complicated, however, by the fact that, as shown later, the reflector characteristics of a klystron are such as to cause an increase in the loop gain as the oscillator is mistuned electrically away from the frequency at which it gives maximum power output. This effect is reduced if the local-oscillator signal is made the smaller of the two, since the falling-off of the i.f. output at the edges of the a.f.c. range will to some extent compensate for the increasing slope of the reflector characteristic.

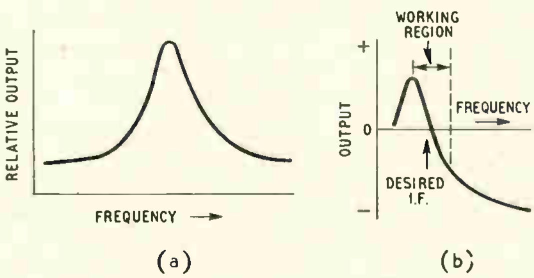


Fig. 8. *Response of single-tuned circuit (a) and output of detector (b).*

In practice, it is usual to operate the mixer with a large transmitter sample and low local-oscillator drive. The mixer output is fed through one or two amplifier stages to a discriminator which then develops an output proportional to the difference between the i.f. and its desired value. The minimum usable i.f. and discriminator bandwidth is determined by the need to accommodate within the pass-band a substantial portion of the spectrum of the transmitted pulse. If this is not done, the a.f.c. may lock to one of the side-lobes of the spectrum. C. Baron, of R.R.E., Malvern, has shown that a discriminator peak separation of at least 2/(pulse width) is desirable to avoid these troubles. A wider separation is sometimes used in order to keep up the 'pull-in' range. The design of the i.f. amplifier stages is conventional and need not be discussed here. Typical designs will be seen in various published accounts of a.f.c. systems.[7]

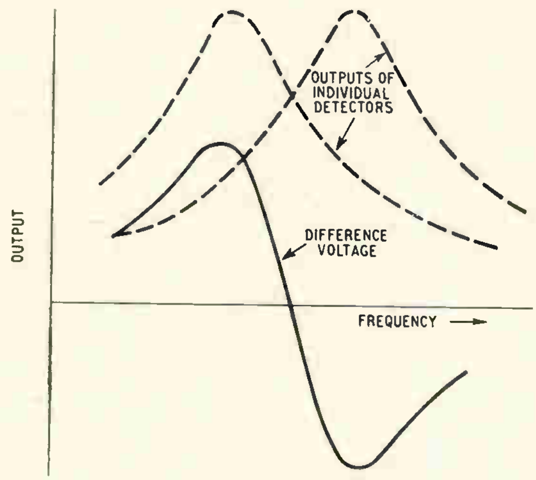


Fig. 9. *Response of discriminator.*

The discriminators are identical in principle with those used in broadcast receivers and a brief summary only will be given here of the various possible circuits. Discriminator circuits can be divided into two classes:—

(a) Those using the frequency response curve of a single-tuned circuit. If a circuit is tuned to a frequency somewhat different from the desired i.f. then the output from a detector connected to it will vary with frequency in the manner shown in Fig. 8(a). If the output corresponding to the desired i.f. is backed-off by a suitable opposing voltage, the curve of Fig. 8(b) is obtained. This output is capable of providing a.f.c. information but it has the disadvantage that the position of the cross-over will vary with the strength of the input signal.

The Round-Travis[8] circuit is the parent of many commonly used discriminator designs. It consists essentially of two circuits each coupled to a detector. One circuit is tuned to a frequency above and the other below the desired i.f. and the frequencies are so chosen that the outputs are equal at the desired i.f. If the two outputs are then subtracted from each other, the difference voltage will vary with frequency in the manner shown in Fig. 9. Among the many possible ways of applying this idea is the 'Weiss' discriminator,[7] often wrongly described as a variant of the Foster-Seeley discriminator.

(b) The Foster-Seeley or 'phase' discriminator uses a band-pass coupling with a centre-tapped secondary. The phase of the voltage induced in the secondary varies with frequency being, at resonance, 90° different from that of the primary voltage. The phase of the secondary voltages is compared with that of the primary with the aid of two diodes in a bridge circuit as shown in Fig. 10. The Foster-Seeley circuit ceases to be very satisfactory when the peak-separation required is much more than 10–15% of the i.f. because a tight coupling between primary and secondary is then required, and it becomes difficult to control this coupling with sufficient accuracy, or to preserve the symmetry. For this reason, it is now usual to employ the Weiss discriminator[7] for wider peak-separations.

The i.f. signals, from which the discriminator output is derived, consist of a succession of pulses having a duty cycle of the order of 1 in 1,000, and an error voltage of this form is not very suitable for controlling the oscillator frequency. A common solution is to make the discharge time-constant R_LC of the diode load in Fig. 10 long compared with the pulse width, so that the capacitor, which is charged during the pulse through the diode, is discharged much more slowly by R_L. The voltage across the diode load thus decays slowly between pulses, giving an output voltage that is more suitable for use in the control circuit. This method of lengthening the pulses introduces several complications, among which are:—

(a) The detection efficiency of the diodes is very low because of the need to charge up a large load capacitance during the pulse. This means that more i.f. gain is needed if the signal level at the diode outputs is not to be too low. It is commonly necessary to use two parallel-input i.f. stages feeding the pair of circuits forming a Round-Travis discriminator in order to supply an adequate charging current for these capacitors.

(b) Because of the use of load capacitors which cannot be charged by the diodes in the period of the pulse, the diodes present very heavy damping to the tuned circuit of the discriminator. This damping is virtually unpredictable and will depend on the relative values of the tuning error during the preceding pulses, because of charges remaining on the capacitors from one pulse to the next.

Tests on the response curve of the discriminator conducted with a c.w. source will offer little guidance as to the performance of the a.f.c. system in its normal role. Nor do tests conducted with a pulsed-signal generator correctly simulate working conditions, since given a steady error the diodes may succeed in charging up their load capacitors to some reasonable fraction of the incoming r.f. voltage, but this situation will not arise when the a.f.c. is operating normally. The effective damping may therefore be appreciably different.

(c) The output from such a discriminator will be a function of the integral of the tuning error, as well as of the error itself. In addition, if the error changes rapidly, only one of the diodes in Fig. 10 will be able to conduct. The other will be biased-off by the charge remaining on the load capacitor from the previous error voltage. Thus the discriminator output voltage will underestimate a large and rapidly changing error. These two effects greatly complicate the task of predicting the performance of an a.f.c. system in which this type of discriminator is used.

It is much better, therefore, to separate the two functions of rectifying and stretching the pulses. This makes possible a simpler design, gives a predictable performance, makes it possible to use a normal c.w. signal generator for the setting up, and reduces the amount of expensive i.f. amplification required.

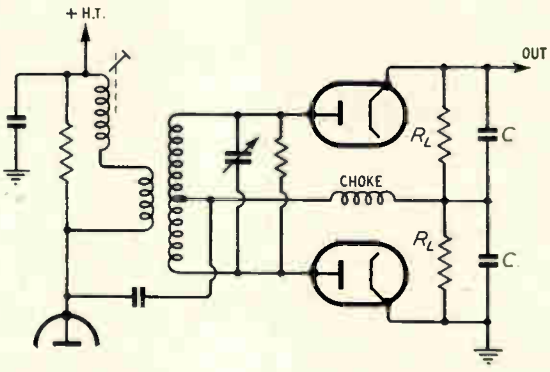
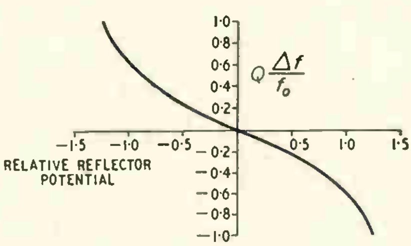


Fig. 10. *Foster-Seeley discriminator.*

A fundamental problem that seems to have received little attention concerns the behaviour of any discriminator, and therefore of any a.f.c. system, when the spectrum of the transmitted pulse differs appreciably from the theoretical. For example, the current delivered to the magnetron from the matching transformer will normally 'droop' to some extent during the pulse, and this 'droop' will result in a certain amount of frequency modulation, usually termed 'pushing'. It now becomes difficult to assign any clear meaning to the term 'magnetron frequency', or to state precisely the conditions under which the receiver is said to be 'on tune'.

Ideally, an operator performing the tuning operation by hand would set the tuner to the point at which small signals were most clearly seen above the background noise. In practice, there may not be a suitable signal available, and there will be human errors, but the a.f.c. is handicapped by the fact that the discriminator cannot use this criterion and must attempt to judge the correct tuner setting by some indirect means.

A normal type of a.f.c. with a linear discriminator will seek a tuner position such that the average frequency of the mixer output coincides with the desired i.f., the average being taken over a band of frequencies roughly equal to the peak separation of the discriminator, but with some weight given to the part of the spectrum lying within the skirts of the discriminator characteristic. Qualitative argument shows that, if this band over which the average is taken is roughly equal to the bandwidth of the radar receiver proper, this criterion is a sensible one, and should result in a good approximation to the optimum performance. The difficulty is that, for reasons previously mentioned, it is otherwise desirable to use a peak separation appreciably greater than the optimum receiver bandwidth. Thus, given a badly asymmetrical spectrum, some compromise may be necessary. On the other hand, the development problem of improving the transmitter must be assessed in relation to any proposed complication of the a.f.c. to deal with the poor spectrum.



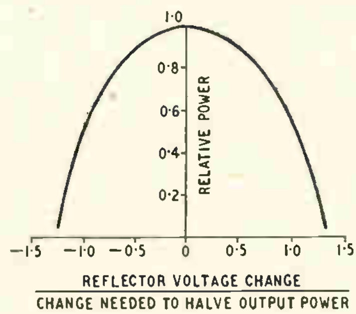


Fig. 11. *Frequency and power output of klystron for varying reflector potential.*

Means of Controlling the Oscillator Frequency

Having obtained, from the discriminator, information about the tuning error, this must be used in some way to correct the local-oscillator frequency. There are two important ways in which the frequency of a reflex klystron, or similar oscillator, can be varied.

(a) By mechanical variation of the dimensions of the resonant circuit.

(b) Electronic tuning, in which the reactance presented to the resonant cavity by the electron stream is varied by changes in the electrical conditions of the klystron. Deliberate frequency changes are normally produced by variation of the reflector voltage. A negligible time delay is incurred in producing a frequency change in this way, and most war-time radars used an a.f.c. system which controlled the oscillator frequency by means of the reflector voltage.

It is not appropriate in this article to give a detailed discussion of the theory of the reflex klystron such as is available elsewhere.[2,9] It will be sufficient to quote some results obtained from first-order theory.[9] Fig. 11 shows the output and frequency of a klystron as a function of reflector potential. The electronic tuning range (Δf) between half power points is given by

$$\Delta f = \frac{1{\cdot}2\, f_0}{Q} \qquad \ldots \quad \ldots \quad \ldots \quad (2)$$

where f_0 is the radio frequency of the oscillator, and Q is the loaded-Q of the resonant cavity. The slope of the reflector-voltage versus frequency characteristic is also inversely proportonal to Q, and increases as the operating point moves away from the centre of the mode. Fig. 12 shows the electronic-tuning rate as a function of the deviation of the reflector voltage from the optimum value.

In general, klystrons designed for use with reflector a.f.c. use a low-voltage high-current (i.e., low impedance) beam, which couples to a low-Q cavity, giving a wide electronic-tuning range. Where the wide electronic-tuning range is not required, it is common to use a high-voltage low-current (high impedance) beam coupled to a high-Q cavity.

The frequency of the klystron may be varied by mechanical means either by changing the volume of the cavity ('inductance' tuning), or by changing the grid spacing ('capacitance' tuning) or both. The choice of tuning method has considerable influence on the performance of the klystron. Capacitance tuning produces a large frequency shift for a very small mechanical motion, and is often employed in valves in which the resonant cavity is inside the valve envelope, in order to simplify the problem of transmitting the mechanical motion. There is, however, a limit to the range over which capacitive tuning can be used without seriously impairing the efficiency of the oscillator, since when the frequency is raised by increasing the gap length, the transit angle through the gap increases rapidly, because the electrons have further to go and less time in which to make the journey. A further difficulty is that a portion of the resonator wall must be flexible. This leads to microphony troubles due to sound waves striking the diaphragm or, if the diaphragm is stiff, to mechanical hysteresis effects or, not infrequently, to both.

If inductance tuning is employed, a relatively large mechanical motion is required. The available tuning range is much greater, since the gap length is constant.

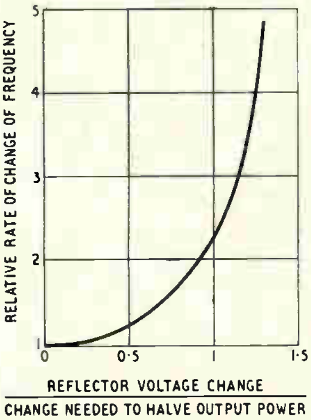


Fig. 12. *Slope of electronic tuning characteristic.*

In view of the limited range over which an a.f.c. system can tune a klystron by varying its reflector voltage, it is becoming more usual to attempt some form of control which can vary the dimensions of the resonant cavity used with the valve and which is therefore able to apply much larger corrections. The tuning mechanism must be light and simple, and capable of varying the oscillator frequency without introducing serious backlash problems. One attempted solution, to which considerable ingenuity has been devoted, is the thermally-tuned klystron. Valves of this type, which are now of little more than historical interest, were developed both in the U.S.A. and in this country.

Writers at the end of World War II painted a rosy picture of the thermally-tuned valve and its advantages. In practice, these are outweighed by two major difficulties: the manufacturing problems, and the microphony problem. The conventional low-voltage klystron is already sufficiently difficult to develop and produce, and the insertion of what is virtually another valve into the same envelope complicates still further the production problem, and greatly increases the amount of research necessary to develop valves for new frequency bands. The microphony troubles arise because of the extreme inefficiency of the thermal tuner strut regarded as an electric motor. Because of the small mechanical force available to perform the tuning operation, the mechanism must be very light and flexible. The microphony troubles then become more or less inevitable. Interested readers should consult the various published accounts[2,7] or, for the later work in this country, the patent literature.[10]

In view of these difficulties, other forms of mechanical frequency control, in which a more conventional and efficient motor mechanism is fitted outside the valve envelope, are now generally being adopted.

The outstanding mechanical problem involved in such a technique is that of designing a tuning mechanism having sufficiently low backlash. The rate of change of frequency with the position of a tuning plunger (if inductive tuning is used) or of a flexible diaphragm (if capacitive tuning is used) will almost certainly exceed 100 Mc/s per cm and may be as high, on X-band, as 20,000 Mc/s per cm. If the tolerable backlash cannot exceed 1 Mc/s or so, the design of a suitable mechanism presents some difficulty. A number of techniques are available, however, which make it possible to supplement the frequency control exercised by this motor by a fine control using the reflector characteristic. Under these circumstances, the mechanical requirements are not so stringent, and a satisfactory design can fairly readily be achieved. To avoid the mechanical problems entailed in breaking the mechanical coupling between the l.o. and the tuning motor when valve replacement is necessary, it is now usual to use one of the 'plug-in' klystrons recently developed for this work. With these valves, much of the resonant cavity and the entire tuning mechanism form a permanent part of the equipment. The valve itself consists of an envelope bearing a pair of contacts which engage with the rest of the resonator.

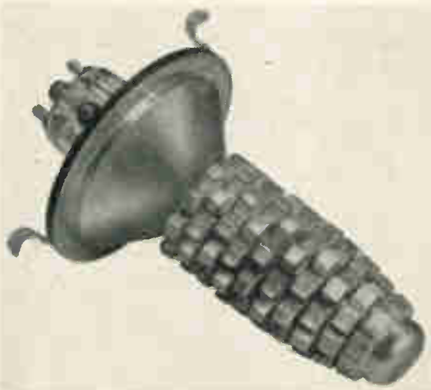
A wide-range a.f.c. system offers considerable advantages over the earlier combination of a narrow-range a.f.c. and the associated collection of preset adjustments. These include the elimination of a number of the presets, a reduction in the local-oscillator noise, and a great increase in the ability of the a.f.c. to deal with serious thermal or other similar drifts. It is necessary to weigh these advantages against the increased complexity of the a.f.c. and this point will be discussed after the circuit techniques have been described.

(*To be continued*)

References will appear at the end of the last instalment.

PHYSICAL SOCIETY'S EXHIBITION

THIS year's exhibition—the 38th—of scientific instruments and apparatus, which was held by the Physical Society from 8th to 13th April at Imperial College, London showed some change of character. In part this has been brought about by some reduction of the space available for the exhibition, for the consequent reduction in the number of exhibits was made much more in production apparatus than in research and development items. A welcome feature of this was the way in which it reduced the overlap with other exhibitions.



An example of the Ediswan Vapotron valve.

In the main, however, the change of character resulted from an alteration in the balance of physics itself. The post-war predominance of electronics is now passing and it is taking its proper place as a branch—albeit an important one—of physics. The trend is now away from an exclusive pre-occupation with the electron and what can be done with it and towards nuclear physics. Even here, however, in one form or another, the electron holds a definite place. Just as the electron is an essential part of the atom, so electronic apparatus seems essential to nuclear research. The electron, however, is now more a means to an end than an end in itself.

Viewed as a whole, this year's exhibition was more representative of physics than some previous ones have been, and the change is a very welcome one. Even so, the older branches of physics do not occupy the place they deserve.

It is, however, the field of electronics which is the main concern of *Wireless Engineer* in this exhibition and so this review of it will be confined to that field. Because of the smaller exhibition and because of the increase in the exhibits in other fields, the electronic section was a good deal smaller than for many years past.

G.E.C. magnetrons; (left) *3-cm type VX3238,* (right) *10-cm type VX3209.*

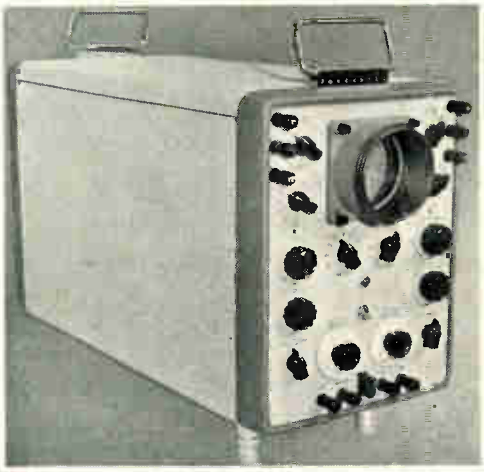
Properly speaking, in its use as a noun, the word 'electronics' should be confined to valves and transistors, but it has been used above in its more popular sense as applying to anything which makes use of these devices. However, electronics in its true sense makes a good starting point for considering the exhibits and here an item of particular interest to the transmitting engineer is the Vapotron valve specially designed for use in the Vapodyne system of cooling, and shown by Ediswan. The anode is segmented externally in order to provide a large surface area and cooling is effected by water vapour. The valve heats the water to boiling point and utilizes the latent heat of evaporation. The advantages claimed for the system are that the heat dissipation is increased for a given size of valve, no pump is needed, the rate of water flow is small and insulation problems are eased.

At the other end of the scale, some new G.E.C. magnetrons are of interest. The VX3238 magnetron for 10,000 Mc/s is built in the usual miniature bulb and utilizes spatial harmonics of the resonator field; in this way operation can be obtained at the same voltage and magnetic field as a normal valve having 10–14 cavities.

Cossor single-beam oscilloscope, type 1058.

Only two cavities are used and an output of 250 mW may be obtained at 900 V and 7 mA with a field of 2,400 Oe. The output is directly into a waveguide and the frequency can be varied over a range of 400 Mc/s with a single tuning control.

The VX3209 is another magnetron for a somewhat lower frequency. It provides an output of 4–8 W over a tuning band of 8·8–11·6 cm and operates at 700–800 V, 30 mA with a magnetic field of 1,200 Oe. It is known as an interdigital magnetron, for the two anode elements



Furzehill oscilloscope intended for general-purpose use and in connection with servo systems.

each have six projecting fingers which interlace when the two are assembled facing each other. An external cavity resonator surrounds the anode structure and is adjustable for tuning. Operation is normally in the E_{010} mode, but the E_{020} mode can be used and with this an output of 2 W at 6·5 cm has been obtained.

As always in this exhibition, voltage stabilization forms a considerable part of the apparatus and for the higher voltages corona stabilizer tubes are now being made by several firms. One example is the Enarde (Nucleonic & Radiological Developments) tube; it is a gas-discharge tube operating in the corona régime. It is claimed to provide stabilization of some 0·5% for supplies of 400–1,300 V, the tube current being 6–120 μA at 400 V and 20–500 μA at 1,300 V. Better stabilization can be obtained by using tubes in cascade and higher voltages can be stabilized by connecting them in series.

Semi-Conductors

The transistor is now no longer a research novelty but, in some types, a production item. Mullard, for instance, showed a range of no less than two point-contact types and five junction types, of which the OC70 and OC71 are for use in production equipment and the OC10, OC11 and OC12 for experimental purposes. A Mullard demonstration of the hole-storage effect in germanium showed how an abnormally-high reverse current may occur immediately after forward-current flow. The output waveform of two diodes excited by a pulse was shown on an oscilloscope, the one having hole storage exhibited a marked overshoot at the end of the pulse with a subsequent slow decay, whereas the one without hole storage exhibited no overshoot in its output waveform.

Although the transistor is almost a normal piece of electronic equipment, some of its capabilities are by no means well known. G.E.C. had a demonstration of a transistor oscillator operating with an h.t. supply of 0·3 V at 7 μA, the 'battery' being two electrodes immersed in a jar of tap water! It is in this capability of functioning on a microscopic input power that the transistor is unique.

The application of germanium to power rectification was illustrated by part of the Standard Telephones & Cables exhibit. Such rectifiers have an exceedingly low voltage drop, 0·5 V mean only in the case of the R50A, which is rated for 100 mA d.c. output and 100 V r.m.s. maximum input. The zero voltage capacitance is 0·003 μF. This firm also showed germanium photocells which have characteristics similar to the vacuum and gas-filled cells. They are intended mainly for 'on-off' applications and the P50A has a sensitivity of 30 mA/lumen with a spectral response peaking at 1·7 micron and a weight of only 0·02 oz.

Oscilloscopes

The cathode-ray oscilloscope in one form or another is still ubiquitous for research in almost every sphere. New instruments differ from the older ones mainly in providing more facilities, an improved performance and smaller physical dimensions. The Cossor 1058 single-beam model is one example; the Y amplifier response is flat within 0·4 db from d.c. to 2·4 Mc/s and is down by just over 2 db at 3·5 Mc/s. A phantastron is used for the saw-tooth generator with a balanced amplifier providing a sweep expansion of up to five times. A 4-in tube is used and the signal sensitivity is 0·35–175 V/cm, variable by a stepped input attenuator and a continuous control.

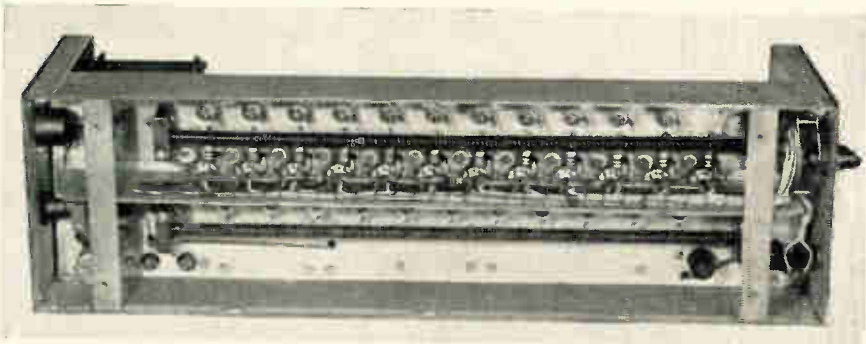
Mullard wideband oscilloscope, Mk. II standing on its power-supply unit.

The complete instrument measures 8 in × 14½ in × 19½ in. A somewhat similar model (1052) with a double-beam tube is available.

The difficulty of achieving accuracy in c.r. measurements is at last being realized and Cossor now make a voltage calibrator unit, Model 1433. It comprises a tapped transformer, attenuator and meter and enables known 50-c/s outputs of 3 mV to 100 V to be obtained with an accuracy of ± 5%.

A much more elaborate instrument was shown by Mullard, the E7581/2. The Y amplifier has a 6-db bandwidth of d.c. to 15 Mc/s and a sensitivity of 10 mV/cm; it is claimed to be able to handle a signal with a rise time of 0·03 μsec. A Miller time-base is used and is of the single-sweep type which may be triggered either by the signal or by an internal oscillator covering 2 c/s to 200 kc/s. A delay circuit is included by means of which the start of the sweep can be delayed by up to ten times the sweep duration.

It is built in two units with forced-air ventilation for the display unit; this unit has 42 valves, of which six are double types, and the power unit has 50. Needless to say, the power supplies are stabilized!



Underside of E.M.I. distributed amplifier.

It is always a difficult matter to secure sufficient output from a Y amplifier when a large bandwidth is needed. An amplifier shown by E.M.I. has this as one of its applications. It is a distributed amplifier having an output of 150 V p-p and a 6-db bandwidth of 30 c/s to 80 Mc/s and a gain of about 12 times.

An even more elaborate oscilloscope is the Southern Instruments E45 with a four-gun c.r. tube. There are four Y amplifiers, balanced and direct-coupled, with a gain of 800 times and a response to 100 kc/s. The time-base covers 1 c/s to 50 kc/s and there is a time-marker which generates pulses at four standard frequencies between 10 c/s and 1,000 c/s. The frequencies are generated by a multivibrator controlled by a tuning fork.

The complexity now shown by oscilloscopes is to be found in other instruments and one example is a voltmeter, VF252, shown by Solartron. It has a feedback circuit which eliminates the effects of changes in the forward/backward resistance ratios of the rectifiers. An absolute accuracy of ± 1% is claimed and the sensitivity is sufficient to permit useful readings to be obtained as low as 20 μV. The ranges are 1·5 mV to 15 V f.s.d. and the input impedance is 50 MΩ, with a

Solartron feedback voltmeter.

frequency range of 10 c/s to 100 kc/s. All told, the instrument embodies 18 valves.

Another voltmeter, which can also be used as a general-purpose laboratory amplifier, is the Cintel signal-level meter. It has a response of 15 c/s to 100 kc/s within ± 0·5 db and a gain of 75 db, while the input attenuator has a range of 80 db. As a voltmeter, there are four ranges of 1 mV to 1 V r.m.s. f.s.d.

As a contrast to the elaborate multi-valve equipment, a simple unit with many useful applications was shown by J. Langham-Thompson. It is a cathode-follower stage, built as a small unit with self-contained batteries capable of giving 48 hours continuous operation. Input and output are by screened connectors. The maximum input is 10 V p-p with 100 MΩ and the output impedance is 4 kΩ.

The application of television in the laboratory was brought out in last year's exhibition and it is now

Cintel signal-level meter.

extended by a camera tube which is sensitive to ultra-violet light. In the equipment shown by E.M.I., a tube is used which is sensitive to wavelengths of 200 Å; it has an end window and mosaic plate of quartz. One application of the apparatus is to the magnification of images produced by the ultra-violet microscope.

An extremely ingenious way of heating rectifier filaments in high-voltage rectifier circuits, which is particularly advantageous when voltage-multiplier circuits are used, was shown by the Admiralty Signals and Radar Establishment. It is of application only when the supply is derived from an r.f. oscillator of, say, 50–300 kc/s. As shown in Fig. 1, the capacitance

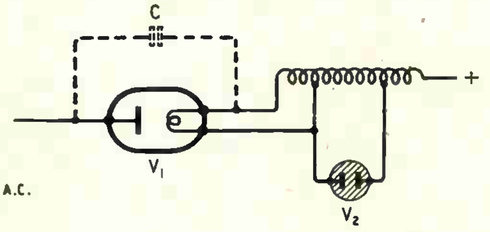
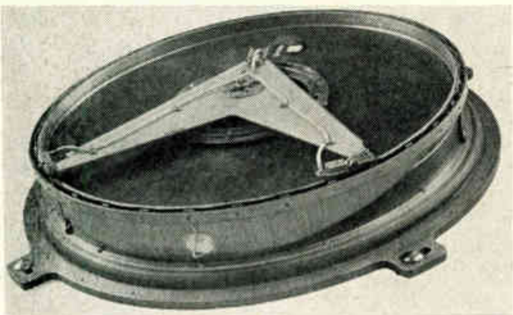


Fig. 1. *Circuit for obtaining filament-heating current for a high-voltage rectifier; C is the anode-filament capacitance.*



Precision sine-cosine potentiometer of 20-in diameter shown by Salford.

C of the rectifier V_1 passes a small alternating current. This is stepped up by an auto-transformer to a suitable value for the valve filament. If desired, a gas-stabilizer tube V_2 can also be connected to the transformer to stabilize the filament supply and so permit the d.c. output to be varied without affecting the filament current. The auto-transformer can be a simple compact device, since no high voltages appear between its parts.

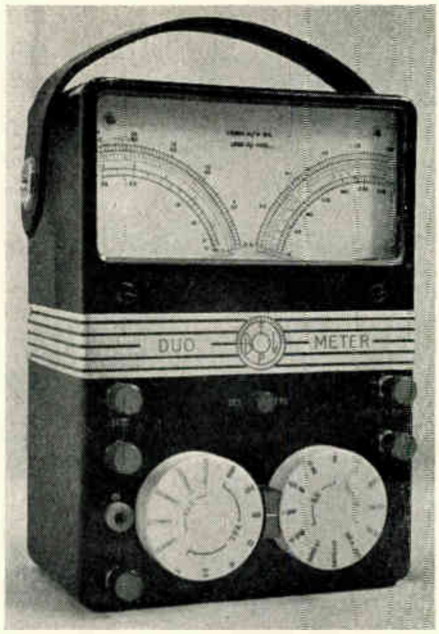
Measuring Instruments

On the electrical side, there was as usual a display of precision components and instruments. Here it is interesting to see that, while the well-tried methods of construction are mostly retained, new methods are beginning to break in. Printed-circuit technique, for instance, is being used for decade resistance boxes by Tinsley. A printed foil method is used with copper-nickel foil, and the resistor values are adjusted to 1%. A three-decade box having 100-Ω, 10-Ω and 1-Ω steps is rated for a maximum current of 0·5 A.

Wayne Kerr capacitance and conductance bridge with direct-reading scales.

The decade principle is applied by Sullivan to an air-dielectric capacitor which comprises a 10-pF section continuously variable combined with two decade sections of 100 pF and 1,000 pF maximum capacitance each. These sections are obtained by variable capacitors of normal basic construction but having segmented vanes and a 'clicker' mechanism so that they move only in steps of 10 pF and 100 pF.

The use of sine-cosine potentiometers in predictors and similar apparatus is well known but few who are not intimately concerned with them realize the lengths to which it is necessary to go to secure the high accuracy required. The Salford types are based on the conventional



British Physical Laboratories Duo Meter; a multi-range test instrument with two meter movements and an unusual scale arrangement.

rotary wire-wound type but have a diameter of about 20 in! Nickel-chrome wire is used and wound on a card cut to the requisite shape and the contact wipers are of platinum ruthenium. The complete unit operates in an oil-filled case and the average accuracy of the law is claimed to be better than 0·07% with a life better than a million revolutions before resolution is affected.

The conventional form of dial and scale has been abandoned by some manufacturers in favour of an indicator of the counter type. One example is to be found in the Wayne Kerr B221 a.f. admittance bridge which is for the measurement of C and R at 10,000 radians/sec. It covers 0·1 pF to 0·1 μF. The indicator is direct-reading in picofarads to four figures and two decimal places and an interpolating drum for the third decimal place, so that there are seven figure-drums which give the value of any capacitance and conductance directly in figures. The range is extended by a multiplier of two decades.

In the case of pointer instruments, there would not appear to be much scope for any change in the styling but, in fact, quite a novel appearance has been obtained in the Duo Meter instrument produced by British Physical Laboratories. It is an instrument in the test-meter category having two independent movements with an unusual, but quite logical, arrangement of the 3½-in scales, as can be seen from the photograph.

The left-hand movement is for the voltmeter range and covers 1 V to 2·5 kV f.s.d. in eight d.c. ranges and 10 V to 1 kV in five a.c. ranges. There are also decibel scales of 0–62 db in five ranges. The right-hand movement is for current: 50 μA to 10 A f.s.d. in six ranges d.c. and 10 mA to 10 A in four ranges a.c. There are also three resistance ranges of 10 kΩ and 1 MΩ f.s.d.

Microwaves

In the microwave field, the measurement of power is still a matter of interest. Last year Elliott showed a method depending upon the rotation of a vane suspended in a waveguide section under the action of a mechanical couple exerted by the wave. This year's model for the 3·2-cm waveband, Type B228, can detect a minimum signal of 100 mW and has a peak power limit of 30 kW. The torque on the vane is measured by a calibrated quartz suspension and torsion head.

Wayne Kerr have introduced a model in which two vanes are used and mounted $\lambda/4$ apart on a spindle which is suspended in a length of vertical waveguide by a quartz fibre. The input and output guides are connected by means of E-plane corners. It is claimed that the accuracy of measurement is not greatly dependent on the matching to the load and that a standing-wave ratio of 0·9 causes an error of 0·5% only in the power indication.

An interesting filter for a coaxial line was shown by Decca Radar. It is formed from a number of radial cavities. A bandwidth of ± 4% is claimed for a mid-band frequency of 3,750 Mc/s and a total volume less than a 4-in cube. Attenuation away from the passband is of the order of 50 db.

NEW BOOKS

Ultra High Frequency Propagation

By HENRY R. REED, Ph.D., and CARL M. RUSSELL, M.S. Pp. 562 + xiv. Chapman & Hall, Ltd., 37 Essex Street, London, W.C.2. Price 76s.

The title of this book is rather misleading, for what is usually understood by 'propagation' comprises a relatively small part of it. After an introductory chapter, the general aspects of propagation are discussed and then meteorological theory is treated. Chapter 4 is on aerials and radiation. Multipath propagation is dealt with in chapter 5 and then comes a comparison of v.h.f. and u.h.f. propagation, dipole-to-dipole, for ground-to-air and air-to-ground conditions. Aerial arrays are treated in the next two chapters, and certain complex forms, such as switched sector aerials, in a third. Chapter 10 covers air-to-air propagation and 11 with lobe modulation interference while the rest of the book treats more general matters.

The scope and character of the book might well be summed up by saying that its title should have been "The effect of propagation on the design and performance of telecommunication systems", with the accent on 'systems'. There is little or nothing about the actual apparatus at each end, the treatment is concerned with the communications link from the input to one aerial to the output of the other and it is concerned with everything that can affect this part of the chain.

Principles of Electronics

By L. T. AGGER, B.E. Pp. 340. Macmillan & Co., Ltd., St. Martin's Street, London, W.C.2. Price 18s.

Starting with atomic structure, this book goes on to deal with electron dynamics, thermionic emission and conduction through gases. The diode and rectification, the triode and voltage amplification and multi-electrode valves and multi-stage amplifiers are then treated. Tuned amplifiers and power amplifiers follow and are succeeded by gas-filled valves, controlled rectification and inversion, oscillators, modulation and demodulation, cathode-ray tubes and photoelectricity.

The book is intended for the electrical student with an electrical and mathematical background corresponding to the Ordinary National Certificate in electrical engineering.

Circuit Theory of Electron Devices

By E. MILTON BOONE. Pp. 483 + vii. Chapman & Hall, Ltd., 37 Essex Street, London, W.C.2. Price 68s.

This is an American book "written primarily for college and university students". It covers ordinary valve types and their equivalent circuits, a.f. voltage and power amplifiers and gas-filled valves. Single and polyphase rectifiers are treated, r.f. voltage and power amplifiers with single- and double-tuned circuit couplings, as well as oscillators, modulation and demodulation. There is a final chapter on transistors.

Electronic Engineering Principles (2nd Edition)

By JOHN D. RYDER, Ph.D. Pp. 505 + ix. Sir Isaac Pitman & Sons, Ltd., 39 Parker Street, London, W.C.2. Price 37s. 6d.

Of American origin, this book starts with the fundamental particles of electronics and goes on to deal with the movement of charged particles in fields and then to the cathode-ray tube. Emission comes in Chapter 4 and is followed by space-charge and then by diodes, triodes and multi-element valves. Small-signal amplifiers and feedback are then treated and, in Chapter 10, large-signal amplifiers. A jump is then made to gaseous conduction, gas diodes and gaseous control valves and circuits. The book concludes with photo-electric cells and solid-state electronics.

Théorie des Fonctions Aléatoires

By A. BLANC-LAPIERRE and ROBERT FORTET. Pp. 693 + xvi. Masson et Cie., 120 Boulevard Saint-Germain, Paris 6e, France. Price 6,500 fr.

After a physical introduction to random functions, there is a chapter on probability theory and the one on general random functions. Poisson processes and Markov processes and chains are treated. A chapter is given to the harmonic analysis of random functions and another to problems connected with it. Energy properties of, and stationary, random functions of second order are discussed as well as Laplacian random functions, the statistical theory of turbulence and the application of the functions to noise and telecommunications.

Manual for Plastic Welding. Vol. II. Polyethylene

By G. HAIM and J. A. NEUMANN. Pp. 128 + xiv. Crosby Lockwood & Son, Ltd., 39 Thurloe Street, London, S.W.7. Price 30s.

This book describes the processes used, and the equipment necessary, for the welding of polyethylene. Although the processes are mainly ones appropriate to a commercial scale of operations, the use of hand tools is treated.

Higher Transcendental Functions

Compiled by the Staff of the Bateman Manuscript Project and based in part on notes left by Harry Bateman, late Professor of Mathematics, Theoretical Physics and Aeronautics at the Californian Institute of Technology. Vol. 1, pp. 302 + xxvi, price 52s. Vol. 2, pp. 396 + xvii, price 60s. McGraw-Hill Publishing Co., Ltd., 95 Farringdon Street, London, E.C.4.

The Magnetic Amplifier (2nd Edition)

By J. K. REYNER, A.C.G.I., B.Sc., D.I.C., M.I.E.E., M.Inst.R.E. Pp. 119. Rockliff Publishing Corporation, Ltd., 1 Dorset Buildings, Salisbury Square, Fleet Street, London, E.C.4. Price 15s.

This book gives a simple and substantially non-mathematical explanation of how magnetic amplifiers function. It provides an introduction to the subject.

Introduction à l'Électronique

By P. GRAU. Pp. 212 + xi. Dunod, 92 rue Bonaparte, Paris 6e. Price 1,650 fr.

Cours Pratique de Télévision, Vol. 1. Amplificateurs M.F. et H.F. Directs à Large Bande.

By F. JUSTER. Pp. 127. Éditions Techniques et Professionnelles. 18 bis Villa Herran, Paris 16e. Price 490 fr.

Bessel Functions and Formulae

Compiled by W. G. BICKLEY. Pp. 11. Extracted from British Association Mathematical Tables, Vol. 10, Bessel Functions, Part 2, Functions of Positive Integer Order. Cambridge University Press, 200 Euston Road, London, N.W.1. Price 3s. 6d.

Radio Interference from Motor Vehicles. Comparison of British and German Measuring Equipment.

By A. H. BALL and S. F. PEARCE. Technical Report M/T 123. Pp. 8. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 10s. 6d.

Wireless and Electrical Trader Year Book 1954 (25th Edition)

Pp. 296. Trader Publishing Co., Ltd., Dorset House, Stamford Street, London, S.E.1. Price 10s. 6d.

Les Filtres a Cristaux Piézoélectriques

By D. INDJOUDJIAN and P. ANDRIEUX. Pp. 177. Gauthier-Villars, 55 Quai des Grands-Augustins, Paris 6e, France. Price 3,300 fr.

Science in the U.S.A. 1953.

British Commonwealth Scientific Office, North America. Pp. 44 + iv. H.M. Stationery Office, York House, Kingsway, London, W.C.2. Price 2s.

Radio Control of Model Aircraft

By G. SOMMERHOFF. Pp. 164. Percival Marshall & Co., Ltd., 19-20 Noel Street, London, W.1. Price 9s. 6d.

Television Receiver Servicing. Vol. 1: Time-Base Circuits

By E. A. W. SPREADBURY, M.Brit.I.R.E. Pp. 310. Trader Publishing Co., Ltd., distributed by Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 21s.

British Plastics Year Book 1954 (24th Edition)

Pp. 600. Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 30s.

The Magnitude of the Radio Interference in the Television Band from Ignition Systems of Motor Vehicles

By A. H. BALL and W. NETHERCOT. E.R.A. Bulletin U/T123. Pp. 11. The Electrical Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 6s.

Enregistrement des Sons

By J. LANDRAC. Pp. 232. Editions Eyrolles. 61 Boulevard Saint-Germain, Paris 5e, France. Price 1,900 fr.

The Radio Amateur's Handbook 1954 (31st Edition)

By the Headquarters Staff of the American Radio Relay League. Pp. 619. American Radio Relay League Inc., West Hartford 7, Connecticut, U.S.A. Price $3.

Dielectric Aerials

By D. G. KIELY, M.Sc., A.M.I.E.E., A.Inst.P. Pp. 132 + xii. Price 8s. 6d.

Magnetic Amplifiers

By GEORGE M. ETTINGER. Pp. 88 + viii. Price 6s. 6d.

Microwave Spectroscopy

By M. W. P. STRANDBERG. Pp. 140 + vii. Price 9s. 6d.

The above three books are of the Methuen Monograph Series published by Methuen & Co., Ltd., 35 Essex Street, London, W.C.2.

The Year that made the Day

Pp. 79. The British Broadcasting Corporation, 35 Marylebone High Street, London, W.1. Price 6s.

An illustrated description of the planning and preparation for the B.B.C. broadcasts on Coronation Day.

Einführung in die Mikrowellen

By H. H. KLINGER. Pp. 117 + viii. S. Hirzel Verlag, Zürich. Price 10.80 fr.

Problèmes et Exercices D'Électricité Générale et de Machines Électriques

By P. JANET, new edition revised by G. Nasse. Pp. 409 + vi. Gauthier-Villars, 55 Quai des Grands-Augustins, Paris 6e. Price 2,700 fr.

BRITISH STANDARDS:

Thermosetting Synthetic-Resin Bonded-Paper Insulating Sheets for use at Radio Frequencies

B.S. 2076 : 1954. Price 2s. 6d.

Characteristics and Performance of Apparatus for Measurement of Radio Interference

B.S. 727 : 1954. Price 4s.

Limits of Radio Interference

B.S. 800 : 1954. Price 4s.

Cotton Covered Round Copper Wires (Metric Units)

B.S. 2084 : 1954. Price 2s. 6d.

Determination of Power Factor and Permittivity of Insulating Materials by the Method of Hartshorn and Ward

B.S. 2067 : 1953. Price 4s.

Electrical Indicating Instruments

B.S. 89 : 1954. Price 7s. 6d.

Code of Practice on the Use of Electronic Valves (Parts 1 and 2)

C. P. 1005. Price 6s.

Glossary of Terms for the Electrical Characteristics of Radio Receivers

B.S. 2065 : 1954. Price 6s.

British Standards Institution, 2 Park Street, London, W.1.

NATIONAL BUREAU OF STANDARDS:

Simultaneous Linear Equations and the Determination of Eigenvalues

National Bureau of Standards Applied Mathematics Series 29. Pp. 126. Price $ 1.50.

This book contains 19 of the papers presented at a Symposium held at the National Bureau of Standards Institute for Numerical Analysis at Los Angeles on 23rd-25th August 1951.

Table of Coefficients for the Numerical Calculation of Laplace Transforms

National Bureau of Standards Applied Mathematics Series 30. Pp. 36. Price 25 cents.

Table of Natural Logarithms for Arguments between Zero and Five to Sixteen Decimal Places

National Bureau of Standards Applied Mathematics Series 31, (revision of MT10). Pp. 501. Price $3.25.

Magnetic Fields of Cylindrical Coils and Annular Coils

National Bureau of Standards Applied Mathematics Series 38. Pp. 29. Price 25 cents.

This booklet contains formulae for calculating the axial and radial components of the magnetic field at any point in space of certain coils. The results are expressed in terms of complete elliptic integrals or of Legendre functions.

Tables of 10^x

National Bureau of Standards Applied Mathematics Series 27. Pp. 543. Price $3.50.

Table I is for 10^x for $x = 0(\cdot00001)\ 1\cdot00000$ to 10D and Table II is a radix table of 10^{nx} 10^{p}, $n = 1(1)999$, $p = 3, 6, 9, 12, 15$ to 15D. Antilogarithms (10^x) are given in an interpolable table to 10-decimal accuracy and in a basic radix table to 15-figure accuracy.

The National Bureau of Standards publications can be obtained from the Government Printing Office, Washington 25, D.C., U.S.A.

MEETINGS

Brit.I.R.E.

5th May. "Microwave Measuring Equipment", by P. M. Ratcliffe, to be held at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, commencing at 6.30.

Television Society

14th May. "Receiver Design for 625-line Systems", by Dr. A. J. Biggs, to be held at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2, at 7 o'clock.

Royal Society of Arts

5th May. "Colour Television", by Commander C. G. Mayer, O.B.E., to be held at John Adam Street, Adelphi, London, W.C.2, at 2.30.

STANDARD FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Values for March 1954

Date 1954 March	Frequency deviation from nominal: parts in 10^8		Lead of MSF impulses on GBR 1000 G.M.T. time signal in milliseconds
	MSF 60 kc/s 1429-1530 G.M.T.	Droitwich 200 kc/s 1030 G.M.T.	
1	−1·3	−1	+ 1·4
2	−1·3	0	+ 1·3
3	−1·3	+1	+ 1·3
4	−1·3	0	− 0·7
5	−1·2	0	− 1·0
6	−1·2	0	NM
7	−1·2	−1	NM
8	−1·3	−1	− 5·1
9	−1·3	0	− 6·4
10	−1·2	0	− 7·4
11	−1·2	−1	− 8·5
12	−1·2	−1	−10·2
13	−1·2	0	NM
14	−1·2	−1	NM
15	−1·1	0	−12·0
16	−1·1	+1	−13·5
17	−1·2	−1	−14·2
18	−1·2	+1	−18·2
19	−1·2	+1	−20·0
20	−1·2	−1	NM
21	−1·2	0	NM
22	−1·2	+1	−25·8
23	−1·2	+1	−27·7
24	−1·2	0	−30·1
25	−1·1	0	−31·9
26	−1·1	0	−33·3
27	−1·1	0	NM
28	−1·1	0	NM
29	−1·2	0	−39·8
30	−1·2	+1	−41·3
31	−1·0	+2	−42·6

The values are based on astronomical data available on 1st April 1954.
The transmitter employed for the 60-kc/s signal is sometimes required for another service.

NM — Not Measured.

ABSTRACTS and REFERENCES

Compiled by the Radio Research Organization of the Department of Scientific and Industrial Research and published by arrangement with that Department.

The abstracts are classified in accordance with the Universal Decimal Classification. They are arranged within broad subject sections in the order of the U.D.C. numbers, except that notices of book reviews are placed at the ends of the sections. U.D.C. numbers marked with a dagger (†) must be regarded as provisional. The abbreviations of journal titles conform generally with the style of the World List of Scientific Periodicals. An Author and Subject Index to the abstracts is published annually; it includes a selected list of journals abstracted, the abbreviations of their titles and their publishers' addresses.

ACOUSTICS AND AUDIO FREQUENCIES

534.2 **1269**

Saw-toothed Wave-forms in Sound.—G. J. Barber & T. F. W. Embleton. (*Nature, Lond.*, 5th Dec. 1953, Vol. 172, No. 4388, pp. 1057–1058.) An examination of the distortion of finite-amplitude pulses in which the leading half-cycle is a rarefaction.

534.2 **1270**

Scattering of Sound in a Turbulent Stream.—V. A. Krasil'nikov & V. I. Tatarski. (*C. R. Acad. Sci. U.R.S.S.*, 11th May 1953, Vol. 90, No. 2, pp. 159–162.) A theoretical treatment based on the assumption that the medium can be represented by the equation of an incompressible viscous fluid. In such a stream the scattering due to temperature inhomogeneities and to variations of the velocity are independent of each other and can be evaluated separately.

534.2 : 534.321.9 **1271**

The Fluctuations of Phase of Ultrasonic Waves propagated in the Ground Layer of the Air.—V. A. Krasil'nikov. (*C. R. Acad. Sci. U.R.S.S.*, 1st Feb. 1953, Vol. 88, No. 4, pp. 657–660. In Russian.) The r.m.s. phase deviation was determined from observations at frequencies up to 51 kc/s for various values of frequency and wind direction, distance between radiator and receiver, wind velocity, and time during which N observations were recorded. The apparatus used is described with the aid of a block diagram. The results are tabulated.

534.321.9 : 534.61 **1272**

The Dependence of the Power of Ultrasonic Radiation on Frequency.—S. Parthasarathy, D. Srinivasan & S. S. Chari. (*Z. Phys.*, 16th Oct. 1953, Vol. 136, No. 1, pp. 17–20.) The radiation intensities of the 3rd, 7th and 11th harmonics of a 1·44-Mc/s quartz crystal immersed in five organic liquids and excited at constant voltage were determined by thermal and direct radiation-pressure measurements. Radiated power decreases continuously as the order of harmonics increases.

534.321.9 : 534.613 **1273**

Mechanical Action of Ultrasonic Waves on Obstacles.—R. Lucas & E. Grossetti. (*C. R. Acad. Sci., Paris*, 25th Jan. 1954, Vol. 238, No. 4, pp. 458–459.) Experiments were made to check theoretically derived expressions for the force exerted by plane ultrasonic waves, using a torsion-balance method. The effects for highly reflecting and nonreflecting surfaces were compared. Obstacles of dimensions about 20 times the wavelength (λ = 1 mm) were used.

534.321.9 : 534.613 **1274**

An Investigation of the Absorption of 5-Mc/s Ultrasonic Waves in Organic Liquids by the Radiation Pressure Method.—S. Parthasarathy, S. S. Chari & D. Srinivasan. (*J. Phys. Radium*, Oct. 1953, Vol. 14, No. 10, pp. 541–546.) Measurements are reported of absorption in 47 liquids. See also 2543 of 1953.

534.321.9-14 **1275**

Variation of Ultrasonic Absorption with Frequency in Organic Liquids.—S. Parthasarathy, S. S. Chari & D. Srinivasan. (*Acustica*, 1953, Vol. 3, No. 5, pp. 363–364.) Certain results of radiation-pressure measurements at 5, 10 and 15 Mc/s lend support to the relaxation theory.

534.79 **1276**

The Relation between the Sone and Phon Scales of Loudness.—D. W. Robinson. (*Acustica*, 1953, Vol. 3, No. 5, pp. 344–358.) A set of statistically controlled experiments is described in which 35 subjects were required to judge two-fold and ten-fold increase and reduction of the loudness of tone and of noise. Loudness scales obtained showed a high consistency and a significant difference between scales relating to increase and to decrease of sensation. Results for loudness reduction are approximately expressed by the formula $\log S = 0{\cdot}029\ (P - 40)$ for the range 20–110 phons, P being the loudness level in phons, S the loudness sensation in sones. Results for free-field and earphone listening were similar.

534.83/.84 **1277**

Calculation of Sound Propagation in Structures.—L. Cremer. (*Acustica*, 1953, Vol. 3, No. 5, pp. 317–335.) Wavelength/frequency relations for sound waves propagated in different structural materials are calculated; critical frequencies for sound radiation from structural elements are discussed. Mechanical impedance and the spectrum of impact sound are considered and an analysis is made of the effectiveness of suitable structural design in reducing the amplitude of longitudinal and flexural waves.

534.862.2 : 534.76 1278
Experiment in Stereophonic Sound.—L. D. Grignon. (*J. Soc. Mot. Pict. Telev. Engrs*, Sept. 1953, Vol. 61, No. 3, Part II, pp. 364–377. Discussion, pp. 377–379.) Microphone placing in stereophonic sound-film recording is discussed.

534.862.3[.4] : 534.76 : 621.395.625.3 1279
Stereophonic Recording and Reproducing Equipment.—J. G. Frayne & E. W. Templin. (*J. Soc. Mot. Pict. Telev. Engrs*, Sept. 1953, Vol. 61, No. 3, Part II, pp. 395–405. Discussion, pp. 405–407.) An outline description of some of the commercial equipment developed for the film industry.

534.862.3 : 534.76 : 621.395.625.3 1280
Multiple-Track Magnetic Heads.—K. Singer & M. Rettinger. (*J. Soc. Mot. Pict. Telev. Engrs*, Sept. 1953, Vol. 61, No. 3, Part II, pp. 390–394.) A brief description of the construction and characteristics of two six-track heads for the stereophonic recording of sound on film.

534.862.4 : 534.76 1281
Stereophonic Recording and Reproducing System.—H. Fletcher. (*J. Soc. Mot. Pict. Telev. Engrs*, Sept. 1953, Vol. 61, No. 3, Part II, pp. 355–361. Discussion, pp. 361–363.) A discussion of the amplifier and loudspeaker requirements for the reproduction of music at the original power level, in large halls, e.g. cinemas.

534.862.4 : 534.76 : 621.375.2 1282
New Theater Sound System for Multipurpose Use.—J. E. Volkmann, J. F. Byrd & J. D. Phyfe. (*J. Soc. Mot. Pict. Telev. Engrs*, Sept. 1953, Vol. 61, No. 3, Part II, pp. 408–414.) An outline description of two commercial multichannel power amplifiers.

534.862.4 : 534.76 : [621.395.623.7 + 621.375.2 1283
Loudspeakers and Amplifiers for Use with Stereophonic Reproduction in the Theater.—J. K. Hilliard. (*J. Soc. Mot. Pict. Telev. Engrs*, Sept. 1953, Vol. 61, No. 3, Part II, pp. 380–389. Discussion, p. 389.) A brief description of equipment and cinema installations.

534.87/.88 + 534.614 1284
The Development of Acoustic Sea-Depth Measurements.—Drubba & Rust. (See 1430.)

621.395.61 1285
Directional Dynamic Microphones.—(*Radio Tech., Vienna*, Dec. 1953, Vol. 29, No. 12, pp. 420–422.) Microphones developed in Austria are described. One type comprises two dynamic systems with individual cardioid characteristics, which can be combined to provide omnidirectional or figure-of-eight characteristics as required.

621.395.61 1286
The Directivity of Spherical Microphones.—R. L. Pritchard. (*Acustica*, 1953, Vol. 3, No. 5, pp. 359–362.) The directional response of a cylindrical microphone mounted in a sphere is calculated by considering the sound field radiated from a spherical cap and applying the reciprocity principle. This principle is also used to derive the frequency response of a completely spherical microphone. Results are compared with those of Kuhl (613 of 1953); good agreement is shown except in the case of Kuhl's calculated values for response at angles between 160° and 180°.

621.395.625.3 1287
Studies on Magnetic Recording: Part 5—Comparison with Experiments. Part 6—Change in the Recording with Time.—W. K. Westmijze. (*Philips Res. Rep.*, Oct. 1953, Vol. 8, No. 5, pp. 343–366.) Print effect and time-lag effects are discussed. 45 references. Parts 3 and 4: 324 of February.

621.395.625.3 1288
The Difference between Pre-echo and Post-echo in the Print-Through Effect.—J. Greiner. (*NachrTech.*, Nov. & Dec. 1953, Vol. 3, Nos. 11 & 12, pp. 506–509 & 543–545, 573.) A report of theoretical and experimental investigations of the print-through effect in magnetic-tape recording.

631.395.625.3 1289
The Effect of High-Frequency Biasing in Magnetic [tape] Recording.—W. Albach. (*Funk u. Ton*, Dec. 1953, Vol. 7, No. 12, pp. 628–630.) The improvement obtained by using h.f. biasing is explained as resulting from reduced hysteresis in the magnetization process.

621.395.625.3 : 621.385.832 1290
Visual Monitor for Magnetic Tape.—R. L. Miller. (*J. Soc. Mot. Pict. Telev. Engrs*, Sept. 1953, Vol. 61, No. 3, Part I, pp. 309–312. Discussion, pp. 313–315.) The monitor comprises a c.r. tube with the second anode forming a section of the tube wall. The tape is passed over a saddle formed in the second anode, and the beam deflection due to the magnetic recording is displayed on the fluorescent screen.

621.395.625.3 : 621.397.5 1291
The Status of Magnetic Recording.—R. E. Zenner. (*Elect. Engng, N.Y.*, Nov. 1953, Vol. 72, No. 11, pp. 951–954.) Limitations of magnetic-tape systems are discussed in relation to the recording of (*a*) sound, (*b*) digital data, (*c*) physical analogue data, and (*d*) video signals.

AERIALS AND TRANSMISSION LINES

621.315.212 1292
The Manufacture, Laying and Splicing of Coaxial-Pair Cable.—C. Lancoud. (*Bull. schweiz. elektrotech. Ver.*, 3rd Oct. 1953, Vol. 44, No. 20, pp. 875–880. In French.) A short account, with special reference to Swiss practice.

621.372.2 1293
The E-H Surface Wave.—A. E. Karbowiak. (*Wireless Engr*, March 1954, Vol. 31, No. 3, pp. 71–73.) The field equations of the travelling E-H surface wave are derived, and an analysis is made of transmission along helical conductors.

621.372.2 1294
Transmission-Line Impedance and Efficiency.—W. W. Macalpine. (*Elect. Engng, N.Y.*, Oct. 1953, Vol. 72, No. 10, p. 868.) Digest only. A method is presented for computing the resistance and the efficiency of a line when the voltage s.w.r. is high. For full paper see *Trans. Amer. Inst. elect. Engrs*, 1953, Vol. 72, Part I, pp. 334–339 or *Elect. Commun.*, Sept. 1953, Vol. 30, No. 3, pp. 238–246.

621.372.2 1295
Irregular Transmission Lines.—A. Rosen. (*Wireless Engr*, March 1954, Vol. 31, No. 3, pp. 59–70.) The Kennelly method of successive reflections is developed to give general expressions for the voltage and current in an irregular line. The expressions are simplified for the case where the impedance deviations are small, e.g. for coaxial cable used for wide-band telephone and television transmission. The formulae are given in series form for

the case where the impedance changes abruptly, and in integral form for the case of continuous impedance changes. The effects of irregularities on the open- and short-circuit impedances are discussed.

621.372.2.029.64/.65 + 621.396.621.029.64 **1296**

Experimental Determination of the Properties of Microstrip Components.—M. Arditi. (*Elect. Commun.*, Dec. 1953, Vol. 30, No. 4, pp. 283–293; *Convention Record Inst. Radio Engrs*, 1953, Part 10, pp. 27–37.) The components investigated include coaxial-to-microstrip matching units, bends, transverse posts, offset junctions, step discontinuities, gaps or slots in the strip conductor, parallel-coupled junctions and directional couplers. A microwave receiver is described in which the whole r.f. circuit except the high-Q cavity resonator consists of microstrip parts.

621.372.21 **1297**

Calculation of the Attenuation and Distortion of Travelling Waves.—K. Moritz. (*Arch. Elektrotech.*, 1953, Vol. 41, No. 3, pp. 160–180.) Mathematical investigation of the propagation of a voltage pulse along a line with an earth return. The losses due to earth eddy currents and corona are taken into consideration; line-resistance losses are neglected.

621.372.8 + 621.372.2 **1298**

TEM Waves in Cylindrical Systems.—P. Moon & D. E. Spencer. (*J. Franklin Inst.*, Oct. 1953, Vol. 256, No. 4, pp. 325–336.) Two simple and rigorous theoretical treatments are presented, namely (*a*) use of the vector Laplacian operator, and (*b*) introduction of a quasi-potential. Equations derived are free from ambiguities and yield simple solutions for **E** and **H** even with complex coordinate systems.

621.372.8 **1299**

Attenuation in Nickel and Mild-Steel Waveguides at 9375 Mc/s.—F. A. Benson. (*Proc. Instn elect. Engrs*, Part III, Jan. 1954, Vol. 101, No. 69, pp. 38–41.) Measurements on rectangular waveguides are reported. Mild-steel guides with machined internal surfaces have attenuation as high as 3·79 db/m, while the permeability of Ni deduced from attenuation measurements on commercial drawn tubing, taking account of surface roughness, was ~ 3.

621.372.8 : 538.614 **1300**

Guided Electromagnetic Waves in Anisotropic Media.—A. A. T. M. van Trier. (*Appl. sci Res.*, Vol. B3, Nos. 4/5, pp. 305–371.) Theory of guided waves in isotropic media is surveyed; a general formulation of the theory for anisotropic media is presented, and particular waveguide structures are analysed. A cavity technique for measuring Faraday rotations is described and experimental results obtained with ferroxcube IVA, B, C, D and E are presented. The physical interpretation of the results is discussed with reference to Rado's theory of the permeability tensor in nonsaturated ferromagnetics (1709 of 1953).

621.396.67 **1301**

Modern Aerial Theories.—P. Neidhardt. (*NachrTech.*, Nov. 1953, Vol. 3, No. 11, pp. 487–492.) A comparative survey with 44 references.

621.396.67 **1302**

Calculation of the Distribution of Current in Thin [linear] Aerials.—R. Sartori. (*Alta Frequenza*, Dec. 1953, Vol. 22, No. 6, pp. 258–281.) Energy considerations lead to a simple way of deriving a general equation for the current distribution, which includes Hallén's equation as a particular case.

621.396.67 : 621.397.5 **1303**

Control of Vertical Radiation Patterns of TV Transmitting Antennas.—F. G. Kear & J. G. Preston. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, pp. 402–407.) Earlier U.S.A. designs concentrating as much of the energy as possible into the horizontal plane are being modified to improve the coverage of the service area. As an example, the 6-bay superturnstile aerial on Mt Wilson has been modified to radiate 2·1 times as much power below the horizontal as above.

621.396.677.45 **1304**

Wide-Frequency-Range Tuned Helical Antennas and Circuits.—A. G. Kandoian & W. Sichak. (*Elect. Commun.*, Dec. 1953, Vol. 30, No. 4, pp. 294–299; *Convention Record Inst. Radio Engrs*, 1953, Part 2, pp. 42–47.) A discussion of helical aerials of diameter small compared with λ. Using a shunt-feed arrangement with a variable tap point and a variable short-circuit, tuning ranges up to 100 : 1 can be obtained.

621.396.677.7 **1305**

Radiation from the Open End of a Lecher Line or Waveguide at a Great Distance from the Opening.—H. Florian. (*Acta phys. austriaca*, Oct. 1953, Vol. 8, No. 1, pp. 42–62.) Schelkunoff's analysis (1779 of 1936) is extended; results are obtained in the form of solvable integrals suitable for practical calculations. Waveguides of rectangular and circular section and coaxial lines are considered.

621.396.677.71 **1306**

Propagation along a Slotted Cylinder.—R. F. Harrington. (*J. appl. Phys.*, Nov. 1953, Vol. 24, No. 11, pp. 1366–1371.) A variational method is presented for determining the attenuation and phase constants for the field of a travelling-wave slot aerial using a circular-section waveguide. Calculated and experimentally determined values are compared for the cases of excitation in the TE_{11} and TM_{01} modes.

621.396.677.71 **1307**

Traveling-Wave Slot Antennas.—V. H. Rumsey. (*J. appl. Phys.*, Nov. 1953, Vol. 24, No. 11, pp. 1358–1365.) A variational method, making use of the generalized reciprocity theorem for travelling-wave line sources, is used to derive approximate formulae for the propagation constant and characteristic field pattern for travelling-wave slot aerials containing a dielectric. For the case of the rectangular-section aerial containing only air, results calculated from the theory are in good agreement with measured values. See also 334 of February (Hines et al.).

621.396.677.75 **1308**

Propagation and Radiation of Electromagnetic Waves along a Dielectric Line with Nonuniform Characteristics.—J. C. Simon & G. Weill. (*C. R. Acad. Sci., Paris*, 4th Jan. 1954, Vol. 238, No. 1, pp. 57–59.) Long aerials comprising nonuniform dielectric lines are discussed, and a method based on the concept of space harmonics is presented for calculating the relation between the radiation and the periodic characteristics of the line.

AUTOMATIC COMPUTERS

681.142 **1309**

An Analogue-Type Multiplier.—J. Isabeau. (*HF, Brussels*, 1953, Vol. 2, No. 8, pp. 213–218.) A simple multiplying circuit is described in which 12-kc/s rectangular pulses are modulated successively in width and amplitude in proportion respectively to the two factors, A and B, to be multiplied. Response times for the circuit tested were 1–10 ms for the factor A (amplitude 5–100 V) and 20 ms irrespective of amplitude for B (0–120 V).

681.142 **1310**

A Simple Electronic Multiplier.—K. H. Norsworthy. (*Electronic Engng*, Feb. 1954, Vol. 26, No. 312, pp. 72–75.) The multiplication process described is based on the equation $(X + Y)^2 - (X - Y)^2 = 4XY$. A method of squaring is used which depends on the fact that the areas of similar triangles are proportional to the squares of their heights; a triangular-waveform generator is described. The device accepts both positive and negative input voltages.

681.142 **1311**

Electronic Analogue Computing.—R. B. Quarmby. (*Wireless World*, March 1954, Vol. 60, No. 3, pp. 113–118.) A survey of modern techniques; an indication is given of the kind of problem for which analogue computers offer advantages over digital types.

681.142 **1312**

A New Analogue Computer.—E. L. Thomas. (*Engineering, Lond.*, 9th Oct. 1953, Vol. 176, No. 4576, pp. 477–479.) A general-purpose computer of differential-analyser type, designed for economic quantity production, is described. Three basic elements are used, viz., (*a*) scaling units, essentially 3-decade variable resistors, (*b*) function units comprising *RC* networks, (*c*) high-gain amplifiers. Facilities for c.r.o. and graphical display are provided.

681.142 **1313**

Note on High-Speed Product Integrator.—I. Cederbaum. (*Rev. sci. Instrum.*, Nov. 1953, Vol. 24, No. 11, pp. 1072–1073.) Errors arising in the potentiometer circuit of the integrator [2058 of 1953 (Macnee)] are discussed.

681.142 **1314**

General Survey of the Operating Principles of Electrical Analogue Computers.—C. Mounier. (*Rev. gén. Élect.*, Nov. 1953, Vol. 62, No. 11, pp. 515–530.) A survey with particular reference to computers constructed by the Société d'Électronique et d'Automatisme; difficulties encountered in studying the accuracy of these machines are discussed.

681.142 **1315**

A Diode-Capacitor Memory for High-Speed Electronic Computers.—(*Tech. News Bull. nat. Bur. Stand.*, Nov. 1953, Vol. 37, No. 11, pp. 171–173.) Ordinary linear capacitors are used as rapid-access storage elements in a matrix arrangement. The basic circuit consists of two diodes in series, with the anode of one connected to the cathode of the other, and the capacitor connected to the junction; the other end of the capacitor is used for reading and writing, and is connected to earth through a resistor.

681.142 **1316**

A Survey of Digital Computer Memory Systems.—J. P. Eckert, Jr. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, p. 413.) Correction to paper abstracted in 41 of January.

681.142 **1317**

Frequency Analysis of Digital Computers operating in Real Time.—J. M. Salzer. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, pp. 457–466.)

681.142 : 512 **1318**

Elements of Boolean Algebra for the Study of Information-Handling Systems.—R. Serrell. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, p. 475.) Correction to paper abstracted in 57 of January.

681.142 : 53 **1319**

Application of Digital Computing Techniques to Physics.—R. A. Brooker. (*Brit. J. appl. Phys.*, Nov. 1953, Vol. 4, No. 11, pp. 321–326.) Problems involving matrices, ordinary and partial differential equations, functions occurring in crystallography and the 'random walk' statistical method are discussed. Machine design and the training of personnel are considered briefly.

681.142 : [538.221 + 537.226 **1320**

Magnetic and Dielectric Elements for Computers.—F. van Tongerloo. (*Tijdschr. ned. Radiogenoot.*, Nov. 1953, Vol. 18, Nos. 5/6, pp. 265–285.) A survey of the applications of materials with rectangular hysteresis loops. Two classes are distinguished, namely (*a*) those depending on a high ratio of remanence to saturation, and (*b*) those for which the 'squareness ratio' is important.

681.142 : 621.373.42 **1321**

A Low-Frequency Oscillator.—R. M. Howe & R. J. Leite. (*Rev. sci. Instrum.*, Oct. 1953, Vol. 24, No. 10, pp. 901–903.) An analogue computer for solving the differential equations of a mass/spring system comprises a circuit producing simple harmonic oscillations with a frequency range of 0·0016–16 c/s.

681.142 : 621.376.22 **1322**

Instantaneous Multiplier for Computers.—M. Mehron & W. Otto. (*Electronics*, Feb. 1954, Vol. 27, No. 2, pp. 144–148.) Multiplication is performed by means of balanced modulators using standard i.f. transformers and other components.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.018.75 : 621.387.4 **1323**

Pulse-Height Analyzer.—J. W. Thomas, V. V. Verbinski & W. E. Stephens. (*Rev. sci. Instrum.*, Nov. 1953, Vol. 24, No. 11, pp. 1017–1020.) The equipment, based on Wilkinson's conversion principle (1085 of 1951), has resolution, linearity and stability to within 1%. It can deal with input pulses at a rate of several thousand per second. Recording is made on Teledeltos paper at a rate of up to 50 pulses/sec.

621.3.018.78 **1324**

A New General Method for Frequency-Distortion Correction of a Given Circuit in Light-Current and Instrument Engineering.—M. Hájková-Jančová. (*Frequenz*, Sept. 1953, Vol. 7, No. 9, pp. 268–269.) The frequency-dependent function, e.g. the amplification factor, is expressed as the ratio of power series of functions of the frequency, and the condition for a minimal frequency dependence is found.

621.3.018.78 : 621.376.3 **1325**

Normalized Phase and Gain Derivatives as an Aid in Evaluation of F.M. Distortion.—J. J. Hupert. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, pp. 438–446.) The method previously described for evaluating the distortion for the quasistationary condition (3550 of 1953) is extended to take account of the finite rate of variation of the input-signal frequency.

621.314.7 : 621.3.015.3 **1326**

Transient Response of the Grounded-Base Transistor Amplifier with Small Load Impedance.—J. S. Schaffner & J. J. Suran. (*J. appl. Phys.*, Nov. 1953, Vol. 24, No. 11, pp. 1355–1357.) A transfer function relating junction-transistor collector current to emitter current is derived from the diffusion equation; the Laplace-transform technique is used to determine the variation of collector current in response to a step variation of emitter current. Collector-current rise times evaluated from the theory are in good agreement with observed values. See also 3513 of 1953 (Chow & Suran).

621.316.86 : 537.312.6 **1327**
Thermistor Production.—W. T. Gibson. (*Elect. Commun.*, Dec. 1953, Vol. 30, No. 4, pp. 263–270.) Reprint, with additional illustrations, of paper abstracted in 2240 of 1953.

621.318.4 **1328**
Tapped Inductances.—C. R. Cosens. (*Wireless Engr*, March 1954, Vol. 31, No. 3, pp. 74–75.) 'Maxwell coils' for a.f. are considered, and a simple method is presented for calculating the position of the tapping to give a specified fraction of the total inductance.

621.372.011/.012 **1329**
Graphical Analysis of Nonlinear Circuits using Impedance Concepts.—J. S. Thomsen. (*J. appl. Phys.*, Nov. 1953, Vol. 24, No. 11, pp. 1379–1382.) Approximate values of the reactance of moderately nonlinear inductors and capacitors are obtained by adding to the usual linear expressions terms involving the square of the current. Using this approximation, the total impedance of an *LRC* circuit is obtained and plotted in the *I-Z* plane, with frequency as a parameter. The method gives a physical picture of the jump phenomenon in nonlinear circuits.

621.372.413 **1330**
Large Reduction of Free Electromagnetic Oscillations in Cylindrical Regions due to Slight Departures from Cylindricity.—Yu. S. Sayasov. (*C. R. Acad. Sci. U.R.S.S.*, 11th May 1953, Vol. 90, No. 2, pp. 163–166.) A theoretical investigation of the effect of small deformations on long cylindrical resonators with perfectly conducting walls. The diminution of the field is proportional to the product of the relative distortion and the square of the ratio of the length of the cylinder to its radius. Standard mathematical notation is used and the expressions for E_r, E_θ and H_ϕ are given in terms of Bessel functions and the function M_{0p} which is defined as the pth root of J_0.

621.372.413 : 517.9 **1331**
An Asymmetrical Finite Difference Network.—R. H. Macneal. (*Quart. appl. Math.*, Oct. 1953, Vol. 11, No. 3, pp. 295–310.) A study is made of a method of solving boundary-value problems by means of electrical network analogies. Consideration is given to the special problems associated with curved boundaries and with the use of meshes of different size at different parts of the network. A method is described by means of which the coefficients of the system of algebraic equations can be computed for an arbitrary distribution of node points, and the position of the nodes can then be chosen to fit the particular conditions. As an illustration, the resonance frequencies and field patterns of a conical-line cavity resonator are calculated.

621.372.5 **1332**
A General *RLC* Synthesis Procedure.—L. Weinberg. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, pp. 427–437; *Convention Record Inst. Radio Engrs*, 1953, Part 5, pp. 2–16.) Procedure for synthesizing lattice networks is described.

621.372.5 **1333**
Unbalanced *RLC* Networks containing Only One Resistance and One Real Transformer.—L. Weinberg. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, pp. 467–475; *Trans. Inst. Radio Engrs*, Dec. 1953, No. PGCT-2, pp. 55–65.)

621.372.5 **1334**
Unilateral Four-Terminal Circuits.—J. S. Foley. (*Electronics*, Feb. 1954, Vol. 27, No. 2, pp. 186–187.) Networks of Ge diodes and carbon resistors, suitable for purposes of directional coupling and isolating, are described.

621.372.512.24 **1335**
High-*Q* Coupled Tuned Circuits.—H. D. Polishuk. (*Wireless Engr*, March 1954, Vol. 31, No. 3, pp. 55–58.) "By means of a set of expressions developed as functions of a frequency ratio, some aspects of inductively-coupled high-*Q* resonant circuits are analysed. Considerations of finite, very high-*Q* circuits lead to simple relations determining impedance characteristics of a fundamental system, resonant frequencies, rate of frequency deviation input conductance, stored energy and power dissipation ratios."

621.372.54 **1336**
Two New Equations for the Design of Filters.—M. Dishal. (*Elect. Commun.*, Dec. 1953, Vol. 30, No. 4, pp. 324–337; condensed version, *Convention Record Inst. Radio Engrs*, 1953, Part 5, pp. 44–47.) Equations are presented for designing constant-*K*-configuration filters with Tchebycheff-type characteristics, for the case when the unloaded *Q* of the elements is sufficiently high for them to be considered nondissipative. Both band-pass and low-pass filters are considered; the band-pass examples are mainly for u.h.f.

621.372.54 **1337**
Old and New Methods for designing Composite High-Frequency Filter Circuits and their Application to Filter Circuits with Low Relative Bandwidth.—R. Rücklin. (*Arch. elekt. Übertragung*, Nov. 1953, Vol. 7, No. 11, p. 554.) Correction to paper abstracted in 84 of January.

621.372.54 **1338**
Nonlinear Filters.—W. D. White : L. A. Zadeh. (*J. appl. Phys.*, Nov. 1953, Vol. 24, No. 11, pp. 1412–1413.) Comment on 2598 of 1953 and author's reply.

621.372.54 : 538.652 **1339**
Electromechanical Filters.—S. P. Lapin. (*Radio & Telev. News, Radio-Electronic Engng Section*, Dec. 1953, Vol. 50, No. 6, pp. 9–11..37.) Design and performance data are presented for i.f. filters for the frequency range 100–1 000 kc/s, of the type comprising metal-plate resonators interconnected by pairs of fine metal wires.

621.372.542.2 **1340**
A General Tchebycheff Rational Function.—C. B. Sharpe. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, pp. 454–457.) The derivation is described of a function useful for the design of low-pass filters.

621.372.543.2 : 621.375.232.029.4 **1341**
Electronic Audio Bandpass Filter.—R. J. Gunderman. (*Radio & Telev. News, Radio-Electronic Engng Section*, Nov. 1953, Vol. 50, No. 5, pp. 16..23.) A narrow-band filter with centre frequency adjustable from 20 to 5 000 c/s is obtained by including a phase-inverter rejection circuit in the negative-feedback circuit of an audio amplifier.

621.372.56 **1342**
Attenuator Design.—N. H. Crowhurst. (*Electronic Engng*, Feb. 1954, Vol. 26, No. 312, pp. 76–78.) A chart is given for the design of constant-resistance types of attenuator.

621.372.6 **1343**
Some Not Necessarily Linear $(n + 1)$-Poles.—A. Stöhr. (*Arch. elekt. Übertragung*, Nov. 1953, Vol. 7, No. 11, pp. 546–548.) In $(n + 1)$-poles composed of linear 2-poles, and in some other $(n + 1)$-poles, linear relations

exist between the voltages and the currents, and the resulting impedance matrix is symmetrical. A generalization, to include nonlinear relations, is given by the condition that $\partial(\phi_k - \phi_0)/\partial i_l$ must be symmetrical in k and l, where $(\phi_k - \phi_0)$ is the p.d. between the kth and the zeroth terminal and i_l is the current flowing into the lth terminal. Examples and properties of such $(n + 1)$-poles are given.

621.373 1344
The Use of Admittance Diagrams in Oscillator Analysis.—H. J. Reich. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, pp. 484–485.) Discussion on 1944 of 1953.

621.373.421 1345
A New Type of *RC* Oscillator.—G. Francini & E. Zaccheroni. (*Alta Frequenza*, Dec. 1953, Vol. 22, No. 6, pp. 282–294.) A circuit requiring a much smaller amount of valve amplification than the usual phase-shift oscillator uses a specially designed twin-T feedback network.

621.373.421 + 621.375.23].001.2 1346
Block-Diagram Analysis of Vacuum-Tube Circuits.—T. M. Stout. (*Elect. Engng, N.Y.*, Oct. 1953, Vol. 72, No. 10, p. 900.) Digest only. The method is illustrated by analyses of (*a*) an amplifier with current feedback from the cathode circuit and (*b*) a phase-shift oscillator.

621.373.422 : 621.376.2/.3 1347
Amplitude Variations in a Frequency-Modulated Oscillator.—W. J. Cunningham. (*J. Franklin Inst.*, Oct. 1953, Vol. 256, No. 4, pp. 311–323.) Analysis indicates how unwanted a.m. is produced when f.m. is accomplished by varying the capacitance in a negative-resistance oscillator circuit. A numerical example is given.

621.373.43 1348
The Design of the Eccles-Jordan Circuit.—R. Piloty, Jr. (*Arch. elekt. Übertragung*, Nov. 1953, Vol. 7, No. 11, pp. 537–545.) Design formulae are derived from a fundamental analysis of the circuit. Their application is illustrated in the design of a high-stability, 2-Mc/s flip-flop circuit using a Type-E90CC valve.

621.373.43 1349
The Electronic Switch.—E. Piepgras. (*Funk u. Ton*, Nov. 1953, Vol. 7, No. 11, pp. 580–589.) An analysis of the operation of square-wave generators.

621.373.431.1 : 621.318.572 1350
Bi-Stable Multivibrator Analysis.—P. A. Neeteson. (*Electronic Applic. Bull.*, Aug./Sept. 1953, Vol. 14, Nos. 8/9, pp. 121–137.) Continuation of paper abstracted in 1006 of April. The operational calculus is used to analyse the Eccles-Jordan flip-flop circuit.

621.373.432 : 621.387 1351
Control of Glow-Discharge Triodes by means of Very Small Currents.—E. Meili. (*Helv. phys. Acta*, 16th Nov. 1953, Vol. 26, No. 6, pp. 574–577. In German.) A discussion of the desirable characteristics of a valve suitable for the generation of sawtooth oscillations, using a grid-cathode capacitor of value between 10 and 50 pF and a grid control current as low as 3×10^{-11} A. The essential design points are (*a*) small cross-sectional area of the discharge space, (*b*) high current density at low currents, (*c*) short ion transit times and (*d*) large difference between the striking and the operating potential. These are achieved by arranging a wire-point control electrode close to the cathode.

621.373.52 1352
An Amplitude-Stabilized Transistor Oscillator.—E. R. Kretzmer. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, pp. 391–401.) An a.f. oscillator using two junction transistors in push-pull class-C operation has its amplitude stabilized to within 1% over wide ranges of supply voltage, loading and temperature by comparing the output with a stable reference voltage obtained from a junction diode operated at breakdown.

621.374.4 : 621.376.233 1353
The Efficiency of Frequency Multipliers using Detector Circuits.—G. B. Hagen. (*NachrTech.*, Nov. 1953, Vol. 3, No. 11, pp. 482–486.) An analysis is made of the harmonic-frequency power obtainable in an oscillatory circuit connected to a generator via a detector whose characteristic is represented approximately by a hyperbola. For harmonics of fourth and higher orders the calculations become very difficult; it cannot be assumed that for any given harmonic the power is less than for the next lower harmonic.

621.375.121.029.4/.5 1354
Design of Wide-Band Tuned Amplifiers.—F. Jaeschke. (*Funk u. Ton*, Oct.–Dec. 1953, Vol. 7, Nos. 10–12, pp. 508–516, 570–579 & 630–642.) Amplifiers with Schienemann (Butterworth) and Tchebycheff band-pass characteristics are considered in detail and formulae, design curves and numerical examples are given.

621.375.2 + 621.395.623.7] : 534.862.4 : 534.76 1355
Loudspeakers and Amplifiers for Use with Stereophonic Reproduction in the Theater.—J. K. Hilliard. (*J. Soc. Mot. Pict. Telev. Engrs*, Sept. 1953, Vol. 61, No. 3, Part II, pp. 380–389. Discussion, p. 389.) A brief description of equipment and cinema installations.

621.375.2 : 621.395.44 1356
The Coaxial-Line Amplifier.—Bauer. (See 1572.)

621.375.2.024 1357
D.C. Amplifiers.—J. Yarwood & D. H. Le Croissette. (*Electronic Engng*, Jan.–March 1954, Vol. 26, Nos. 311–313, pp. 14–19, 64–70 & 114–117.) A survey paper with 81 references.

621.375.2.024 1358
Investigation of the Effect of Unbypassed Screen-Grid Resistors on Amplification Factor.—E. G. Woschni. (*NachrTech.*, Oct. 1953, Vol. 3, No. 10, pp. 444–446.) A calculation is made of the negative feedback introduced by unbypassed resistors in the screen-grid lead; this arrangement is usual in d.c. amplifiers. Experimental results confirming the theory are presented.

621.375.221.2 1359
Distributed Amplifiers: Some New Methods for Controlling Gain/Frequency and Transient Responses of Amplifiers having Moderate Bandwidths.—H. G. Bassett & L. C. Kelly. (*Proc. Instn elect. Engrs*, Part III, Jan. 1954, Vol. 101, No. 69, pp. 5–14.) Distributed amplifiers of moderate bandwidths for steady-state applications may be constructed for almost constant gain up to 80% or 90% of cut-off by methods including the insertion of extra sections into the networks or the use of networks whose image impedance at a shunt-capacitance point falls to zero at the cut-off frequency. For waveform amplification, the use of *m*-derived low-pass networks with added resistive elements is suggested. The image delay is then almost constant over 85% of the non-dissipative pass band, and the image attenuation varies in approximately Gaussian fashion with frequency over most of the pass band. In this second case the maximum useful number of valves per stage is five.

621.375.23 1360
Development of a High-Fidelity Preamplifier for Use in the Recording of Bioelectric Potentials with Intracellular Electrodes.—S. J. Solms, W. L. Nastuk & J. T. Alexander. (*Rev. sci. Instrum.*, Oct. 1953, Vol. 24, No. 10, pp. 960–967.) The cathode-follower circuit conventionally used to minimize the time constant of the recording system is discussed and its shortcomings are analysed. An improved circuit using positive feedback is described.

621.375.23 : 621.3.016.35 1361
Gain Stability of Feedback Amplifiers.—D. L. H. Gibbings & A. M. Thompson. (*Proc. Instn elect. Engrs*, Part III, Jan. 1954, Vol. 101, No. 69, pp. 35–37.) By proper choice of the phase angle of the loop gain, either the magnitude or the phase angle of the amplifier gain may be made independent, to a first order, of changes in the active elements. The general theory is developed. Results obtained with an experimental amplifier show that, over a narrow frequency range, the unit can be made as stable as the passive components in the feedback network.

621.375.23.029.42 1362
A Low-Frequency Selective Amplifier.—F. M. Gardner. (*Trans. Inst. Radio Engrs*, Nov./Dec. 1953, Vol. AU-1, No. 6, pp. 10–12.) Analysis similar to that for a simple resonant circuit is presented for a feedback amplifier. Design and performance of an amplifier with a resonance frequency of about 30 c/s are outlined.

621.375.232 1363
A Minimal Noise Preamplifier for Proportional Counters and Similar Applications.—K. Enslein & B. Brainerd. (*Rev. sci. Instrum.*, Oct. 1953, Vol. 24, No. 10, pp. 916–919.) A negative-feedback amplifier is described which is linear over an input range of 74 db. The maximum gain is 1 900, and is attained over a frequency range of about 10–500 kc/s. Signals of 2 μV can be recognized.

621.375.3 1364
Fast Response of Magnetic Amplifiers.—D. G. Scorgie. (*Elect. Engng, N.Y.*, Nov. 1953, Vol. 72, No. 11, p. 973.) Digest of paper to be published in *Trans. Amer. Inst. elect. Engrs*, 1953, Vol. 72.

621.375.3 : 538.245 1365
Instability of Self-Saturating Magnetic Amplifiers.—S. B. Batdorf & W. N. Johnson. (*Elect. Engng, N.Y.*, Nov. 1953, Vol. 72, No. 11, p. 1013.) Digest of paper to be published in *Trans. Amer. Inst. elect. Engrs*, 1953, Vol. 72. Differences between the major and the minor hysteresis loops of hipernik 5 and their importance in d.c. triggering are discussed.

621.375.4 1366
Gain-Stabilized Transistor Amplifier.—C. A. Krause. (*Electronics*, Feb. 1954, Vol. 27, No. 2, pp. 183–185.) Gain is stabilized by using an unbypassed resistor in the emitter circuit of a junction transistor.

621.375.4.024 1367
D.C. Amplifier employing Junction-Type Transistors.—E. Keonjian. (*Elect. Engng, N.Y.*, Nov. 1953, Vol. 72, No. 11, pp. 961–964.) Temperature-sensitive resistors and junction diodes are used in conjunction with compensating networks to eliminate drift effects. A two-stage amplifier circuit having a drift <1% in 106 hours at room temperature, is described.

621.375.5 : 621.319.4 1368
Building and Using Dielectric Amplifiers.—A. Silverstein. (*Electronics*, Feb. 1954, Vol. 27, No. 2, pp. 150–153.) A detailed account is given of the process developed at the National Bureau of Standards for preparing the (Ba-Sr)TiO_3 capacitors used in dielectric amplifiers. A two-stage voltage amplifier and an output stage capable of driving a loudspeaker are described.

621.396.822 + 537.311.3 1369
Low-Temperature Electronics.—C. A. Swenson & A. G. Emslie. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, pp. 408–413.) A survey is made of the temperature dependence of noise and resistance over a range of temperatures approaching absolute zero. Practical applications of the results of low-temperature research are discussed.

GENERAL PHYSICS

53 : 519.2 1370
On Statistical Estimation in Physics.—M. Annis, W. Cheston & H. Primakoff. (*Rev. mod. Phys.*, Oct. 1953, Vol. 25, No. 4, pp. 818–830.)

534.2 + 538.566 1371
Wave Propagation in Stratified Media at Normal Incidence, and Application to Transmission-Line Theory, Electric Waves, Optics, Acoustics, Wave Mechanics, and Mechanical and Electrical Quadripoles.—K. Altenburg & S. Kästner. (*Ann. Phys., Lpz.*, 20th Oct. 1953, Vol. 13, Nos. 1/5, pp. 1–43.) A comprehensive analysis with numerous references.

535.12 : 535.31 1372
Step-by-Step Transition from Wave Optics to Ray Optics in Inhomogeneous Anisotropic Absorbing Media: Part 2 — Solution of the Equations for Wave Normal and Refractive Index by WBK Approximation. Ray-Optical Reflection and Alternation.—K. Suchy. (*Ann. Phys., Lpz.*, 20th Oct. 1953, Vol. 13, Nos. 1/5, pp. 178–197.) The equations given in part 1 (2954 of 1953) are solved. The existence of particular points is established for which the transition cannot be made.

535.376 1373
The Mechanism of Electroluminescence: Part 1 — Theoretical Considerations.—D. Curie. (*J. Phys. Radium*, Oct. 1953, Vol. 14, No. 10, pp. 510–524.) An account based on Destriau's treatment, attributing the phenomena of electroluminescence to collisions of field-accelerated electrons in the conduction band. 35 references.

535.421 : 538.566 1374
Rigorous Analysis of the Diffraction of Electromagnetic Waves by Strip-Gratings.—R. Müller. (*Z. Naturf.*, Jan. 1953, Vol. 8a, No. 1, pp. 56–60.) A solution which is valid without restriction on wavelength, angle of incidence, polarization or grating constants is obtained in the form of two Fredholm integral equations of the first kind, of the same structure as those derived to represent diffraction by slotted diaphragms in rectangular waveguides (1583 of 1953).

537.122 1375
A Collective Description of Electron Interactions: Part 3 — Coulomb Interactions in a Degenerate Electron Gas.—D. Bohm & D. Pines. (*Phys. Rev.*, 1st Nov. 1953, Vol. 92, No. 3, pp. 609–625.) Part 2: 1021 of April.

537.122 1376
A Collective Description of Electron Interactions: Part 4 — Electron Interaction in Metals.—D. Pines. (*Phys. Rev.*, 1st Nov. 1953, Vol. 92, No. 3, pp. 626–636.) Part 3: 1375 above.

537.221 1377

Contact Electrification.—P. S. H. Henry. (*Sci. Progr.*, Oct. 1953, Vol. 41, No. 164, pp. 617–634.) The observed phenomena are described, and various explanatory hypotheses are discussed. Effects of 'static' and methods of eliminating them are indicated. 50 references.

537.52 1378

Some Measurements on a Not Selfsustaining Gas Discharge, with an Axial Magnetic Field.—J. Kistemaker & J. Snieder. (*Physica*, Oct. 1953, Vol. 19, No. 10, pp. 950–960.) Report of investigations of the potential distribution inside the central arc column of the discharge. The experimental arrangement consists of a cylindrical anode with a filamentary cathode at one end and a reflector at the other, and a hot probe. With electronegative gases deep troughs of negative potential are observed; with electropositive gases the central plasma potentials are still negative in relation to the anode.

537.521.7 1379

Ions and Barriers in Electric Discharges.—G. K. M. Pfestorf & R. S. N. Rau. (*J. Indian Inst. Sci.*, Section B, Oct. 1953, Vol. 35, No. 4, pp. 179–186.) Report of investigations on the effect of injecting ions into the spark gap, and of the effectiveness of paper screens in blocking the ions.

537.525 1380

A Condition on Uniform Field Breakdown in Electron-Attaching Gases.—R. Geballe & M. L. Reeves. (*Phys. Rev.*, 15th Nov. 1953, Vol. 92, No. 4, pp. 867–868.) The form of the curve relating E/p to p/d at breakdown (where E is the field strength, p the pressure and d the electrode separation) indicates the existence, for high values of pd, of a value of E/p below which breakdown does not occur. A study of the equation for steady-state current in electron-attaching gases suggests that this limiting value is nearly that for which the ionization and attachment coefficients are equal; this is confirmed experimentally.

537.525.001.11 1381

Development of the Theory of the Positive Column at Low Pressures: Part 1.—E. H. Ludwig. (*Z. angew. Phys.*, Oct. & Nov. 1953, Vol. 5, Nos. 10 & 11, pp. 377–386 & 421–426.)

537.533/.534 : [537.291 + 538.691 1382

Dioptrics of Electron and Ion Beams with Circular Principal Paths.—H. Grümm. (*Acta phys. austriaca*, Dec. 1953, Vol. 8, No. 2, pp. 119–140.)

537.533 : 537.534.9 1383

Secondary Emission due to Bombardment of Metallic Targets with Multiple-Charge Ions.—Yu. A. Dunaev & I. P. Flaks. (*C. R. Acad. Sci. U.R.S.S.*, 1st July 1953, Vol. 91, No. 1, pp. 43–45. In Russian.) An experimental investigation of the dependence of the coefficient of secondary emission on the energy of the ions. Sb, Bi, and Te targets were bombarded with Sb, Bi, and Te ions, respectively, and Ni targets with Na, Ba and Ca ions. The results are shown graphically.

537.533 : 538.691 1384

The Motion of Electrons in Two Combined Magnetic Fields.—S. G. Nilsson. (*Kungl. tek. Högsk. Handl., Stockholm*, 1953, No. 72, 22 pp. In English.) The focusing properties of the field of a homogeneously wound toroid have been investigated (383 of 1953). Analysis is now given for the case when this field is combined with a homogeneous field perpendicular to the plane of the toroid.

537.533 : 539.23 1385

Work Function of Clean and of Oxygen-Coated Au, Pt and Pd, based on the Contact-Potential Difference with respect to Ag.—J. Giner & E. Lange. (*Naturwissenschaften*, Oct. 1953, Vol. 40, No. 19, p. 506.) Values of the work function were found to be up to 1·2 V higher for the oxygen-coated than for the clean surfaces.

537.533.8 1386

Auger Peaks in the Energy Spectra of Secondary Electrons from Various Materials.—J. J. Lander. (*Phys. Rev.*, 15th Sept. 1953, Vol. 91, No. 6, pp. 1382–1387.) Measurements on C, Be, Al, Ni, Cu, Ba, Pt and oxides of some of these are reported; a description is given of the highly sensitive apparatus used. Characteristic peaks due to Auger electrons emitted as a result of absorption of a valence electron by an excited X-ray level were observed for all these materials. The structure exhibited by the peaks is related to the energy distribution of electrons in the valence band, and complements that observed in soft-X-ray emission. Excitation of Auger peaks by low-velocity electron beams provides a method of investigating surfaces.

537.56 1387

Generalized Ionization Formula for a Plasma.—G. Elwert. (*Z. Naturf.*, Nov. 1952, Vol. 7a, No. 11, pp. 703–708.) A formula is derived which includes as special cases Saha's equation, the gas-cloud ionization formula, and the solar-corona ionization equation.

538.12 1388

The Field along the Axes of Symmetry of Equal Semi-infinite Rectangular Magnetic Pole-Pieces.—W. Snowdon & N. Davy. (*Brit. J. appl. Phys.*, Nov. 1953, Vol. 4, No. 11, pp. 339–341.) The method of conformal representation is used. The field along the axes of symmetry is calculated for a number of values of the ratio of the width of the pole-pieces to the distance separating them. Expressions for the potential function are also given. See also 2152 of 1945 (Davy).

538.21 1389

Magnetic Behaviour of a Linear Atomic Chain at the Absolute Zero Point, for Positive Exchange Integral.—E. Ledinegg & P. Urban. (*Acta phys. austriaca*, Dec. 1953, Vol. 8, No. 2, pp. 167–174.) A calculation of the magnetic moment indicates that the linear atomic chain is not spontaneously magnetizable.

538.3 : 531.19 1390

On the Statistical Mechanics of Matter in an Electro-Magnetic Field: Part 1 — Derivation of the Maxwell Equations from Electron Theory.—P. Mazur & B. R. A. Nijboer. (*Physica*, Oct. 1953, Vol. 19, No. 10, pp. 971–986.) An ensemble-averaging method is used.

538.311 1391

Magnetic Field due to a Direct Current traversing a Solid Conductor of Arbitrary Shape. Application to a Cylindrical Conductor.—R. Cazenave. (*Rev. gén. Élect.*, Nov. 1953, Vol. 62, No. 11, pp. 536–542.) Laplace's law (usually known as Biot & Savart's law) is shown to be more suitable than Ampère's magnetic-sheet concept as a basis for deriving formulae for the magnetic field of a conductor. The vector potential is introduced.

538.561.029.6 1392

Cerenkov Effect at Microwave Frequencies.—M. Danos, S. Geschwind, H. Lashinsky & A. van Trier. (*Phys. Rev.*, 1st Nov. 1953, Vol. 92, No. 3, pp. 828–829.) Radiation of power $\simeq 10^{-7}$ W excited by a 10-kV, 0·2-mA beam, bunched at 24 kMc/s, and travelling close to the surface of a TiO_2 polycrystalline dielectric, has been detected.

539.162 : 537.212 : 533.15 **1393**
On the Diffusion of Decaying Particles in a Radial Electric Field.—J. Keilson. (*J. appl. Phys.*, Nov. 1953, Vol. 24, No. 11, pp. 1397–1400.) An analysis is made of the diffusion of charged particles in a radial field in which the intensity is distributed according to an inverse-square law.

548.0 : 539.15 **1394**
Electronic Polarizabilities of Ions in Crystals.—J. R. Tessman, A. H. Kahn & W. Shockley. (*Phys. Rev.*, 15th Nov. 1953, Vol. 92, No. 4, pp. 890–895.)

548.0 : 539.15 **1395**
Interaction of a Nonrelativistic Particle with a Scalar Field with Application to Slow Electrons in Polar Crystals.—T. D. Lee & D. Pines. (*Phys. Rev.*, 15th Nov. 1953, Vol. 92, No. 4, pp. 883–889.)

621.3.011.4 **1396**
Capacitance of a Spherical Capacitor.—F. Bertolini. (*Nuovo Cim.*, 1st Sept. 1952, Vol. 9, No. 9, pp. 852–854.) In a practical spherical capacitor, the capacitance is not given exactly by the theoretical formula, because the outer sphere has an aperture. Upper and lower limits are derived for the magnitude of the error involved.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.165 : 621.396.822 **1397**
Radio-Frequency Emission from Cosmic-Ray Electrons.—H. Siedentopf & G. Elwert. (*Z. Naturf.*, Jan. 1953, Vol. 8a, No. 1, pp. 20–23.) Theory developed by Schwinger (*Phys. Rev.*, 1949, Vol. 75, p. 1912) is used for the quantitative investigation of the intensity and spectral distribution of r.f. radiation from cosmic-ray electrons in interstellar magnetic fields. An upper limit is deduced for the density of an electron component of the cosmic radiation.

523.5 **1398**
The Strength of Meteoric Echoes from Dense Columns.—L. A. Manning. (*J. atmos. terr. Phys.*, Dec. 1953, Vol. 4, Nos. 4/5, pp. 219–225.) Calculations taking into account the refractive effects produced by ionization distributed at radii greater than the critical-density radius have been made for large highly ionized trails, using geometrical optics and ray-tracing methods. The computed maximum radiated power from a diffusion-formed trail is only 70% of that calculated on the critical-density radius method.

523.5 : 621.396.96 **1399**
Meteor Echo Duration and Radio Wavelength.—D. W. R. McKinley. (*Canad. J. Phys.*, Nov. 1953, Vol. 31, No. 7, pp. 1121–1135.) "The durations of radar echoes from meteors have been observed simultaneously on 9·22 m and 5·35 m, and also on 9·22 m and 2·83 m. The ratio of durations on two wavelengths decreases with increasing duration by a factor of two over the observed range, deviating significantly from the accepted square law of wavelengths. Plotting the log of the ratio against the log of the duration yields two straight lines of different slopes, one in the short-duration range and the other applying to the longer echoes. General empirical formulae are developed to predict the echo duration on one radio equipment in terms of the duration of the same echo recorded by another apparatus of different sensitivity and wavelength."

523.72 : 621.396.822 **1400**
Bailey's Theory of Sunspot Noise.—J. W. Dungey. (*J. atmos. terr. Phys.*, Dec. 1953, Vol. 4, Nos. 4/5, pp. 148–162.) A discussion of the exchange of energy between the drifting electrons and the wave radiated from a transient disturbance is given which is more general than Bailey's (1909 of 1950) and which shows that amplification can occur under certain conditions. Consideration of a sunspot model having axial symmetry leads to the conclusion that amplification will occur only in exceptional regions.

523.72 : 621.396.822 **1401**
The Equations for a Problem arising in Dungey's Investigation of Bailey's Theory of Sunspot Noise.—R. E. Loughhead. (*J. atmos. terr. Phys.*, Dec. 1953, Vol. 4, Nos. 4/5, pp. 163–174.) See 1400 above.

523.746 **1402**
The Magnetic Field Strength in Sunspots.—W. Mattig. (*Naturwissenschaften*, Oct. 1953, Vol. 40, No. 20, p. 523.) Reply to Thiessen's criticism (2303 of 1953).

523.746 : 621.396.822 **1403**
Theories of Solar Phenomena depending on Sunspot Fields moving in the Chromosphere and Corona.—J. H. Piddington. (*Mon. Not. R. astr. Soc.*, Oct. 1953, Vol. 113, No. 2, pp. 188–197.) Theories advanced by Giovanelli (78 and 376 of 1949) and various other workers are found to be untenable when mechanical reactions between the magnetic fields and the conducting gas are taken into account.

523.75 : 538.6 **1404**
A Family of Solutions of the Magneto-hydrostatic Problem in a Conducting Atmosphere in a Gravitational Field.—J. W. Dungey. (*Mon. Not. R. astr. Soc.*, Oct. 1953, Vol. 113, No. 2, pp. 180–187.) A theoretical study of the equilibrium conditions in a quiescent solar prominence. A simple model is obtained.

523.75 : [550.386 + 551.510.535 **1405**
Ionospheric and Geomagnetic Effects of Solar Flares.—J. W. Beagley. (*N.Z. J. Sci. Tech. B*, Sept. 1953, Vol. 35, No. 2, pp. 141–151.) Geomagnetic crochets observed at Amberley and Apia, New Zealand, between 1947 and 1951, simultaneously with Dellinger fadeouts, are considered in relation to subsequent magnetic and ionospheric disturbances. Their hourly and seasonal frequencies are examined and their augmentation of the normal diurnal inequality verified.

523.75 : 551.510.535 **1406**
The *H*α Radiation from Solar Flares in relation to Sudden Enhancements of Atmospherics on Frequencies near 27 kc/s.—M. A. Ellison. (*J. atmos. terr. Phys.*, Dec. 1953, Vol. 4, Nos. 4/5, pp. 226–239.)

523.8 : 621.396.822 **1407**
Radio Astronomy: Part 2 — Results of Observations of Cosmic Radio-Noise Sources.—H. Siedentopf. (*Arch. elekt. Übertragung*, Nov. 1953, Vol. 7, No. 11, pp. 507–517.) A survey with 46 references. Part 1: 390 of February (Dieminger).

523.81 : 621.396.822 **1408**
A Survey of 23 Localized Radio Sources in the Northern Hemisphere.—R. H. Brown & C. Hazard. (*Mon. Not. R. astr. Soc.*, Oct. 1953, Vol. 113, No. 2, pp. 123–133.) Report of a survey at a wavelength of 1·89 m, made with the Jodrell Bank aerial system. A marked concentration of the intense sources near the galactic plane was found; the distribution of the weaker sources may be more nearly isotropic.

523.85 : 621.396.822 **1409**
A Radio Survey of the Milky Way in Cygnus, Cassiopeia and Perseus.—R. H. Brown & C. Hazard. (*Mon.

Not. R. astr. Soc., Oct. 1953, Vol. 113, No. 2, pp. 109–122.) Report of a survey at a frequency of 158·5 Mc/s, using the Jodrell Bank 2°-beam aerial, and covering the region between $l = 40°$ and $l = 130°$ and between $b = 14°$ and $b = -14°$. The isophotes of the absolute intensities are shown.

523.852.3 : 621.396.822 **1410**

Fine Structure of the Extraterrestial Radio Source Cygnus I.—R. C. Jennison & M. K. Das Gupta. (*Nature, Lond.*, 28th Nov. 1953, Vol. 172, No. 4387, pp. 996–997.) Observations made at Jodrell Bank are reported.

523.854 : 621.396.822 **1411**

Radio Astronomy.—H. H. Klinger. (*J. Franklin Inst.*, Oct. 1953, Vol. 256, No. 4, pp. 353–366.) A survey paper. See 126 of January.

550.37 : 550.384 **1412**

The Relation between Earth Currents and Geomagnetic Variations.—A. P. Bondarenko. (*C. R. Acad. Sci. U.R.S.S.*, 21st March 1953, Vol. 89, No. 3, pp. 443–445. In Russian.) A comparison was made between the time variations of $curl_z\ E$ and H'_z, where E is the electric field and H'_z is the resultant vertical component of the geomagnetic variations. Fair agreement between the curves was obtained.

550.384.4 **1413**

Rapid Periodic Fluctuations of the Geomagnetic Field: Part 1.—E. R. R. Holmberg. (*Mon. Not. R. astr. Soc., geophys. Supplement*, Oct. 1953, Vol. 6, No. 8, pp. 467–481.) A new analysis is made of observational data, mainly from Eskdalemuir. The type of fluctuation changes at sunset from a continuous flux of disturbance to a comparative quiet punctuated by a short damped wave train. A definite fine structure is observed in the spectrum of the daytime fluctuations.

551.510.535 **1414**

The Analysis of Ionospheric Records (Ordinary Ray): Part 1.—D. H. Shinn. (*J. atmos. terr. Phys.*, Dec. 1953, Vol. 4, Nos. 4/5, pp. 240–254.) Tables presented enable the effect of the earth's magnetic field to be taken into account when using the method of analysis of Ratcliffe (1292 of 1952) or of Appleton & Beynon (3290 of 1940). Using these tables, theoretical *h'f* curves can be constructed for a parabolic or a linear distribution of ionization and for all magnetic latitudes up to about 70°.

551.510.535 **1415**

Variations of D-Layer Attenuation at 245 kc/s.—E. A. Lauter. (*Z. Met.*, Nov. 1953, Vol. 7, No. 11, pp. 321–330.) Results of daytime reflection-coefficient measurements made over a period of several years are analysed. The noon value of the attenuation is 2 neper in winter, nearly 7 neper in summer. Though the scatter of values is considerably greater in winter than in summer, the excessive absorption observed in winter on short waves is not observed at this frequency. The influence of the D layer on the propagation of atmospherics is discussed, and the attenuation variations are compared with those of geomagnetic activity.

551.510.535 **1416**

The Contribution of Solar X-Rays to E-Layer Ionization.—E. T. Byram, T. A. Chubb & H. Friedman. (*Phys. Rev.*, 15th Nov. 1953, Vol. 92, No. 4, pp. 1066–1067.) A brief description of rocket experiments which provide positive evidence of soft X-rays in the ionosphere, to an extent sufficient to account for all the E-layer ionization.

551.510.535 **1417**

Electric Currents in the Ionosphere: Part 1 — The Conductivity.—W. G. Baker & D. F. Martyn. (*Phil. Trans. A*, 16th Dec. 1953, Vol. 246, No. 913, pp. 281–294.) The effective height-integrated conductivity of the ionosphere, calculated on the dynamo theory, and taking account of inhibition of the Hall current due to polarization of the medium, is greater than the Pedersen conductivity by a factor of at least 6, and, near the magnetic equator, is further increased by a factor of 2 to 5. This calculation is shown to overestimate the reduction in total current flow in the ionosphere due to the 'shunting' effect of the F_2 region, when the motion of the F_2 region is considered. The dynamo theory, as presented here, gives results in agreement with observations, and accounts in particular for the anomalously large magnetic variations observed near the equator.

551.510.535 **1418**

Electric Currents in the Ionosphere: Part 2 — The Atmospheric Dynamo.—W. G. Baker. (*Phil. Trans. A*, 16th Dec. 1953, Vol. 246, No. 913, pp. 295–305.) Assuming semidiurnal tidal air flow, the atmospheric dynamo problem is solved, the ionosphere being divided into three regions, each of appropriate conductivity. Compared with calculations assuming Pedersen conductivity alone effective, results give a current system similar in shape and phase, though more intense, and an electric field system markedly different. An abnormally large east-west current is found at the equator.

551.510.535 **1419**

Electric Currents in the Ionosphere: Part 3 — Ionization Drift due to Winds and Electric Fields.—D. F. Martyn. (*Phil. Trans. A*, 16th Dec. 1953, Vol. 246, No. 913, pp. 306–320.) The motion of a cylinder of ionization, of density differing from that of the surrounding medium, tends to be such that the ionization density is greatly increased over part of its surface and diminished over another part. The significance of this result in relation to sporadic-E ionization and to long-duration meteor trails is pointed out. Formulae are derived for the horizontal and vertical drift of ionization at all atitudes. Graphs are given which permit derivation of the true wind or field in a given ionosphere region from experimental observations of the drift velocities.

551.510.535 **1420**

Semidiurnal Currents and Electron Drifts in the Ionosphere.—J. A. Fejer. (*J. atmos. terr. Phys.*, Dec. 1953, Vol. 4, Nos. 4/5, pp. 184–203.) The differential equations of the dynamo theory for the ionosphere are solved numerically under simplifying assumptions. The tidal amplification estimated is about 60. For the solar tide, the current system in the E layer is in phase with the ground tide, but for the lunar tide it is in phase opposition. The calculated vertical electron drift is in reasonable agreement with lunar tide observations. The calculated horizontal electron drift agrees with observations on long-duration meteor-trail echoes, but the calculated phases are opposed to those obtained from fading measurements, indicating that the latter refer to air movements and not to electron drift.

551.510.535 **1421**

Solar Tides in the F_2 Region from the Study of Night-Time Critical Frequencies.—A. A. Weiss. (*J. atmos. terr. Phys.*, Dec. 1953, Vol. 4, Nos. 4/5, pp. 175–183.) "Night-time critical frequency variations at 25 ionospheric stations are analysed by season and by latitude for semi-diurnal solar tidal terms. The amplitude and phase of the vertical drift velocity of electrons so found are consistent with accepted tidal theory, and an estimate of the height-gradient of the vertical drift is obtained.

Two parallel analyses are made, on the alternative assumptions that decay proceeds according to a recombination law or to an attachment law. The low values found for the decay coefficients preclude any decision as to which of these two decay processes is actually operative."

551.510.535 : 523.78 1422

Anomalies of the Ionosphere [F_2-layer] **Critical Frequencies during a Solar Eclipse.**—G. Zanotelli. (*Ann. Geofis.*, July 1953, Vol. 6, No. 3, pp. 367–372.) Soundings made at Rome during the partial eclipse of 25th February 1952 are reported. Electron-concentration minima were observed before and after the eclipse and at the maximum phase. The cause of the first and last of these maxima is assumed to reside in the zone outside the visible disk of the sun.

551.510.535 : 550.385 1423

Determination of the Location of the Ionospheric Current System responsible for Geomagnetic Effects of Solar Flares.—A. P. Mitra & R. E. Jones. (*J. atmos. terr. Phys.*, Dec. 1953, Vol. 4, Nos. 4/5, pp. 141–147.) The height of the flare current system is calculated by a method depending on the time of maximum intensity of a geomagnetic flare effect and the enhancement of electron density at the relevant level. If the flare current system forms part of the *Sq* current system, its height is 100–120 km, but if it is independent, its height is about 60 km.

551.510.535 : 551.55 : 523.5 1424

Measurements of Winds in the Upper Atmosphere by means of Drifting Meteor Trails: Part 1.—D. S. Robertson, D. T. Liddy & W. G. Elford. (*J. atmos. terr. Phys.*, Dec. 1953, Vol. 4, Nos. 4/5, pp. 255–270.) Description of the 27-Mc/s doppler-radar system and the associated equipment.

551.510.535 : 551.55 : 523.5 1425

Measurements of Winds in the Upper Atmosphere by means of Drifting Meteor Trails: Part 2.—W. G. Elford & D. S. Robertson. (*J. atmos. terr. Phys.*, Dec. 1953, Vol. 4, Nos. 4/5, pp. 271–284.) Results of measurements made during Oct.–Dec. 1952 by the method described in 1424 above are discussed. Winds at heights between 80 and 105 km are, in general, horizontal, with a prevailing direction in October towards the north-east, and in November and December towards the east. The 12-hour and 24-hour harmonic components represent anticlockwise rotation of the wind vectors, the 12-hour component being consistent with the phase of a semidiurnal tidal wind as deduced from barometric oscillations. Over the height range investigated, the direction of the wind remains the same but the mean velocity increases with height.

551.510.535 : [621.396.822 : 523.8 1426

The Measurement of Ionospheric Absorption using Observations of 18·3-Mc/s Cosmic Radio Noise.—A. P. Mitra & C. A. Shain. (*J. atmos. terr. Phys.*, Dec. 1953, Vol. 4, Nos. 4/5, pp. 204–218.) Ionospheric absorption is specified by the ratio, expressed in decibels, of P, the received cosmic noise power, to P_0, the power that would have been received in the absence of absorption. From about a year's observations of cosmic noise, a standard curve of P_0/ sidereal time can be drawn for all aerial directions. Analysis of records made at Hornsby, N.S.W., from June 1950 to June 1951, shows that two main components due to absorption in the F_2 and D regions respectively can be distinguished.

551.594.6 1427

The Waveforms of Atmospherics.—M. W. Chiplonkar. (*Endeavour*, Oct. 1953, Vol. 12, No. 48, pp. 190–196.) A review of research during the preceding fifty years on lightning and on atmospherics, showing the relation between the two phenomena. 28 references.

551.594.6 : 538.566 1428

Harmonic Fields in the Propagation of Long Electric Waves round the Earth, and Lightning Waveforms.—Schumann. (See 1544.)

551.594.6 : 538.566 1429

The Propagation of Very Long Electric Waves round the Earth, and Atmospherics.—Schumann. (See 1545.)

LOCATION AND AIDS TO NAVIGATION

534.87/.88 + 534.614 1430

The Development of Acoustic Sea-Depth Measurements.—H. Drubba & H. H. Rust. (*Z. angew. Phys.*, Oct. 1953, Vol. 5, No. 10, pp. 388–400.) A historical survey of methods used in measurements of the velocity of sound in water and in sound ranging, from 1826 to date. 104 references.

621.396.933 1431

Raydist Systems for Radiolocation and Tracking.—J. M. Benson & J. E. Swafford. (*Elect. Engng, N.Y.*, Nov. 1953, Vol. 72, No. 11, pp. 983–987.) Phase-measurement methods making use of the heterodyne signal between c.w. transmitters obviate the need for phase-locking the transmitters or for very high accuracy of frequency control. Several particular arrangements are described.

621.396.96 1432

The Story of Radar.—A. F. Wilkins. (*Research, Lond.*, Nov. 1953, Vol. 6, No. 11, pp. 434–440.) An account of the main points in the development of radar in Britain, from 1935 onwards.

621.396.96 1433

How Long-Line Effect impairs Tunable Radar.—J. F. Hull, G. Novick & R. Cordray. (*Electronics*, Feb. 1954, Vol. 27, No. 2, pp. 168–173.) The conditions are analysed under which long mismatched output lines cause frequency jumping in magnetrons and other valve oscillators. Design data are given for eliminating the gaps in the tuning range which occur when the r.f. generator cannot be mounted directly on the aerial.

621.396.962.2 : 621.376.3] : 629.13 1434

Improved Radio Altimeter.—A. Bloch, K. E. Buecks & A. G. Heaton. (*Wireless World*, March 1954, Vol. 60, No. 3, pp. 138–140.) The instrument uses a transmission frequency varying linearly between 1.605 and 1.655 kMc/s, the reflected wave being heterodyned with an oscillation always 110 Mc/s higher than the transmitted wave. The parameters are chosen so that a beat frequency of 10 kc/s is produced at a height of 900 ft, a servomechanism being used to limit the beat frequency to this value at greater altitudes, so as to avoid the need for a wide-band amplifier, and the consequent increase of noise.

621.396.969 1435

The Harbour Radar System for Rotterdam and the New Waterway.—N. Schimmel. (*Tijdschr. ned. Radiogenoot.*, Nov. 1953, Vol. 18, Nos. 5/6, pp. 301–311.) Equipment under construction is discussed; the transmitter frequency range is to be 8·9–9·2 kMc/s, and the peak power at least 10 kW. The operational procedure and methods of measurement are outlined. The system should be completed by 1955.

621.396.969.33 1436

Marine Radar.—(*Overseas Engr*, Oct. 1953, Vol. 27, No. 310, pp. 97–101.) Brief illustrated descriptions and some performance figures are given for British equipment for installation on board ship.

MATERIALS AND SUBSIDIARY TECHNIQUES

535.37 : 535.215.1 1437

The Photoconductivity of Phosphors with Different Luminescence Mechanisms.—H. Gobrecht, D. Hahn & H. J. Kösel. (*Z. Phys.*, 16th Oct. 1953, Vol. 136, No. 1, pp. 57–66.) Measured photoelectric currents (down to 10^{-14} A) of 49 powder phosphor preparations are listed. These indicate the correspondence of high and low values of photoconductivity respectively with bimolecular and unimolecular luminescence mechanisms.

535.37 : 546.472.21 1438

The Connection between Darkening and Luminescence of Zinc Sulphide.—H. Gobrecht & W. Kunz. (*Z. Phys.*, 16th Oct. 1953, Vol. 136, No. 1, pp. 21–25.) The phenomenon of darkening due to irradiation by light is investigated.

535.37 : 548.55 1439

On Growing Single Crystals of Thallium-Activated Alkali Halides.—J. Franks. (*Brit. J. appl. Phys.*, Dec. 1953, Vol. 4, No. 12, pp. 377–378.) A description is given of a suitable furnace. Activated iodide crystals gave very intense luminescence under electron bombardment.

535.37 : 621.317.373 1440

Measurement of Luminescence Decay Time by means of the Phase [-detector] **Valve.**—Rohde. (See 1504.)

535.372 : 546.284$_o$ 1441

A New 6 100-Å Band in Zinc Orthosilicate activated with Manganese.—P. Zalm & H. A. Klasens. (*Philips Res. Rep.*, Oct. 1953, Vol. 8, No. 5, pp. 386–392.) Activation in the presence of ammonium phosphate at low temperatures gives the additional band, the properties of which are discussed.

535.376 1442

The Light Yield of Phosphors excited by Electron Beams with Accelerating Voltages of 5–60 kV.—H. Arend & H. Irmler. (*Naturwissenschaften*, Nov. 1953, Vol. 40, No. 22, pp. 577–578.) Measurements were made of the light emitted in both forward and backward directions. The relation between the light yield and the accelerating voltage for constant beam current is shown graphically for phosphors of various compositions and grain sizes. The shape of the curves depends on the direction of observation. The divergence between the theoretical and actual light yield is discussed; the actual yield is independent of layer thickness as long as the latter is greater than the electron penetration depth.

537.224 1443

Electrets.—G. G. Wiseman & E. G. Linden. (*Elect. Engng, N.Y.*, Oct. 1953, Vol. 72, No. 10, pp. 869–872.) A survey and nonmathematical discussion of electret materials, theories and applications. Tables are given of reported electrets of 5 pure substances and of 20 substances showing only a decaying charge and 17 giving a charge reversal or growth of charge. The applications noted include microphones, radiation dosimeters, electrometers and an e.s. vibration voltmeter.

537.226 1444

Characteristics of Ferroelectric Ceramics near the Curie Point.—N. P. Bogoroditski & T. N. Verbitskaya. (*C. R. Acad. Sci. U.R.S.S.*, 21st March 1953, Vol. 89, No. 3, pp. 447–449. In Russian.) Report of an investigation of ferroelectric materials with Curie points near 120°C, 35°C and 150°C, respectively. Graphs show the variation with time (in months) of the capacitance and of the loss-tangent of ferroelectric capacitors and the effect of aging on the capacitance/electric-field-strength characteristic. The results are discussed in relation to the orientation of the domains and the change in the electric moment.

537.226 : 546.321.85 1445

The Properties of Colloidal Ferroelectric Materials: Part 2 — Theoretical Considerations.—W. Känzig & R. Sommerhalder. (*Helv. phys. Acta*, 16th Nov. 1953, Vol. 26, No. 6, pp. 603–610. In German.) The spontaneous-polarization effects described by Jaccard et al. (776 of March) can be explained by introducing the energy of the depolarizing field and the energy of the domain walls into the free energy of the crystal given by Mueller's theory (109 of 1941). The interaction of a polarized ferroelectric crystal with its depolarizing field is discussed. The wall problem is also considered.

537.226 : 546.431.824-31 : 546.817.831.4 1446

Ferroelectric Properties of $BaTiO_3$-$PbZrO_3$ Solid Solutions.—G. A. Smolenski, A. I. Agranovskaya & N. N. Krainik. (*C. R. Acad. Sci. U.R.S.S.*, 1st July 1953, Vol. 91, No. 1, pp. 55–58. In Russian.) Experimental determination of the temperature dependence of the permittivity, in weak fields, and of $\Delta l/l$, where l is the length of the specimen. These results and the derived variation of the Curie point with $PbZrO_3$ concentration are shown graphically.

537.226 : 546.817.824 1447

Domain Structure of Lead Titanate.—E. G. Fesenko. (*C. R. Acad. Sci. U.R.S.S.*, 11th Feb. 1953, Vol. 88, No. 5, pp. 785–786. In Russian.) The phase transition near 500°C was investigated by an optical method. Photographs of a twinned crystal show the permanent structural change on heating above 500°C.

537.226 : 546.817.882.5-33 1448

Ferroelectric Properties of Lead Metaniobate.—G. Goodman. (*J. Amer. ceram. Soc.*, Nov. 1953, Vol. 36, No. 11, pp. 368–372.) "Ferroelectric lead metaniobate, $Pb(NbO_3)_2$, is structurally distinct from the ABO_3 perovskite-type ferroelectrics presently known. Dielectric and dilatometric data indicate a 570°C Curie point. In ceramic form the material can be polarized to retain a piezoelectric constant of the same order of magnitude as that of barium titanate."

537.226 : 621.315.612.4 1449

Dielectrics containing Barium Titanate.—W. Soyck. (*Schweiz. Arch. angew. Wiss. Tech.*, Oct. 1953, Vol. 19, No. 10, pp. 316–322.) A short review; aspects discussed include the ceramic structure and electrical properties of $BaTiO_3$, ageing, effect of nonuniform fields and of high temperatures and field strengths, and behaviour at high frequency.

537.311.3 1450

The Resistance of 72 Elements, Alloys and Compounds to 100 000 kg/cm².—P. W. Bridgman. (*Proc. Amer. Acad. Arts Sci.*, March 1952, Vol. 81, No. 4, pp. 165–251.)

537.311.33 1451

On Conduction in Impurity Bands.—W. Baltensperger. (*Phil. Mag.*, Dec. 1953, Vol. 44, No. 359, pp. 1355–1363.) "The idea of conduction by electrons in the energy bands of an impurity system is examined. For a lattice of hydrogen-like impurities the edges of the 1s, 2s, and 2p bands are calculated. Effective masses for electrons in these bands are introduced. With their help measurements of the conductivity and the Hall constant are interpreted. Depending on the density of the impurities and on the temperature, conduction takes place predominantly either in the band of the medium, or in excited impurity states, or in the 1s impurity band. In this last case the activation energy vanishes. This interpretation implies a description of the electronic state of the impurities with band wave functions and indicates the validity of such a description up to rather large values of the lattice constant. This can however be reconciled with the insulating properties of the oxides of transition metals."

537.311.33 **1452**

Modification of the Conductivity of Thin Semiconductor Films by Capacitively Applied Barrier-Layer Fields.—K. Zückler. (*Z. Phys.*, 16th Oct. 1953, Vol. 136, No. 1, pp. 40–51.) The principle used by Shockley & Pearson (3438 of 1948) was applied to determine barrier-layer properties for Se and Cu_2O. An evaporated semiconductor film formed one electrode of a mica capacitor. The variation of the resistance of the semiconductor with the voltage applied across the capacitor was measured at − 78°, + 25° and + 80°C by means of an auxiliary circuit. Values for the thickness of the barrier layer, the concentration of impurity centres and the mobility of charge carriers in the semiconductor are calculated assuming exhaustion of impurity centres (*a*) across the whole film, (*b*) within the barrier layer only.

537.311.33 **1453**

Apparatus for the Graphical Determination of the Fermi Energy Level in Semiconductors.—E. Mooser. (*Z. angew. Math. Phys.*, 15th Nov. 1953, Vol. 4, No. 6, pp. 433–449.) A method of determining the Fermi energy from the temperature and band-structure parameters is described in detail, with examples. The method also gives the temperature dependence of the concentration of charge carriers, taking account of degeneracy.

537.311.33 **1454**

New Semiconducting Compounds.—H. Welker. (*Z. Naturf.*, Nov. 1952, Vol. 7a, No. 11, pp. 744–749.) An investigation of compounds formed from Al, Ga or In on the one hand and P, As or Sb on the other. Such semiconducting compounds may have properties greatly superior to those of diamond, Si, Ge or grey tin. Electron mobilities up to 25 000 cm/s per V/cm have been measured in InSb.

537.311.33 **1455**

A Simple Demonstration Model of a *p-n* Junction.—W. Heywang. (*Naturwissenschaften*, Oct. 1953, Vol. 40, No. 20, pp. 527–528.)

537.311.33 : 535.215 **1456**

Quantum-Statistical Treatment of the Internal Photoeffect.—H. Müser. (*Z. Naturf.*, Nov. 1952, Vol. 7a, No. 11, pp. 729–734.) The distribution of electrons between possible energy levels is investigated for the case where a given number of electrons per second is shifted from a lower to a higher level.

537.311.33 : 537.312.6 **1457**

Rectification in Semiconductors in a Thermal Field.—I. M. Tsidil'kovski. (*C. R. Acad. Sci. U.R.S.S.*, 1st July 1953, Vol. 91, No. 1, pp. 63–66. In Russian.) Theoretical investigation of rectification by a system comprising a semiconductor layer between a pair of metal electrodes between which a potential difference and a temperature difference exist. Semiconductors considered are Cu_2O, Ge and Si. The calculated and the experimentally determined relations between *K* (ratio of backward to forward resistance) and *V* (potential difference) are shown graphically for a semiconductor with specified constants.

537.311.33 : 537.312.62 **1458**

Superconductivity of Impurity Semiconductors (PbS).—E. Justi & H. Schultz. (*Z. Naturf.*, Feb./March 1953, Vol. 8a, Nos. 2/3, pp. 149–155.) Measurements on evaporated films of controlled composition are reported. Superconductivity is not observed with films containing an excess of S or a small excess of Pb, but is observed with a large excess of Pb, the resistivity dropping sharply below 7·26°K. These results are discussed in relation to the possible mechanisms involved.

537.311.33 : 546.18-171 **1459**

The Electrical Properties of Black Phosphorus.—R. W. Keyes. (*Phys. Rev.*, 1st Nov. 1953, Vol. 92, No. 3, pp. 580–584.) Electrical conductivity and Hall constant were determined over the temperature range − 195°C to 350°C. The conductivity at pressures up to 8 000 kg/cm², magnetoresistance coefficients at − 195°C and − 80°C and infrared absorption between 2 μ and 30 μ were also determined. At low temperatures *p*-type impurity conduction was observed; at high temperatures the phosphorus is an intrinsic semiconductor with an energy gap of 0·33 eV.

537.311.33 : [546.28 + 546.289 **1460**

Production of Acceptor Centers in Germanium and Silicon by Plastic Deformation.—W. C. Ellis & E. S. Greiner. (*Phys. Rev.*, 15th Nov. 1953, Vol. 92, No. 4, pp. 1061–1062.) Ge crystals have been converted from *n* to *p* type by compression at high temperature; the accompanying changes of resistivity correspond to the introduction of 10^{15} acceptor centres/cm³. Similar results were obtained with Si at greater compression and higher temperature.

537.311.33 : 546.289 **1461**

On the Effective Mass of the Conduction Electron in Germanium.—W. Sasaki & M. Kuno. (*J. phys. Soc. Japan*, Nov./Dec. 1953, Vol. 8, No. 6, pp. 791–792.) Determinations based on Hall-effect and thermoelectric measurements on *n*-type single crystals are tabulated and compared with results obtained by Debye & Conwell (425 of 1953).

537.311.33 : 546.289 **1462**

Drift Mobilities in Semiconductors: Part 1—Germanium.—M. B. Prince. (*Phys. Rev.*, 1st Nov. 1953, Vol. 92, No. 3, pp. 681–687.) The drift mobilities μ_p and μ_n of holes in *n*-type and of electrons in *p*-type material respectively were determined over the temperature range 150°–350°K for samples with a range of resistivities from 0·05 to 30 Ω.cm at 300°K. For single crystals of resistivity > 10 Ω.cm the relations between mobility and temperature are given by $\mu_n = 3{\cdot}5 \times 10^7 T^{-1{\cdot}6}$ and $\mu_p = 9{\cdot}1 \times 10^8 T^{-2{\cdot}3}$. The relation between resistivity and concentration of impurity centres is shown graphically.

537.311.33 : 546.289 **1463**

Solubility and Ionizability of Impurities in Germanium Single Crystals.—W. Dürr, J. Jaumann & K. Seiler. (*Z. Naturf.*, Jan. 1953, Vol. 8a, No. 1, pp. 39–46.) Rod-shaped single crystals were grown from a melt of pure Ge with controlled additions of Ga, As or Sb. Measurements were made of the variation of Hall constant and conductivity along the direction of growth, and of the temperature dependence of these constants. The actual impurity content of a homogeneous middle portion of the crystal is determined by remelting and recrystallizing and comparing the constants with curves prepared for crystals from melts with known impurity concentrations. The results indicate that every donor atom (within ± 30%) yields one charge carrier, i.e., the ionizability has the value unity.

537.311.33 : 546.289 1464

A Method of estimating Impurity Concentrations in Germanium.—F. W. G. Rose & E. W. Timmins. (*Proc. phys. Soc.*, 1st Nov. 1953, Vol. 66, No. 407B, pp. 984–986.) Families of theoretical curves of log resistivity against inverse temperature for different values of impurity concentration were prepared corresponding to two sets of assumptions, namely (*a*) carrier and impurity concentrations equal, lattice scattering predominant, and (*b*) carrier and impurity concentrations unequal, both lattice and impurity scattering significant. The impurity content of a specimen is estimated by selecting the theoretical curve which best fits the experimental curve.

537.311.33 : 546.289 1465

Some Consequences of Possible Degeneracy of Energy Bands in Ge.—E. N. Adams, II. (*Phys. Rev.*, 15th Nov. 1953, Vol. 92, No. 4, pp. 1063–1064.) Critical examination of theory developed by Herman & Callaway (1699 of 1953).

537.311.33 : 546.289 1466

Further Measurements of the Effect of Pressure on the Electrical Resistance of Germanium.—P. W. Bridgman. (*Proc. Amer. Acad. Arts Sci.*, April 1953, Vol. 82, No. 2, pp. 71–82.) For reports of previous measurements see 1450 above and 2439 of 1951.

537.311.33 : 546.289 : 538.224 1467

The Magnetic Susceptibility of Germanium.—D. K. Stevens & J. H. Crawford, Jr. (*Phys. Rev.*, 15th Nov. 1953, Vol. 92, No. 4, pp. 1065–1066.) Measurements have been made on both *p*- and *n*-type specimens over the temperature range 65°–300°K. Some results are shown graphically and used to estimate the ratio of free-electron mass to effective carrier mass.

537.311.33 : 546.289 : 538.569.4.029.6 1468

Observation of Cyclotron Resonance in Germanium Crystals.—G. Dresselhaus, A. F. Kip & C. Kittel. (*Phys. Rev.*, 1st Nov. 1953, Vol. 92, No. 3, p. 827.) Diamagnetic resonance has been observed at 4°K in 38-Ω.cm *n*-type Ge at a field strength of 370 ± 5 oersted, and in *p*-type Ge at 125 ± 5 and at 970 ± 50 oersted, at a frequency of 9·05 kMc/s.

537.311.33 : 546.289 : 548.4.021 1469

Annealing of Bombardment Damage in Germanium: Experimental.—W. L. Brown, R. C. Fletcher & K. A. Wright. (*Phys. Rev.*, 1st Nov. 1953, Vol. 92, No. 3, pp. 591–596.) The damage produced by 3-MeV electrons, consisting primarily in the production of isolated vacancy-interstitial pairs, was determined by conductivity measurements on *n*-type samples. The activation energy for the diffusion of vacancies is found to be ~ 1·7 eV. The annealing curves are compared with curves derived from the theoretical model discussed by Fletcher & Brown (1477 below).

537.311.33 : 546.289 : 620.185 1470

New Etches for Germanium.—R. C. Ellis, Jr, & S. P. Wolsky. (*J. appl. Phys.*, Nov. 1953, Vol. 24, No. 11, pp. 1411–1412.) Preliminary report of an investigation of etching solutions other than hydrofluoric acid.

537.311.33 : 546.3-1-46-289-811 1471

Electrical Conductivity of Mixed Crystals of Intermetallic Compounds.—G. Busch & U. Winkler. (*Helv. phys. Acta*, 16th Nov. 1953, Vol. 26, No. 6, pp. 578–583. In German.) The lattice constant, activation energy and variation of conductivity with temperature were determined experimentally for twelve different $Mg_2(Ge_y Sn_{1-y})$ compounds. The results are shown graphically and tabulated.

537.311.33 + 535.215.1] : 546.36.863 1472

Studies on the Cs_3Sb Photo-Cathode.—T. Sakata. (*J. phys. Soc. Japan*, Nov./Dec. 1953, Vol. 8, No. 6, pp. 723–730.) Determinations of spectral and energy distributions indicate that Cs_3Sb is a semiconductor with values of δ about 0·2–0·3 eV, where δ is the difference between the Fermi level and the top of the occupied energy band. The value of the work function found by the photoelectric method was about 1·8 ± 0·1 eV.

537.311.33 + 535.215.1] : 546.36.863 : 538.632 1473

The Hall Effect in Cs_3Sb Photo-Cathode.—T. Sakata. (*J. phys. Soc. Japan*, Nov./Dec. 1953, Vol. 8, No. 6, pp. 793–795.) Results of measurements at a frequency of 800 c/s confirm that Cs_3Sb is a *p*-type semiconductor.

537.311.33 : 546.482.21 1474

Production of a *P*-Type CdS Rectifier by High Local Heating of *N*-Type Crystals.—G. Strull. (*J. appl. Phys.*, Nov. 1953, Vol. 24, No. 11, p. 1411.) Experimental evidence is given of *n*-type CdS crystals changing to *p*-type on application of intense local heating.

537.311.33 : 546.811-17 1475

Investigation of the Mechanism of Electrical Conduction in Grey Tin.—G. Busch & J. Wieland. (*Helv. phys. Acta*, 15th Dec. 1953, Vol. 26, Nos. 7/8, pp. 697–730. In German.) Results of earlier measurements of conductivity, Hall effect and variation of resistivity with applied magnetic field [2438 of 1951 (Busch et al.)] are discussed in detail in the light of present theory of semiconductors. Calculated values for charge-carrier concentrations and mobilities are considered in relation to different scattering processes, and the effects of added impurities and of incomplete transition are assessed. By means of a suitable model the absolute conductivity can be determined. At the transition point it is $2{\cdot}7 \times 10^3 \Omega^{-1}.cm^{-1}$, about one fortieth of that for the metallic modification.

537.311.33 : 546.811-17 : 538.22 1476

The Magnetic Properties of Semiconductors, with Particular Reference to Grey Tin.—G. Busch & E. Mooser. (*Helv. phys. Acta*, 16th Nov. 1953, Vol. 26, No. 6, pp. 611–656. In German.) The electrons and holes in a semiconductor are divided into three groups: (*a*) electrons in the valency band and in lower energy states, (*b*) free charge-carriers, i.e. electrons in the conduction band and holes in the valency band, and (*c*) electrons and holes which occupy the impurity levels and impurity bands between the conduction and the valency band. The susceptibilities corresponding to these groups are, respectively, the 'atom-susceptibility', the 'charge-carrier susceptibility' and the 'impurity-centre susceptibility'. These are discussed from the theoretical point of view and the results are used to interpret the susceptibility measurements made on grey tin with and without added impurities.

537.311.33 : 548.4.021 1477

Annealing of Bombardment Damage in a Diamond-Type Lattice: Theoretical.—R. C. Fletcher & W. L. Brown. (*Phys. Rev.*, 1st Nov. 1953, Vol. 92, No. 3, pp. 585–590.) A description is given of a three-stage process by which isolated pairs of interstitials and vacancies are thought to be removed. Approximate analytical expressions are derived for these stages. An outline is given of a more complete treatment with a quantitative solution for one particular phase of the annealing in the diamond-type lattice.

537.312.5 : 546.482.21 1478

Influence of Temperature and Oxygen on the Build-Up and Decay of the Photoconductivity of CdS Single Crystals.—B. Seraphin. (*Ann. Phys., Lpz.*, 20th Oct. 1953, Vol. 13, Nos. 1/5, pp. 198–213.)

537.32 1479

Thermoelectric Power of Monovalent Metals at High Temperature.—D. K. C. MacDonald & S. K. Roy. (*Phil. Mag.*, Dec. 1953, Vol. 44, No. 359, pp. 1364–1370.) An analysis based on band theory.

537.323 : 669.7.018 1480

Thermoelectric Power of Alloys.—J. Friedel. (*J. Phys. Radium*, Nov. 1953, Vol. 14, No. 11, pp. 561–565.) Mott's calculation for the resistivity when polyvalent impurities (e.g. Zn, Ga, Ge) are substituted in monovalent metals such as Cu is extended to determine the thermoelectric power. The order of magnitude and the variation as a function of impurity concentration are in agreement with experimental results. For Al alloys, in order to obtain theoretical results in agreement with observations, it is necessary to assume two overlapping energy bands.

537.533.8 1481

Some Characteristics of Secondary Emission from BeCu.—F. J. F. Osborne. (*Canad. J. Phys.*, Nov. 1953, Vol. 31, No. 7, p. 1189.) An investigation was made of the energy distribution of secondary electrons emitted from BeCu and other metal surfaces bombarded by primary electrons; the target was placed at the centre of a sphere to which a variable positive or negative bias was applied. The results are plotted as percentage of total secondary current against sphere bias.

538.221 1482

Quantum Theory of a Newly Proposed Origin of Ferromagnetism.—G. Heber. (*Ann. Phys., Lpz.*, 20th Oct. 1953, Vol. 13, Nos. 1/5, pp. 44–72.) Zener's theory, that ferromagnetism originates from the interaction between the 3*d* and the 4*s* electrons of a crystal, is discussed in conjunction with Heisenberg's theory, based on interaction between the 3*d* electrons among themselves.

538.221 1483

Orientational Superstructures due to Mechanical Deformations.—L. Néel. (*C. R. Acad. Sci., Paris*, 18th Jan. 1954, Vol. 238, No. 3, pp. 305–308.) Development of work previously noted (1101 of April).

538.221 1484

Magnetic Moments and Crystal Structures of Ferromagnetic Metals and Alloys.—F. Gal'perin. (*C. R. Acad. Sci. U.R.S.S.*, 1st Feb. 1953, Vol. 88, No. 4, pp. 643–646. In Russian.) An expression for the magnetic moment is given by analogy with a previously published formula (2444 of 1951) in terms of lattice constants. These constants are given in Table 1 for some pure metals, pure ferrites and materials of ferroxdure type. The calculated magnetic moments, given in fractional numbers of magnetons, are in good agreement with experimental values given in the last column. The dependence of the molecular magnetic moments of mixed ferrites on the relative concentrations of the components is shown in Fig. 1, where the curves, calculated from the given expression, are compared with the results of measurements by Gorter (1931 of 1950) and by Guillaud.

538.221 : 539.382 : 546.74 1485

Investigation of the ΔE Effect and the Damping of Elastic Waves in Polycrystalline Nickel by an Acoustic Method.—V. P. Sizov. (*C. R. Acad. Sci. U.R.S.S.*, 21st March 1953, Vol. 89, No. 3, pp. 427–430. In Russian.) Young's modulus (E) of 99·5% pure Ni wire was determined by the method of longitudinal resonant oscillations at the fundamental frequency (about 12 kc/s). The effects of magnetic fields up to 1 215 oersted were measured. Graphs of E/H, of $(\Delta E/E)/(J/J_s)$, where J_s is the intensity of magnetization at saturation, and of the variation in the amplitude and the decrement with H are given for differently treated wires.

538.221 : 621.318.12/.13 1486

Investigation of the Frequency Dependence of the Material Constants of Mixed Ferromagnetic Bodies up to Very High Frequencies.—W. Heister. (*Arch. Elektrotech.*, 1953, Vol. 41, No. 3, pp. 142–160.) The dielectric and magnetic properties of Ni-Zn, Cu-Zn and Mn-Zn ferrites and of dust cores of various grades and grain sizes of carbonyl iron, carbonyl nickel, hametag iron and cobalt were investigated at frequencies between 50 c/s and 4 kMc/s. At high frequencies volume resonance effects, due to capacitive eddy currents, were observed; these are explained by using the results of the dielectric measurements. The frequency characteristics can be determined from the properties of the individual particles; a comparison with experimental results is made.

538.221 : 621.318.134 1487

Ferrites — Properties and Applications.—H. Lennartz. (*Funk u. Ton*, Dec. 1953, Vol. 7, No. 12, pp. 613–627.) A survey. A table is given of the magnetic characteristics of 29 commercial magnetically soft ferrites manufactured in Holland and Germany. 33 references.

538.221 : 621.318.134 : 538.662 1488

Temperature Dependence of Magnetization Curves of Nickel-Zinc Ferrites in Weak Fields.—A. P. Komar & N. M. Reinov. (*C. R. Acad. Sci. U.R.S.S.*, 1st Nov. 1953, Vol. 93, No. 1, pp. 19–20. In Russian.) I/H characteristics determined at room temperature and at the temperatures of liquid N, H and He are shown graphically.

538.221: 621.318.2 1489

Steels for Permanent Magnets.—J. C. Williamson. (*Elect. Rev., Lond.*, 13th Nov. 1953, Vol. 153, No. 20, pp. 1101–1105.) The main types are surveyed briefly; two categories are distinguished, namely, quench-hardened steels and precipitation-hardened alloys. Composition and properties are tabulated.

546.23 : 537.226.8 : 621.314.634 1490

The Dielectric Behaviour of Selenium Barrier-Layers under Temperature Loading in the Blocking Region.—H. H. Rust. (*Arch. elekt. Übertragung*, Nov. 1953, Vol. 7, No. 11, pp. 549–553.) The capacitance/temperature characteristic of Se barrier layers initially exhibits a hysteresis effect which vanishes in subsequent temperature cycles. The variations of capacitance with time, following exposure to an increased temperature, and following a change in the applied bias potential, are shown graphically. The results are discussed and similarities with the characteristics of ferroelectric materials are noted.

548.7 1491

Imperfections in Matter.—G. W. Rathenau. (*Philips tech. Rev.*, Oct. 1953, Vol. 15, No. 4, pp. 105–113.) A general survey of the effects of crystal lattice imperfections on the properties of solids.

621.3.042.017.3 1492

Combined Magnetization of Magnetic Materials.—

J. E. Parton & W. D. Sutherland. (*Engineering, Lond.*, 27th Nov. & 4th Dec. 1953, Vol. 176, Nos. 4583 & 4584, pp. 687–700 & 731–732.) A detailed examination is made of the conditions produced when a magnetic core is simultaneously subjected to two or more magnetizing forces of different frequencies; the resulting iron losses are investigated.

669.04 **1493**

Preparation and Casting of Metals and Alloys under High Vacuum.—J. D. Fast, A. I. Luteijn & E. Overbosch. (*Philips tech. Rev.*, Oct. 1953, Vol. 15, No. 4, pp. 114–121.) A method is described for producing materials having the high degree of purity and precise composition required for physical investigations.

669.24 : 548.5 **1494**

Production of Single Crystals of Nickel.—R. F. Pearson. (*Brit. J. appl. Phys.*, Nov. 1953, Vol. 4, No. 11, pp. 342–344.) The growth by cooling from the melt, and the preparation of faces parallel to given crystal planes are described.

MATHEMATICS

512.3 **1495**

The Location of the Roots of Polynomial Equations by the Repeated Evaluation of Linear Forms.—L. Tasny-Tschiassny. (*Quart. appl. Math.*, Oct. 1953, Vol. 11, No. 3, pp. 319–326.)

517.512.3 **1496**

Legendre Functions of Fractional Order.—M. C. Gray. (*Quart. appl. Math.*, Oct. 1953, Vol. 11, No. 3, pp. 311–318.) Formulae are presented which were developed in connection with Schelkunoff's theory of aerials but are of general interest; computed values of the functions are tabulated and shown in curves.

MEASUREMENTS AND TEST GEAR

621.317.3 : 538.632 **1497**

Measurement of the Hall Effect in Cylinders without an External Magnetic Field.—G. Busch & R. Jaggi. (*Z. angew. Math. Phys.*, 15th Nov. 1953, Vol. 4, No. 6, pp. 425–433.) A current flowing in a cylindrical conductor gives rise to a Hall effect due to its own magnetic field. A simple method of measuring the effect, using either d.c. or a.c., is described. Results of measurements on polycrystalline Bi at 77°K and 290°K are shown graphically for different values of primary current; they are in good agreement with other published results.

621.317.3 : 621.314.632 : 546.289 **1498**

Use of the Germanium Rectifier for the Measurement of Current, Voltage and Power at High Frequency: Part 1 — Measurement of Current and Voltage.—J. Schiele. (*Arch. tech. Messen*, Dec. 1953, No. 215, pp. 285–288.) A survey relating particularly to Siemens Ge rectifiers, in which the crystal and point contact are sealed into a ceramic tube with metal end caps.

621.317.3 : 621.372.2.029.64 **1499**

Determination of Equivalent Circuit Parameters for Dissipative Microwave Structures.—L. B. Felsen & A. A. Oliner. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, pp. 477–483.) Measurement procedures are proposed based on Weissfloch's method of separating the network into lossy and loss-free parts (403 of 1944) and applicable for investigations of structures such as junctions between surface-wave or microstrip lines and their feed lines. Sample calculations are presented.

621.317.3 : 621.372.8 **1500**

An Elliptically-Polarized-Vibration Analyser for a Circular Waveguide in the 3-cm Waveband.—G. Raoult & A. Marcon. (*C. R. Acad. Sci., Paris*, 11th Jan. 1954, Vol. 238, No. 2, pp. 218–220.) An arrangement analogous to that used for optical polarization experiments is described. Two small aerials associated with resonators and crystal detectors are used to pick up the two components of the elliptically polarized wave. The ellipticity is determined by making measurements with and without a quarter-wave phase shifter in position.

621.317.32 : 621.314.63 **1501**

The Application of Barrier-Layer Rectifiers to the Measurement of Very Small Alternating Voltages.—F. Moeller. (*Arch. tech. Messen*, Nov. 1953, No. 214, pp. 263–266.) A comparison of the characteristics of Cu_2O, Se and Si or Ge point-contact rectifiers from the point of view of measurement of voltages <10 mV.

621.317.331 : 546.289 **1502**

Resistivity Measurements on Germanium for Transistors.—L. B. Valdes. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, pp. 420–427.) A method using four aligned probes is described; current is passed through the outer pair and the floating potential across the inner pair is measured. Formulae and curves are given for computing the resistivity for some particular arrangements.

621.317.35 : 535.37 **1503**

A New Method to Determine Short Decay Times of Phosphors excited with Ultraviolet Light.—A. Bril, H. A. Klasens & P. Zalm. (*Philips Res. Rep.*, Oct. 1953, Vol. 8, No. 5, pp. 393–396.) A c.r. tube with an ultraviolet-transmitting filter is used to provide excitation. The decay time of Sb-activated halophosphates is $\sim 5 \times 10^{-6}$ sec.

621.317.373 : 535.37 **1504**

Measurement of Luminescence Decay Time by means of the Phase [-detector] Valve.—F. Rohde. (*Z. Naturf.*, Feb./March 1953, Vol. 8a, Nos. 2/3, pp. 156–161.) The screen is excited by an electron beam whose intensity is modulated at h.f., and the emitted light is picked up by a photomultiplier, producing a signal which is phase-shifted with respect to the modulating signal. The two signals are applied to a phase-detector valve, whose output gives an indication of the luminescence decay time. Measurements on various organic phosphors are reported

621.317.411.029.64 **1505**

The Determination of the Apparent Permeabilities of Ferromagnetic Metals at cm-Wavelengths.—E. Ledinegg & P. Urban. (*Arch. elekt. Übertragung*, Nov. 1953, Vol. 7, No. 11, pp. 523–530.) Methods based on cavity-resonator and Lecher-wire measurements are described, the permeabilities being calculated from the detuning effect and the damping produced by a probe formed of the material under test.

621.317.42 : 538.221 **1506**

Investigation of Self-Field Distortion in the Förster Probe in the presence of a Ferromagnetic Material.—F. Brandstaetter. (*Elektrotech. u. Maschinenb.*, 15th Oct. 1953, Vol. 70, No. 20, pp. 452–455.) The Förster probe consists basically of a twin-core transformer with the lines of force completed through air paths, the secondaries being wound so as to provide compensation in the absence of external magnetic fields. When used for testing ferromagnetic materials, the probe field gives rise to irreversible processes which are however reduced to a small residual value due to the movement of the probe along the test piece.

621.317.431/.44 **1507**

An Improved Form of Hysteresis-Loop Plotter for Magnetic Materials.—A. D. Booth. (*J. sci. Instrum.*, Oct. 1953, Vol. 30, No. 10, pp. 384–385.) The use of a feedback integrator in the conventional c.r.o. hysteresis-curve plotter circuit results in a decreased time constant for a given accuracy, increased stability and freedom from unwanted pick-up. Hysteresis curves of toroidal cores can be obtained by winding one or two turns only and using a 1:60 step-up transformer.

621.317.444 **1508**

A Recording Fluxmeter.—R. S. Tebble. (*J. sci. Instrum.*, Oct. 1953, Vol. 30, No. 10, pp. 369–371.) The deflection of the Grassot fluxmeter coil is recorded as a change in the voltage induced in a mutual inductor, the primary of which is fixed and the secondary attached to the fluxmeter coil. The apparatus is described and the elimination of various errors is discussed.

621.317.7 : 621.3.018.78 **1509**

Measurement of Harmonic Distortion.—T. D. Conway. (*Wireless World*, March 1954, Vol. 60, No. 3, pp. 110–112.) Description of a self-contained direct-reading instrument for works testing and servicing, particularly for magnetic-tape recorders.

621.317.7.029.63/.64 : 621.372.43 **1510**

A U.H.F. and Microwave Matching Termination.—R. C. Ellenwood & W. E. Ryan. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, pp. 476–477.) Discussion on 1073 of 1953.

621.317.71 **1511**

High-Sensitivity Monofilar Electrometer.—Ouang Te-Tchao, E. Montel & P. Pannetier. (*J. Phys. Radium*, Nov. 1953, Vol. 14, No. 11, pp. 627–629.) An instrument capable of detecting a charge of the order of 20 000 electrons is described.

621.317.72.027.2.083.5 **1512**

Moving-Coil Compensator for recording Small Direct Voltages.—E. Samal. (*Elektrotech. Z.*, *Edn A*, 11th Oct. 1953, Vol. 74, No. 20, pp. 590–593.) The difference between the currents passed through a resistor from a variable source and due to application of the unknown e.m.f. is used to operate a variable mutual inductor which controls the current source.

621.317.725 **1513**

An Electrostatic Voltmeter with Linear Indication.—H. Greinacher. (*Bull. schweiz. elektrotech. Ver.*, 26th Dec. 1953, Vol. 44, No. 26, pp. 1081–1083.) The voltmeter described previously (947 of 1951) is modified to give a linear indication by using appropriately curved plates instead of plane ones.

621.317.729 **1514**

Low-Input-Capacity Probe.—G. L. Shultz. (*Rev. sci. Instrum.*, Nov. 1953, Vol. 24, No. 11, p. 1068.) Input capacitance is 4·5 pF measured at 1·5 Mc/s. Attenuation is linear for 10-μs pulses of amplitude between −6 V and + 11 V.

621.317.734 : 621.314.7 **1515**

Transistorized Megohmmeter.—P. B. Helsdon. (*Wireless World*, March 1954, Vol. 60, No. 3, pp. 121–123.) Description of a compact two-range instrument with a transistor h.v. generator.

621.317.755 : [621.314.632 + 621.314.7 **1516**

A Double-Pulse Instrument for the Measurement of Time-Lag Phenomena in Crystal Diodes and Transistors.—T. Einsele. (*Funk u. Ton*, Nov. 1953, Vol. 7, No. 11, pp. 557–569.) The operation and parts of the circuit of the c.r.o. instrument are described. The duration of either pulse can be varied independently between 0·5 and 25 μs, the pulse separation can be varied between 0·5 and 50 μs and the pulse repetition frequency between 10 and 2 000/sec. The pulse amplitudes are equal, and variable between 1 and 200 V. Applications of the instrument include measurement of the variation with time of the barrier-layer resistance.

621.317.755 : 621.385.832 **1517**

A Sealed-Off Cathode-Ray Tube with a Very High Writing Speed.—Jackson, Hardy & Feinberg. (See 1619.)

621.317.755 : 621.385.832 **1518**

Multibeam Cathode-Ray Oscillograph.—Fert, Lagasse & Ollé. (See 1620.)

621.317.79 : 537.533 **1519**

High-Energy Bunched Beam Analyzer.—I. Kaufman. (*J. appl. Phys.*, Nov. 1953, Vol. 24, No. 11, p. 1413.) An arrangement for measuring the length of the bunches in an undulated high-energy electron beam, such as that described by Motz (2411 of 1951) for producing millimetre waves, includes a cavity resonator for converting the bunch length into an electron-energy range, followed by a magnetic field for separating the electrons according to their energies.

621.317.79 : 621.372.412 **1520**

A Review of Methods for Measuring the Constants of Piezoelectric Vibrators.—E. A. Gerber. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, p. 446.) Correction to paper abstracted in 3670 of 1953.

621.373 : 621.396.822 **1521**

Primary Standard Thermal Noise Generator.—G. Lynch. (*Radio & Telev. News, Radio-Electronic Engng Section*, Nov. 1953, Vol. 50, No. 5, pp. 10–12.) The noise generator described comprises a heated precision resistor matched to a coaxial line.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

539.32 : 534.321.9 **1522**

Determination of the Elastic Constants of Isotropic Solid Bodies, using Ultrasonic Waves.—E. Ledinegg & P. Urban. (*Acta phys. austriaca*, Oct. 1953, Vol. 8, No. 1, pp. 16–27.) Description of a resonance method using a cylindrical acoustic resonator into which rod or plate specimens are introduced. Formulae derived for thin specimens are in approximate agreement with corresponding formulae previously derived from perturbation theory (922 of April).

621.317.083.7 **1523**

Radio Telemetering.—E. D. Whitehead & J. Walsh. (*Proc. Instn elect. Engrs*, Part III, Jan. 1954, Vol. 101, No. 69, pp. 41–42.) Discussion on 1762 of 1953.

621.317.083.7 **1524**

A Transducer System for Remote Indication.—(*Engineer, Lond.*, 23rd Oct. 1953, Vol. 196, No. 5100, pp. 537–538.) The amount of unbalance introduced in a bridge-type circuit by a change of the e.m. coupling at the transducer is measured by a remote moving-coil meter. A 50-c/s mains supply is used.

621.317.083.7 : 621.396.934 **1525**

Telemetry for Guided Weapons.—(*Engineering, Lond.*, 23rd Oct. 1953, Vol. 176, No. 4578, pp. 518–519.) Airborne and ground-station equipment developed by the Ministry of Supply is described. For the transmission of information on control-surface positions, strains, pressures and torques a 23-channel low frequency time-sharing multiplex system is used, with an additional channel for synchronization. Information on waveforms occurring in the airborne electronic equipment is transmitted by 20 high-frequency channels, using p.p.m. and time-division systems.

621.318.5 : 551.571.3 **1526**

The Effect of Humidity Variation on the Operation of an Electronic Proximity Switch.—R. A. K. Long. (*J. sci. Instrum.*, Nov. 1953, Vol. 30, No. 11, pp. 422–424.) The change in electrode capacitance due to adsorption by the oxide layer and to permittivity and temperature variations can be eliminated by enclosing the electrode.

621.318.572 : 621.383 **1527**

A Bidirectional Electronic Counter for Use in Optical Interferometry.—F. H. Branin, Jr. (*J. opt. Soc. Amer.*, Oct. 1953, Vol. 43, No. 10, pp. 839–848.) An arrangement is described for counting interference fringes by deriving electrical sine waves from them by means of a stepped mirror and two photocells. Either a binary or a decimal system can be provided. Counting rates $>$150 000/sec have been achieved. Other applications of the counter are indicated, including use in analogue-to-digital converters.

621.384.611 **1528**

Favourable Operating Conditions for the Electron Cyclotron.—C. Schmelzer. (*Z. Naturf.*, Dec. 1952, Vol. 7a, No. 12, pp. 808–817.)

621.384.612 **1529**

Nonlinearities in the Strong-Focusing Accelerator.—E. R. Caianiello. (*Nuovo Cim.*, 1st May 1953, Vol. 10, No. 5, pp. 581–593. In English.) The effects of the nonlinearity of the magnetic field, due to the fact that it must satisfy the Maxwell equations, are shown to be negligible compared with other causes of error in the strong-focusing accelerator.

621.384.612 **1530**

Stability and Periodicity in the Strong-Focusing Accelerator.—E. R. Caianiello & A. Turrin. (*Nuovo Cim.*, 1st May 1953, Vol. 10, No. 5, pp. 594–603. In English.)

621.384.612 **1531**

Alignment Errors in the Strong-Focusing Synchrotron.—M. Sands & B. Touschek. (*Nuovo Cim.*, 1st May 1953, Vol. 10, No. 5, pp. 604–613. In English.) Distortion of orbits due to misalignment of the sectors is investigated.

621.384.612 **1532**

Orbital Instabilities due to Nonlinearities in the Cosmotron.—J. Seiden. (*C. R. Acad. Sci., Paris*, 11th Jan. 1954, Vol. 238, No. 2, pp. 230–232.)

621.384.622.2 **1533**

8-MeV Linear Accelerator for X-Ray Therapy.—(*Engineer, Lond.*, 30th Oct. 1953, Vol. 196, No. 5101, pp. 554–556.) Description of travelling-wave accelerator installed at Hammersmith Hospital, London.

621.385.832[/.833] : 621.3.032.28 : 538.691 **1534**

Magnetic Electron Lens Aberrations due to Mechanical Defects.—G. D. Archard. (*J. sci. Instrum.*, Oct. 1953, Vol. 30, No. 10, pp. 352–358.) A modification of Sturrock's computational procedure (1074 of 1952) is used. The results are presented in the form of universal curves designed to facilitate the assignment of tolerances for lenses of any magnitude and any accelerating potential.

621.385.833 **1535**

Numerical Integrations of the Equation of Electron Trajectories.—M. Laudet. (*J. Phys. Radium*, Nov. 1953, Vol. 14, No. 11, pp. 604–610.)

621.385.833 **1536**

The Sensitivity of Simple Electron-Optical Schlieren Arrangements.—W. Rollwagen & C. Schwink. (*Optik, Stuttgart*, 1953, Vol. 10, No. 11, pp. 525–530.) Methods of the type described by Marton & Lachenbruch (1211 of 1950) for investigating electromagnetic fields are considered. A study is made of the different possible arrangements including an electron lens.

621.385.833 **1537**

Numerical Calculation of the Paths in Rotationally Symmetrical Electron-Optical Systems.—P. Gautier. (*J. Phys. Radium*, Oct. 1953, Vol. 14, No. 10, pp. 524–532.)

621.387.424 **1538**

The Mechanism of the Discharge in Argon-Filled Counters.—L. Colli & U. Facchini. (*Nuovo Cim.*, 1st Dec. 1952, Vol. 9, No. 12, pp. 1183–1217.)

621.387.424 **1539**

Investigation of the Discharge and of Post-Discharge Phenomena in G-M Counters, by means of X-Ray Pulses.—P. Müller. (*Ann. Phys., Lpz.*, 20th Oct. 1953, Vol. 13, Nos. 1/5, pp. 110–135.)

621.387.424 **1540**

Geiger-Müller Counters with Binary Mixtures of Rare Gas and Organic Vapour.—R. Meunier, M. Bonpas & J. P. Legrand. (*J. Phys. Radium*, Nov. 1953, Vol. 14, No. 11, pp. 630–634.)

621.397.3 **1541**

Processing of Two-Dimensional Patterns by Scanning Techniques.—L. S. G. Kovasznay & H. M. Joseph. (*Science*, 23rd Oct. 1953, Vol. 118, No. 3069, pp. 475–477.) A system comprising a flying-spot scanner and oscilloscope monitor is used to study processes involved in the recognition and recollection of patterns. Contour enhancement is achieved by combining the picture signal with its second derivative. The possibility of achieving various other unusual effects by circuit means is indicated.

535.37 : 621.387.464 **1542**

Luminescence and the Scintillation Counter. [Book Review]—S. C. Curran. Publishers: Butterworths Scientific Publications, London, 32s. 6d. (*Engineering, Lond.*, 20th Nov. 1953, Vol. 176, No. 4582, p. 644.) A compact and comprehensive guide to modern theory and practice.

PROPAGATION OF WAVES

538.566 **1543**

Note on W. H. Wise's Proof of the Nonexistence of the Zenneck Surface Wave in the Field of an Aerial.—H. Ott. (*Z. Naturf.*, Jan. 1953, Vol. 8a, No. 1, pp. 100–103.) It is shown that Wise's proof (1690 of 1937) does not exclude all possibility of the existence of a surface-wave component in the distant field of a dipole.

538.566 : 551.594.6 **1544**

Harmonic Fields in the Propagation of Long Electric Waves round the Earth, and Lightning Waveforms.—

W. O. Schumann. (*Naturwissenschaften*, Oct. 1953, Vol. 40, No. 19, pp. 504–505.) The work noted in 1772 and 3597 of 1953 is extended to include a study of the harmonic fields of a vertical and of a horizontal dipole. The analysis indicates that the harmonic fields of vertical lightning flashes vanish at large distances, owing to attenuation; for horizontal flashes the lowest possible propagation frequency is 3 330 c/s, and only the harmonics are propagated, the lowest being the least attenuated.

538.566 : 551.594.6 **1545**

The Propagation of Very Long Electric Waves round the Earth, and Atmospherics.—W. O. Schumann. (*Nuovo Cim.*, 1st Dec. 1952, Vol. 9, No. 12, pp. 1116–1138.) Using the method of singular eigenfunctions, a formula is found for the propagation of long waves, taking account of the influence of the ionosphere. Expressions for the propagation of atmospherics are hence found by Fourier integration, assuming various simple time functions for the lightning waveform.

621.396.11 **1546**

Theoretical Resonance Curves in the Gyro-interaction of Electromagnetic Waves in the Ionosphere.—F. H. Hibberd. (*Nuovo Cim.*, 1st April 1953, Vol. 10, No. 4, pp. 380–385. In English.) Motzo's results (2111 of 1953) are discussed and it is shown that for vertically incident waves either single or double maxima may occur, and that there is little difference in the general shape of the curves resulting from vertically incident and obliquely incident waves.

621.396.11 **1547**

The Application of High-Frequency Radio-Propagation Predictions in the New Zealand Area.—G. McK. Allcock. (*N.Z. J.Sci.Tech.B*, Sept. 1953, Vol. 35, No. 2, pp. 198–212.) The results of propagation measurements at 9·15 Mc/s over an 800-km path along a geomagnetic meridian indicate that the m.u.f.'s for 3000-km and 800-km paths are related by the equation (M800) = 0·38(M3000) + 0·37. The frequency separation between the m.u.f.'s for the ordinary and extraordinary waves is approximately one-half the gyro-frequency.

621.396.11 : 551.510.52 **1548**

The Troposphere as a Medium for the Propagation of Radio Waves: Part 1.—H. Bremmer. (*Philips tech. Rev.*, Nov. 1953, Vol. 15, No. 5, pp. 148–159.) A review paper.

621.396.11 : 551.510.535 **1549**

Double Refraction in the Ionosphere.—R. W. Larenz. (*Naturwissenschaften*, Oct. 1953, Vol. 40, No. 20, p. 527.) The variation of the real part of the refractive index with the plasma frequency is shown graphically for different values of the angle between the direction of wave propagation and the magnetic field. When the effect of electron pressure is taken into account triple refraction is found to be produced. Only two of the wave components have group velocities of the order of the velocity of light. The results are consistent with the triple refraction observed by Dieminger & Möller (2791 of 1949).

621.396.11 : 551.510.535 **1550**

Some Notes on the Absorption of Radio Waves Reflected from the Ionosphere at Oblique Incidence.—W. J. G. Beynon. (*Proc. Instn elect. Engrs*, Part III, Jan. 1954, Vol. 101, No. 69, pp. 15–20.) For conditions in which partial reflection or scattering at the E region is the dominant cause of attenuation of the first-order F-layer reflection, a new equivalence theorem in better agreement with observations on both long and short transmission paths is proposed to replace Martyn's relation (*Proc. phys. Soc.*, 1935, Vol. 47, pp. 323–339). In this new theorem, the apparent absorption at frequency f and angle of incidence i is equivalent to the apparent absorption at frequency $f \cos i$ and normal incidence. The influence of multiple echoes on received signal strength is also considered.

621.396.11.029.422 **1551**

An Experimental Investigation of Short-Distance Ionospheric Propagation at Low and Very Low Frequencies.—H. G. Hopkins & L. G. Reynolds. (*Proc. Instn elect. Engrs*, Part III, Jan. 1954, Vol. 101, No. 69, pp. 21–34.) Observations were made between 1948 and 1951 at distances between 60 and 210 km from commercial c.w. transmitters operating at four frequencies in the range 16–85 kc/s. The experimental method mainly used was similar to that described by Best et al. (*Proc. roy. Soc. A*, 1936, Vol. 156, p. 614). The equipment used is described and the results obtained are discussed critically in relation to similar work performed elsewhere. Pulse-sounding technique has advantages over the c.w. method for the frequency band considered.

621.396.11.029.64 : 551.510.52 **1552**

The Effect of the Oceanic Duct on Microwave Propagation.—L. J. Anderson & E. E. Gossard. (*Trans. Amer. geophys. Union*, Oct. 1953, Vol. 34, No. 5, pp. 695–700.) Radio and meteorological observations obtained over Cardigan Bay are analysed. For propagation at a wavelength of 3 cm, agreement between observation and theory improves as wind speed increases. At the lower wind speeds scatter is noted; possible explanations of this scatter are discussed. For propagation at a wavelength of 9 cm more scatter is observed and the transition to trapping conditions is less definite.

621.396.81 **1553**

Radio Survey Technique.—S. H. Wilkinson. (*A.T.E. J.*, Oct. 1953, Vol. 9, No. 4, pp. 216–228.) A description is given of the survey unit previously mentioned (234 of January). Experimental and theoretical methods of determining path attenuation are discussed. An account is given of typical surveys which have been made to obtain data on propagation and on equipment performance.

621.396.812.3.029.65 **1554**

Some Measurements of Fading at a Wavelength of 8 mm over a Very Short Sea Path.—D. G. Kiely. (*J. Brit. Instn Radio Engrs*, Feb. 1954, Vol. 14, No. 2, pp. 89–92.) Measurements were made, over a five-week period, of the fluctuations of signals transmitted over a 1-mile path, using a transmitter site about 15 ft and a receiver site about 100 ft above sea level. The results indicate very large atmospheric-refraction effects.

RECEPTION

621.396.621.029.64 + 621.372.2.029.64/.65 **1555**

Experimental Determination of the Properties of Microstrip Components.—Arditi. (See 1296.)

621.396.82 : 061.3 **1556**

Radio Interference Conference.—(*Elect. J.*, 13th Nov. 1953, Vol. 151, No. 20, p. 1594.) Brief report of the proceedings of an international conference held in London, October 1953.

621.396.82 : 621.3.066.6 **1557**

Sliding Contacts — a Review of the Literature.—F. Spayth & S. East. (*Elect. Engng, N.Y.*, Oct. 1953, Vol. 72, No. 10, pp. 912–917.) The review includes results of measurements of mechanical and electrical phenomena at motor or generator brush contacts. Tables are given of the variation of electrical noise with brush and ring material and with brush pressure. The experimental results are summarized in sets of general rules for designers. 43 references.

621.396.828 + [621.397.828 : 535.623 **1558**

Color Television and the Amateur.—G. Grammer. (*QST*, Nov. 1953, Vol. 37, No. 11, pp. 31–34..124.) Interference between transmissions in the 80-m band and the 3·58-Mc/s colour subcarrier was investigated. Interference in both services could largely be suppressed by good design in the layout, the screening and the filters of the television receiver.

621.396.828 **1559**

The Most Suitable Interference-Suppressor Circuit.—G. Strobel & H. Scherenzel. (*Frequenz*, Sept. & Oct. 1953, Vol. 7, Nos. 9 & 10, pp. 269–275 & 295–298.) The choice of the best arrangement for suppressing interference at the source requires a knowledge of the source impedance, the magnitude of the interference, the permissible interference limits and the electrical safety regulations. These points are discussed in detail in relation to the West German regulations for the 0·1–20-Mc/s frequency range, and the methods of measurement and application of the results are described.

STATIONS AND COMMUNICATION SYSTEMS

621.376 : 621.396 **1560**

Comparison of Amplitude and Angle Modulation for Narrow-Band Communication of Binary-Coded Messages in Fluctuation Noise.—G. F. Montgomery. (*Proc. Inst. Radio Engrs*,, Feb. 1954, Vol. 42, No. 2, pp. 447–454.) Consideration is given to the problem of choosing the best modulation system for transmitting messages over a given radio channel with less than a specified error and at the lowest cost for terminal equipment. Frequency-shift, phase-shift and on-off systems are examined. Curves of fractional error as a function of average carrier/noise ratio are derived for fading and nonfading carriers.

621.376.2 : 621.395.44 **1561**

Properties of a Sine Wave with Double Amplitude Modulation.—L. Le Blan. (*C. R. Acad. Sci., Paris*, 11th Jan. 1954, Vol. 238, No. 2, pp. 220–222.) Analysis indicates that crosstalk is present to a greater degree in a two-channel system with separate modulation of the positive and negative portions of the carrier than in the system using alternate positive and negative pulses (1176 of April).

621.376.3/.4 : 621.396.8 **1562**

Comparison between Frequency and Phase Modulation for transmitting Speech.—G. Fontanellaz. (*Tech. Mitt. schweiz. Telegr.-Teleph Verw.*, 1st Dec. 1953, Vol. 31, No. 12, pp. 371–374. In German.) Calculation indicates that for the frequency range 300–3 400 c/s, ph.m. gives a receiver-output signal/noise ratio 8·2 db better than f.m., for the same h.f. signal/noise ratio and the same mean frequency deviation. The relations between intelligibility and signal/noise ratio for the two systems are also compared.

621.376.3.001.11 : 621.316.729 **1563**

Communications Synchronizing Systems.—F. T. Turner. (*Elect. Engng, N.Y.*, Oct. 1953, Vol. 72, No. 10, pp. 874–876.) The application of f.m. theory to conventional synchronizing systems leads to a simple evaluation of the minimum signal/noise ratio permissible in facsimile transmission. Expressions are also derived for the servo-mechanism loop function and for the requirements for establishing synchronism on the initial application of the synchronizing signal.

621.376.5.001.2 **1564**

Quantizing Noise of a Single-Integration Delta-Modulation System with an *N*-Digit Code.—H. van de Weg. (*Philips Res. Rep.*, Oct. 1953, Vol. 8, No. 5, pp. 367–385.) The signal/noise ratio of Δ-modulation is evaluated, for different numbers of coding digits, as a function of the ratio between sampling frequency and maximum signal frequency, and compared with Bennett's results (895 of 1949) for p.c.m. By applying the results to the case of speech transmission, Δ-modulation is shown to be superior to p.c.m. for any given sampling frequency and number of digits.

621.39 **1565**

[British] **Commonwealth Telecommunications.**—J. A. Smale. (*Proc. Instn elect. Engrs*, Part III, Jan. 1954, Vol. 101, No. 69, pp. 1–4.) Chairman's address, Radio Section, I.E.E. A survey of developments in the complementary use of cable and wireless routes.

621.39.001.11 : 016 **1566**

A Bibliography of Information Theory (Communication Theory—Cybernetics).—F. L. Stumpers. (*Trans. Inst. Radio Engrs*, Nov. 1953, No. PGIT-2, pp. 1–60.) A comprehensive bibliography, including books and papers, arranged under the following headings:—(*a*) general theory; (*b*) bandwidth and transmission capacity, time-frequency uncertainty; signal/noise ratios, comparison of systems; instantaneous frequency; analytical signals; (*c*) definition, relation to statistical mechanics, philosophy; (*d*) correlation, prediction, filtering, storage; (*e*) radar; radio navigation; (*f*) speech; hearing; vision; linguistics; semantics; (*g*) other biophysical applications; human engineering; group communication; (*h*) television; (*i*) miscellaneous applications; optics; games; servo-mechanisms; (*j*) mathematics; statistics; games; relay algebra; noise analysis; (*k*) pulse modulation; multiplex coding.

621.39.001.11 : 519.2 **1567**

Fundamentals of Information Theory.—C. Lafleur. (*HF, Brussels*, 1953, Vol. 2, No. 8, pp. 219–228.) The two axioms stated by Woodward & Davies (1724 of 1952) based on *a priori* and *a posteriori* probabilities are applied to derive Wiener's criterion for optimum filtering and Shannon's formulae regarding entropy and equivocation.

621.391 : 621.376.5 **1568**

A Recent Development in Communication Technique.—C. W. Earp. (*Proc. Instn elect. Engrs*, Part III, Jan. 1954, Vol. 101, No. 69, p. 20.) Discussion on 2889 of 1952.

621.395.44 : 621.315.052.63 **1569**

Transmission Power and Range of Carrier-Frequency Communication Equipment for High-Voltage Lines.—H. K. Podszeck & A. Schmid. (*Elektrotech. Z., Edn A*, 11th Oct. 1953, Vol. 74, No. 20, pp. 586–589.) Multi-channel single- and double-sideband transmissions using carrier frequencies in the range 30–450 kc/s are considered from the power efficiency point of view. Formulae and graphs are given for the effects due to the depth of modulation, the number of channels and sidebands, and the type of application, e.g., telephony, remote control and measurement.

621.395.44 : 621.315.052.63 **1570**

New Line of Power-Line Carrier Equipment.—F. B. Gunter. (*Elect. Engng, N.Y.*, Nov. 1953, Vol. 72, No. 11,

p. 965.) Digest of paper to be published in *Trans. Amer. Inst. elect. Engrs*, 1953, Vol. 72. Performance characteristics of multi-purpose equipment are outlined.

621.395.44 : 621.315.212 **1571**

Potentialities and Limitations of a Coaxial-Cable Multichannel System.—F. Locher. (*Bull. schweiz. elektrotech. Ver.*, 3rd Oct. 1953, Vol. 44, No. 20, pp. 861–875.) A review of development and present-day coaxial-cable technique in Europe and the U.S.A.

621.395.44 : 621.375.2 **1572**

The Coaxial-Line Amplifier.—J. Bauer. (*Bull. schweiz. elektrotech. Ver.*, 3rd Oct. 1953, Vol. 44, No. 20, pp. 881–884; *Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st Jan. 1954, Vol. 32, No. 1, pp. 31–35.) Description of the amplifier designed for the Bern-Morteau line, and comprising two units in tandem, with associated equalizer, temperature compensator and separating network equipment.

621.396 + 621.397] : 061.3 **1573**

The New C.C.I.R. Resolutions.—Fetzer. (See 1587.)

621.396.4 : 621.396.65 **1574**

Experimental Radio Bearer Equipment for Carrier Telephone Systems.—W. S. McGuire & A. G. Bird. (*A.W.A. tech. Rev.*, Oct. 1953, Vol. 9, No. 4, pp. 227–254.) Reprint. See 3412 of 1953.

621.396.41.029.62 **1575**

Some Factors in the Engineering Design of V.H.F. Multichannel Telephone Equipment.—W. T. Brown. (*J. Brit. Instn Radio Engrs*, Feb. 1954, Vol. 14, No. 2, pp. 51–74. Discussion, pp. 75–77.) The principal clauses of a specification for a v.h.f. multichannel radiotelephone installation are discussed generally. Particular attention is given to ancillary equipment for automatic change-over, remote control and fault warning. The layout and aerial arrangements are described.

621.396.65 : 621.396.41.029.64 **1576**

A Multichannel Microwave Relay System.—R. D. Boadle. (*A.W.A. tech. Rev.*, Oct. 1953, Vol. 9, No. 4, pp. 209–226.) Reprint. See 3110 of 1953.

621.396.65.029.6.001.4(44 + 494) **1577**

Testing Radio-Link Transmission over a Long Line-of-Sight Path between France and Switzerland.—W. Klein & L. J. Libois. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.* 1st Nov. 1953, Vol. 31, No. 11, pp. 305–317. In French.) A report of measurements made, during the period 1950–1952, of test transmissions on 300 and 3 000 Mc/s over a 160-km path between Chasseral and Mont-Afrique. Results show that multichannel or television transmission satisfying C.C.I.F. specifications is quite practicable. Path attenuation during the period was less variable than for other paths only half as long; this is attributed to the presence of obstacles along the path which scarcely affect the direct wave, but cause considerable attenuation of indirect waves by diffraction. The correlation of reception conditions with meteorological data is discussed, in particular the coincidence of severe fades at 300 Mc/s with the presence of zones of superrefraction. See also *Onde élect.*, Dec. 1953, Vol. 33, No. 321, pp. 665–677.

621.396.664 : 621.396.712 **1578**

Random Sequence Switching.—A. B. Ettlinger. (*Electronics*, Feb. 1954, Vol. 27, No. 2, pp. 165–167.) In a system for automatic control of a group of broadcasting stations for civil-defence purposes, the programme is continuously fed to all the transmitters in the group and each transmitter is equipped with a tone-operated relay so that power is applied only when a 7-kc/s tone is superimposed on the line; this tone is switched in a random manner by means of a thermal delay device.

621.396.712.2 : 534.76 **1579**

Audio Equipment for Binaural Broadcasts.—L. J. Kleinklaus. (*Electronics*, Feb. 1954, Vol. 27, No. 2, pp. 134–135.) Description of two portable units, namely a two-channel preamplifier-mixer and a monitor amplifier, used at the WQXR station, which broadcasts simultaneously in an a.m. and a f.m. channel.

621.396.932 **1580**

Re-equipping Coast Radio Stations.—(*Elect. J.*, 6th Nov. 1953, Vol. 151, No. 19, pp. 1475–1476.) Brief details are given of equipment installed by the British Post Office to meet developments in ship-to-shore communications and related techniques.

621.396.933 : 621.396.3 **1581**

Notes on the Radiotelegraphic Connection between the K.L.M. Liftmaster 'Dr. Ir. M. H. Damme' and the Schiphol Air Traffic Control Station PKH during the Christchurch Flight on 8th, 9th and 10th Oct. 1953.—(*Tijdschr. ned. Radiogenoot.*, Nov. 1953, Vol. 18, Nos. 5/6, pp. 313–315.) A log is given of the times during which contact was made. The Karachi, Biak and Djakarta stations co-operated in the check.

SUBSIDIARY APPARATUS

621-526 **1582**

The Application of Statistical Methods to Servomechanisms.—R. E. Vowels. (*Aust. J. appl. Sci.*, Dec. 1953, Vol. 4, No. 4, pp. 469–488.) "The optimum transfer function for the desired response to a stationary random input signal containing noise may be determined by the Wiener-Lee method. In general, when applied to servomechanisms design, the output will not necessarily have zero steady-state error. In order to overcome this disadvantage, constraints may be applied in the Wiener-Hopf equation such that any of the error coefficients of the servomechanism are zero, and at the same time the output is optimized. It is also possible to include prediction, differentiation, or integration of the input function as desirable outputs."

621.316.721/.722 **1583**

Series Operation of a Glow-Discharge Tube and a Barretter.—F. A. Benson. (*Elect. J.*, 23rd Oct. 1953, Vol. 151, No. 17, pp. 1291–1293.) The replacement of the series resistor by a barretter results in improved stabilization. The operation of the Type-CV1199 glow-discharge tube (180 mA max.) with Type-161 barretter (160 mA) was investigated and the batch variations of the Type-161 barretter characteristics were examined.

621.316.722.1 **1584**

Stabilizer for Alternating Voltages.—A. Riedel. (*Nachr-Tech.*, Oct. 1953, Vol. 3, No. 10, pp. 460–464.) The design of a biased-reactor arrangement having good frequency independence and satisfactory speed of operation is discussed.

621.316.722.1.076.7 **1585**

A Stable Source of High Voltage.—L. U. Hibbard & D. E. Caro. (*J. sci. Instrum.*, Oct. 1953, Vol. 30, No. 10, pp. 378–380.) A voltage regulator suitable as a voltage reference at about 1 000 V with current up to several milliamperes is described. With the temperature controlled to within $\pm$ 1°C, the output is stable to within $\pm$ 1 part in 10^4 over 8 hours. Effects of varying magnetic fields $<$ 15 gauss are negligible.

621.316.93 : 621.396.933 1586

Aircraft Protection from Thunderstorm Discharges to Antennas.—J. M. Bryant, M. M. Newman & J. D. Robb. (*Elect. Engng, N.Y.*, Oct. 1953, Vol. 72, No. 10, pp. 880–884.) The protection unit described consists of a 10^{-9}F 10-kV capacitor in the aerial feeder lead together with a spark gap in parallel with a resistor, connected between the aerial side of the capacitor and the fuselage. A peak-current recorder, in the form of a steel strip magnetized by the current flow, is included. Units of this type have been tested for over two years in commercial airliners.

TELEVISION AND PHOTOTELEGRAPHY

621.397 + 621.396] : 061.3 1587

The New C.C.I.R. Resolutions.—V. Fetzer. (*Funk u. Ton*, Nov. & Dec. 1952, Vol. 6, Nos. 11 & 12, pp. 591–596, 642–648 and Jan.–Nov. 1953, Vol. 7, Nos. 1–11, pp. 34–43, 84–89, 145–156, 205–208, 250–256, 315–318, 369–377, 414–419, 472–476, 535–544 & 590–593.) Detailed report of recommendations, numbered from 36 to 85, made by 13 study groups at the 6th Plenary Assembly, Geneva, 1951.

621.397.335 : 535.623 1588

Color Synchronization in the N.T.S.C. Color Receiver.—W. E. Good. (*Trans. Inst. Radio Engrs*, Oct. 1953, No. PGBTR-4, pp. 23–29.) The necessary phase accuracy is discussed, and the design and performance of several synchronizing circuits are compared. See also 1749 of 1952 (Dome).

621.397.5 : 535.623 1589

Color Television—a Primer on the N.T.S.C. System.—W. Feingold. (*Trans. Inst. Radio Engrs*, Oct. 1953, No. PGBTR-4, pp. 30–37.) An elementary treatment intended as an introduction to the subject.

621.397.5 : 535.623 1590

The Application of Colour to Television Broadcasting.—F. C. McLean. (*Engineering, Lond.*, 2nd Oct. 1953, Vol. 176, No. 4575, pp. 441–444.) Possible colour-television systems for use in Britain are discussed in relation to experience already gained with the N.T.S.C. system in the U.S.A. It is not yet certain that all the colour information can be transmitted within the 5-Mc/s channel. Separation of a colour subcarrier as used in the N.T.S.C. system would be more difficult with the British system because the sound channel is amplitude modulated. Receiver requirements are also discussed. For a summarized version, with comments, see *Wireless World*, Nov. 1953, Vol. 59, No. 11, p. 523.

621.397.5 : 621.395.625.3 1591

The Status of Magnetic Recording.—Zenner. (See 1291.)

621.397.62 1592

Design Techniques for Color Television Receivers.—M. H. Kronenberg & E. S. White. (*Electronics*, Feb. 1954, Vol. 27, No. 2, pp. 136–143.) Circuits for receiving the N.T.S.C. signals are discussed; details are given of particular designs, (*a*) for a receiver using the full potentialities of the system, and (*b*) for a simplified circuit with a colour bandwidth of 0·5 Mc/s.

621.397.62 : 535.623 1593

Color-Television-Signal Receiver Demodulators.—D. H. Pritchard & R. N. Rhodes. (*Trans. Inst. Radio Engrs*, Oct. 1953, No. PGBTR-4, pp. 1–22.) Reprint. See 3436 of 1953.

621.397.62 : 535.88 1594

An Apparatus for Aperture-Response Testing of Large Schmidt-Type Projection Optical Systems.—D. J. Parker, S. W. Johnson & L. T. Sachtleben. (*J. Soc. Mot. Pict. Telev. Engrs*, Dec. 1953, Vol. 61, No. 6, pp. 721–730.)

621.397.62 : 621.385.3 1595

The PCC 84 Double Triode.—(*Electronic Applic. Bull.*, Aug./Sept. 1953, Vol. 14, Nos. 8/9, pp. 113–120.) Valve data are given and the use of the valve as a cascode amplifier for the h.f. stage of a television receiver is described.

621.397.828 : 535.623] + 621.396.828 1596

Color Television and the Amateur.—Grammer. (See 1558.)

TRANSMISSION

621.396.61 1597

Some Aspects of the Design of Master-Oscillator Power-Amplifier Type Transmitters.—P. Howell. (*Radio & Electronics, Wellington, N.Z.*, 1st Dec. 1953, Vol. 8, No. 10, pp. 13–15, 31.) Various known circuits are discussed, and precautions necessary to prevent self-oscillation of the amplifier are indicated.

621.396.61.029.53/.55 1598

Automatic-Tuning Communication Transmitter.—M. C. Dettman. (*Elect. Commun.*, Dec. 1953, Vol. 30, No. 4, pp. 271–278.) Slightly modified version of paper in *Convention Record Inst. Radio Engrs*, 1953, Part 2, pp. 137–144. The transmitter is designed to meet service conditions, and has a frequency range 300 kc/s–26 Mc/s. There are ten preset channels and manual tuning facilities. Automatic-tuning time is about 30 sec for most frequencies. Nominal power output is 100 W over the range 300 kc/s–2 Mc/s and 100 W or 500 W over the range 2–26 Mc/s.

621.396.61.029.62 : 621.376.3 : 621.314.7 1599

Single-Transistor F.M. Transmitter.—D. E. Thomas. (*Electronics*, Feb. 1954, Vol. 27, No. 2, pp. 130–133.) Frequency modulation is achieved, in an experimental transmitter with a range of a few hundred feet, by shifting the alpha-cut-off frequency (about 40 Mc/s) of a point-contact transistor, the transmitter oscillator operating at about 105 Mc/s.

621.396.662 : 621.316.7 1600

Automatic Control System with Provision for Scanning and Memory.—N. H. Young. (*Elect. Commun.*, Dec. 1953, Vol. 30, No. 4, pp. 279–282; *Trans. Amer. Inst. elect. Engrs*, 1953, Vol. 72, pp. 392–395.) See 884 of March.

VALVES AND THERMIONICS

537.533.8 : 621.373.4.029.63 1601

On the Time Delay of Secondary Emission.—G. Diemer & J. L. H. Jonker. (*Philips Res. Rep.*, Oct. 1953, Vol. 8, No. 5, p. 397.) Correction and addendum to paper noted in 1014 of 1951.

621.314.632 : 546.289 : 621.396.822.029.422/.5 1602

Measurements of Noise Spectra of a Point Contact Germanium Rectifier.—F. J. Hyde. (*Proc. phys. Soc.*, 1st Dec. 1953, Vol. 66, No. 408B, pp. 1017–1024.) The excess noise due to the passage of d.c. was measured at 29·5°C over the frequency range 0·117 c/s–14 Mc/s, with the reverse current I as parameter. The noise spectrum consists of three types of component, namely (*a*) a basic component $\propto f^{-1}$, detectable over a frequency range of seven decades, (*b*) two components $\propto [1 + (2\pi f\tau)^2]^{-1}$ associated with relaxation times τ_1 and τ_2 and (*c*) a uniform component detectable at high frequencies and equal to the shot noise for small currents. The relaxation times are dependent on *I*.

621.314.632 : 546.289 : 621.396.822.029.426 **1603**

The Reduction of Rectifier Noise by Illumination.—J. W. Granville and A. F. Gibson. (*Proc. phys. Soc.*, 1st Dec. 1953, Vol. 66, No. 408B, pp. 1118–1119.) Noise in a Ge point-contact diode was measured at room temperature using an amplifier with a bandwidth of 1·4 c/s tuned to 16·5 c/s. The nonlinear variation of noise power per unit dynamic resistance with variation of the reverse current is shown graphically for several values of the distance between the light source and the rectifier.

621.314.7 **1604**

Transistor Reliability Studies.—R. M. Ryder & W. R. Sittner. (*Proc. Inst. Radio Engrs*, Feb. 1954, Vol. 42, No. 2, pp. 414–419.) The useful life of transistors may be shortened by conditions of high humidity or high temperature; the characteristics may also change due to surface contamination, mechanical disturbance or electrical or chemical effects. The mechanisms involved are described. A good measure of protection is obtained by sealing the transistor with a plastic.

621.314.7 **1605**

The Drift Transistor.—H. Krömer. (*Naturwissenschaften*, Nov. 1953, Vol. 40, No. 22, pp. 578–579.) The name 'drift transistor' is given to a junction transistor in which the concentration of impurity centres in the base falls exponentially between emitter and collector. An expression is derived for the rise of the upper frequency limit as compared with that for the ordinary junction transistor with uniform distribution of impurity centres in the base.

621.314.7 **1606**

German Transistors.—C. Möller. (*Funk-Technik, Berlin*, Nov. 1953, Vol. 8, No. 21, pp. 668–669.) Characteristics and operating data are given for several types of German-produced transistors. Applications are indicated.

621.314.7 : 546.28 **1607**

Enhanced Alpha in Formed Silicon Point-Contact Transistors.—H. Jacobs, W. Matthei & F. A. Brand. (*J. appl. Phys.*, Nov. 1953, Vol. 24, No. 11, pp. 1410–1411.) Point-contact transistors have been prepared by causing an impurity such as Sb to be diffused into a small region at or near the surface of *p*-type Si, using an arcing technique. High values of α (up to 10 or even more) are obtained. The transistor action is further enhanced by passing large currents in the reverse direction through the emitter. The properties of such Si transistors are compared with those of Ge types.

621.383.2 **1608**

Alkali Photocells: Part 1.—M. Ploke. (*Arch. tech. Messen*, Nov. 1953, No. 214, pp. 259–262.) A review of the theory and a survey of the principal types. Comparative data are given.

621.383.2 : 537.531 **1609**

Effect of X Rays on Photocells.—G. Blet. (*C. R. Acad. Sci., Paris*, 4th Jan. 1954, Vol. 238, No. 1, pp. 72–73.) The current output of an Se cell was measured for various values of incident X-ray energy. Taking account of the variation of absorption with wavelength, the results indicate that the current output per watt absorbed is constant. Estimates are made of the number of electrons emitted per photon absorbed.

621.383.27 **1610**

Recent Developments in Photocells with Secondary-Electron Multipliers.—N. Schaetti. (*Bull. schweiz. elektrotech. Ver.*, 14th Nov. 1953, Vol. 44, No. 23, pp. 989–995.) An account of work done at the Institut für technische Physik, Zürich. The photocathodes and multiplier arrangements are described, and some applications of photomultipliers are indicated.

621.383.27 : 546.36.86 **1611**

Control of the Characteristic of a Cs-Sb Photocathode by addition of Other Elements.—N. Schaetti. (*Z. angew. Math. Phys.*, 15th Nov. 1953, Vol. 4, No. 6, pp. 450–459.) Measurements on photomultipliers are reported. The dark current and the delayed emission following a period of illumination can be reduced by addition of various elements to the cathode material. The results for 14 different elements are tabulated.

621.383.4 **1612**

A Method of Describing the Detectivity of Photoconductive Cells.—R. C. Jones. (*Rev. sci. Instrum.*, Nov. 1953, Vol. 24, No. 11, pp. 1035–1040.) Detectivity in the reference condition C is given by an expression involving sensitive area and noise equivalent power of the cell, noise equivalent bandwidth of the amplifier used, and chopping frequency. Conditions of validity of the expression are stated and certain conventions relating to the measurement of the various quantities explained. The detectivity figure enables direct comparison to be made between two cells.

621.383.5: 546.561-31 **1613**

The Infrared Sensitivity of Cuprous-Oxide Photocells prepared at Reduced Pressure in a High-Frequency Field.—A. I. Andrievski & A. L. Rvachev. (*C. R. Acad. Sci. U.R.S.S.*, 11th March 1953, Vol. 89, No. 2, pp. 245–247. In Russian.) Two methods of manufacture using h.f. heating ($\sim$ 3 Mc/s) are described. Diverse spectral-sensitivity characteristics, shown graphically, were obtained by varying the pressure, the temperature and the time of oxidation and reduction. A cell with a maximum front-wall sensitivity in the green region and a maximum back-wall sensitivity in the red-to-infrared region, and a cell with maximum front-wall sensitivities in the green, red and infrared regions have been produced.

621.385.029.6 : 538.69 **1614**

Magnetrons.—P. H. J. A. Kleijnen. (*Tijdschr. ned. Radiogenoot.*, Nov. 1953, Vol. 18, Nos. 5/6, pp. 287–299.) Theory of the interaction between the electrons and the field is presented, with special reference to the mode spectrum of a rising-sun system.

621.385.029.63/.64 **1615**

The Effect of Line Attenuation on the Power Gain of a Travelling-Wave Valve.—W. Kleen & K. Pöschl. (*Fernmeldetech. Z.*, Nov. 1953, Vol. 6, No. 11, pp. 509–516.) Theoretical treatment of the travelling-wave valve with (*a*) distributed and (*b*) localized attenuation introduced into the delay line to suppress unwanted feedback effects. Results are presented graphically for various values of space-charge and loss parameters. Distributed attenuation has an adverse effect on the attenuation constant for the amplified wave and on the partition of input power between the three waves excited. Localized attenuation causes a gain reduction dependent on the length of the attenuating element and on the plasma frequency.

621.385.029.63/.64 **1616**

Coaxial-to-Helix Transducers for Traveling-Wave Tubes.—R. E. White. (*Elect. Commun.*, Dec. 1953, Vol.

30, No. 4, pp. 300–304; *Convention Record Inst. Radio Engrs*, 1953, Part 10, pp. 42–45.) Design data are given for matching sections of ferrule type, with a tuning range up to 2 : 1, for small-diameter helices, and of tapered type, with a tuning range up to 4 : 1, for large-diameter helices.

621.385.029.63/.64 : 621.372.2 **1617**

Wave Propagation along a Helix with a Cylindrical Outer Conductor.—K. Pöschl. (*Arch. elekt. Übertragung*, Nov. 1953, Vol. 7, No. 11, pp. 518–522.) Formulae and curves are derived for the phase velocity, the characteristic impedance and the transfer impedance. These are valid over a wide range of wavelength and linear dimensions of the helix and cylinder, and reduce to a simple form when the phase velocity is small compared with the velocity of light.

621.385.029.63/.64 : 621.396.822 **1618**

Microwave Shot Noise in Electron Beams and the Minimum Noise Factor of Travelling Wave Tubes and Klystrons.—F. N. H. Robinson. (*J. Brit. Instn Radio Engrs*, Feb. 1954, Vol. 14, No. 2, pp. 79–86.) "A theorem recently proposed by J. R. Pierce concerning the intrinsic noise of electron streams is verified for electron beams originating in thermionic diodes under arbitrary conditions. The theorem is applied to the calculation of the minimum noise factor of klystrons and travelling wave tubes which is found to be 6 db. The treatment of partition noise is made possible by a generalization of the theorem."

621.385.032.21 : 546.841-31 **1619**

Thermionic Emission from Thin Layers of Thoria and Thorium on Molybdenum.—A. R. Shul'man & A. P. Rumyantsev. (*C. R. Acad. Sci. U.R.S.S.*, 21st Nov. 1953, Vol. 93. No. 3, pp. 455–458. In Russian.) Emission depends on several factors, in particular on (*a*) the penetration of the electric field inside the semiconducting surface layer, and (*b*) chemical or catalytic processes due to the base metal. Emission characteristics of variously treated cathodes were determined and the variation of work function and emissivity with thickness θ of the surface layer are shown graphically. θ is expressed as a number of monolayers; its value was determined from the α-particle emission.

621.385.032.216 **1620**

Cathode Parasitic Impedance.—M. Berthaud. (*Bull. Soc. franç. Élect.*, Nov. 1953, Vol. 3, No. 35, pp. 673–675.) The internal impedance developing in aged cathodes and generally ascribed to the formation of an interface layer has been measured by three methods which are outlined. Results are at variance with those of Eisenstein and others (2052 of 1951, 1812 of 1950 and back references), particularly as regards the dependence of this impedance on cathode temperature and valve current; it is inferred that the impedance is due to phenomena occurring not necessarily at the interface.

621.385.3 : 621.397.62 **1621**

The PCC 84 Double Triode.—(*Electronic Applic. Bull.*, Aug./Sept. 1953, Vol. 14, Nos. 8/9, pp. 113–120.) Valve data are given and the use of the valve as a cascode amplifier for the h.f. stage of a television receiver is described.

621.385.4.002.2 : [621.395.64 + 621.396.65 **1622**

The Telephone-Repeater Valve.—P. Meunier. (*Bull. Soc. franç. Élect.*, Nov. 1953, Vol. 3, No. 35, pp. 676–685.) Requirements in the design and manufacture of long-life valves of conventional type are discussed, in particular the steps taken to minimize cathode deterioration and its effects. Details are given of two tetrodes recently developed: (*a*) Type-PTT301 for submarine use, with a guaranteed life of 80 000 hours; (*b*) Type-PTT 243P, with a gain-bandwidth product of 200 Mc/s. The control-grid/cathode spacing of the latter is 0·0625 mm.

621.385.832 : 621.317.755 **1623**

A Sealed-Off Cathode-Ray Tube with a Very High Writing Speed.—B. Jackson, D. R. Hardy & R. Feinberg. (*Nature, Lond.*, 5th Dec. 1953, Vol. 172, No. 4388, pp. 1056–1057.) In an e.s.-deflection tube for direct observation and photographic recording of nonrecurrent high-voltage signals, the vertical deflection system comprises a straight twin-wire transmission line arranged perpendicular to the tube axis. The low-frequency deflection sensitivity is 0·006 mm/V at a beam-accelerating voltage of 25 kV. Writing speeds as high as $6{\cdot}6 \times 10^{10}$ cm/s have been attained.

621.385.832 : 621.317.755 **1624**

Multibeam Cathode-Ray Oscillograph.—C. Fert, J. Lagasse & J. Ollé. (*C. R. Acad. Sci., Paris*, 4th Jan. 1954, Vol. 238, No. 1, pp. 59–61.) A tube is described in which all the beams when undeflected strike the screen at the same spot. The single gun produces a beam which diverges from a narrow crossover and passes through apertures arranged in a coaxial ring in a diaphragm; a magnetic lens is used to bring the beams together again on the screen. Common magnetic horizontal-deflection and individual e.s. vertical-deflection systems are used. An illustration is shown of a four-trace recording obtained.

621.385.832 + 621.387] : 621.318.572 **1625**

Decimal Counting Tubes.—K. Kandiah. (*Electronic Engng*, Feb. 1954, Vol. 26, No. 312, pp. 56–63.) A survey of available types, classed as gas-filled, c.r.-tube and trochotron. Resolving times of circuits using these tubes, and tolerances on components and supply voltages are discussed.

621.385.832 : 621.395.625.3 **1626**

Visual Monitor for Magnetic Tape.—Miller. (See 1290.)

621.387 : 621.373.432 **1627**

Control of Glow-Discharge Triodes by means of Very Small Currents.—Meili. (See 1351.)

621.387 : 621.395 **1628**

New Thyratrons for Telephone-Circuit Engineering: Part 2 — Coincidence Thyratrons with Screen Grids and their Static Ignition Characteristics. Dynamic Ignition Characteristics.—K. L. Rau. (*Frequenz*, Sept. 1953, Vol. 7, No. 9, pp. 249–255.) The effect of various constructions of the screen grid on the valve characteristics is discussed. Part 1: 3156 of 1953.

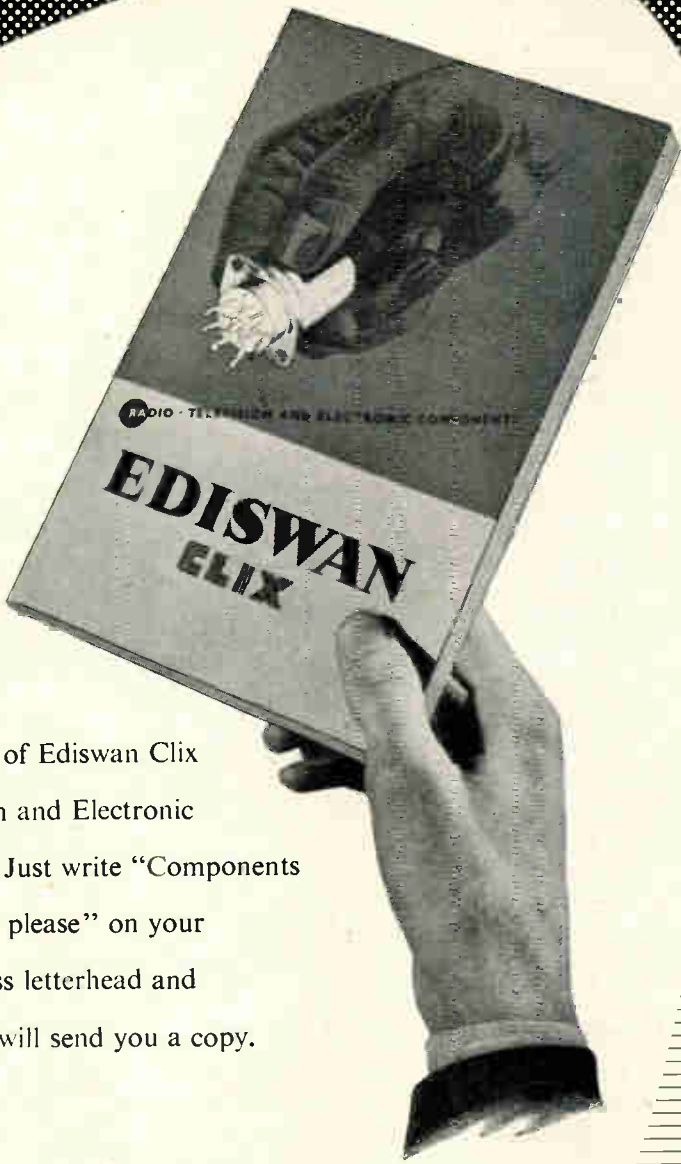
MISCELLANEOUS

061.6 : 538.56.029.6 **1629**

Centre for the Study of Microwave Physics [at Florence]. —N. Carrara. (*Ricerca sci.*, Jan. 1954, Vol. 24, No. 1, pp. 31–34.) Report of activities during the year 1952; the construction of new instruments for wavelength measurements and devices for investigating microwave optics is mentioned.

061.6 : 621.3 **1630**

The Galileo Ferraris National Electrotechnical Institute. —P. Lombardi. (*Ricerca sci.*, Dec. 1953, Vol. 23, No. 12, pp. 2161–2231.) A report is given of the activities of the institute during the period 1949–1951, and the organizational structure is described. The subjects investigated include magnetic and dielectric materials, electro-acoustics, electron tubes and radio engineering.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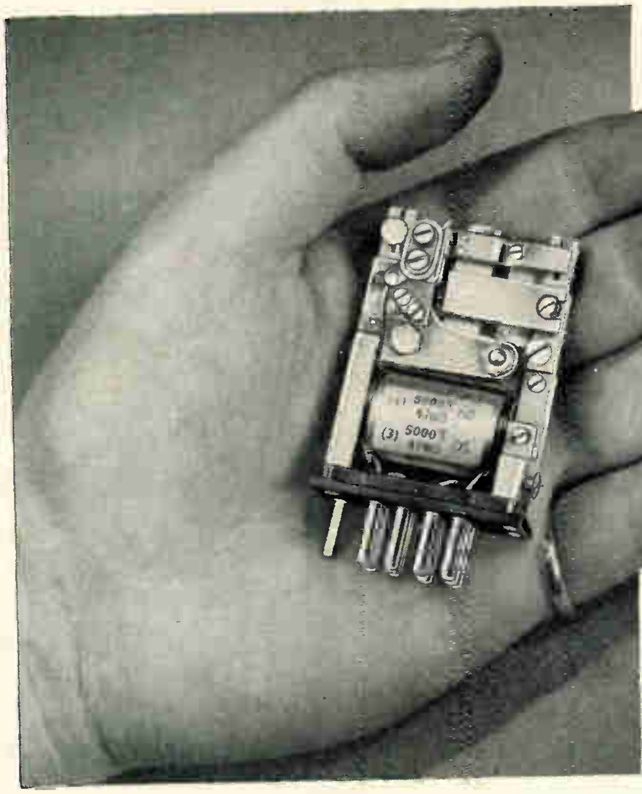

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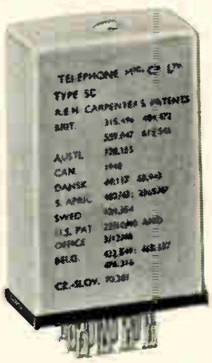

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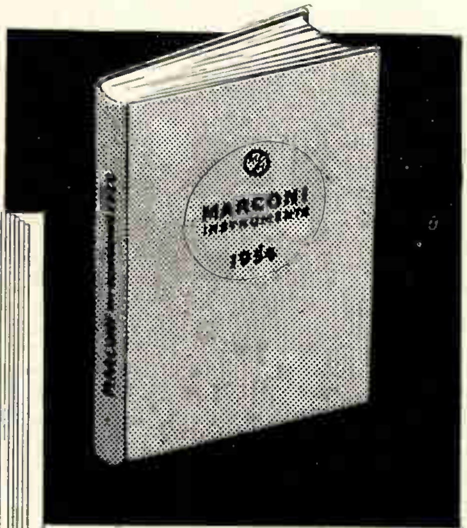

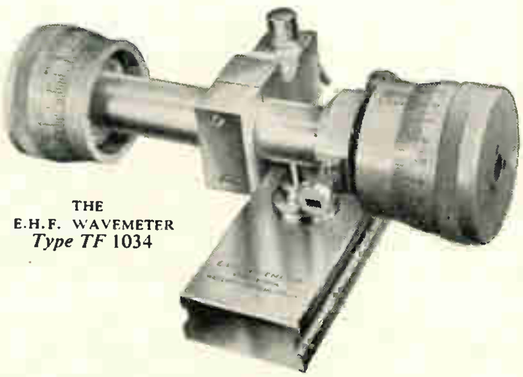

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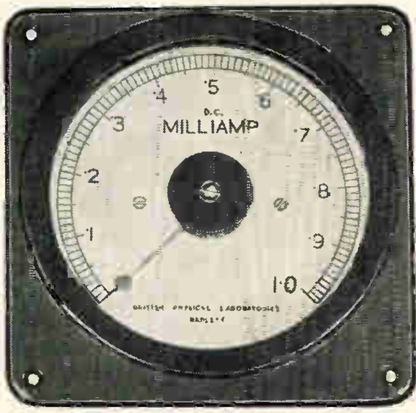

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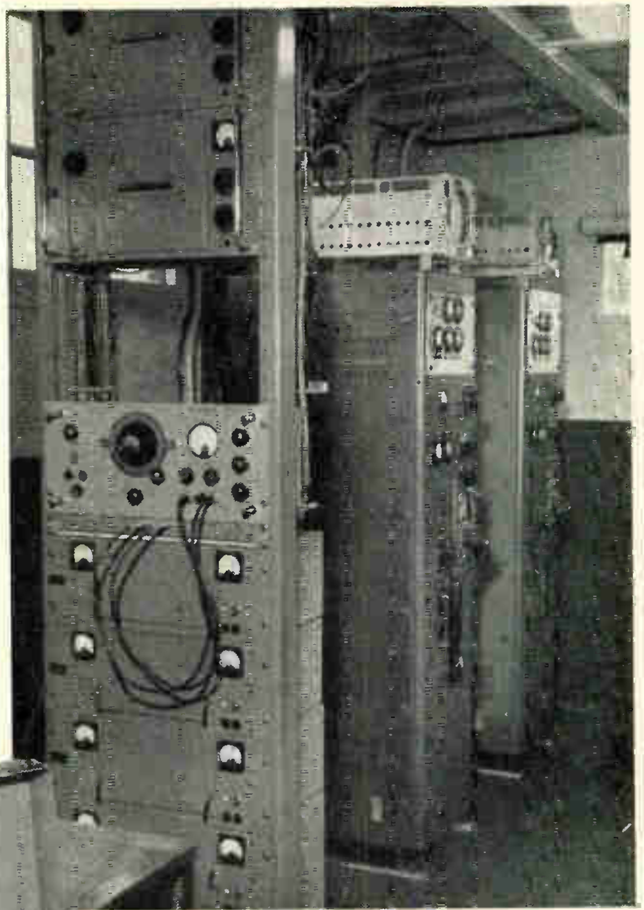

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